

# Association Between Eliminating Water From Surgical Hand Antisepsis at a Large Ophthalmic Surgical Hospital and Cost

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**IMPORTANCE** Alcohol-based surgical scrub is recommended for presurgical antisepsis by leading health organizations. Despite this recommendation, water-based scrub techniques remain common practice at many institutions.

**OBJECTIVE** To calculate the potential financial savings that a large, subspecialty ophthalmic surgical center can achieve with a conversion to waterless surgical hand preparation.

**DESIGN, SETTING, AND PARTICIPANTS** A review of accounting records associated with the purchase of scrubbing materials and water company invoices was conducted to assess direct costs attributable to water consumption and scrub materials for brushless, alcohol-based surgical scrub and water-based presurgical scrub. The flow rate of scrub sinks to estimate water consumption per year was tested. Savings associated with operating room (OR) and personnel time were calculated based on the prescribed scrub times for waterless techniques vs traditional running-water techniques. The study was conducted from January 5 to March 1, 2019.

**MAIN OUTCOMES AND MEASURES** The primary outcomes for this study were the quantity of water consumed by aqueous scrubbing procedures as well as the cost differences between alcohol-based surgical scrub and water-based scrub procedures per OR per year.

**RESULTS** Scrub sinks consumed 15.9 L of water in a 2-minute period, projecting a savings of 61 631 L and \$277 in water and sewer cost per operating room per year. Alcohol-based surgical scrub cost \$1083 less than aqueous soap applied from wall-mounted soap dispensers and \$271 less than preimpregnated scrub brushes per OR per year in supply costs. The decrease in scrub time from adopting waterless scrub technique could save between approximately \$280 000 and \$348 000 per OR per year.

**CONCLUSIONS AND RELEVANCE** Adopting waterless scrub techniques has the potential for economic savings attributable to water. Savings may be larger for surgical facilities performing more personnel-intensive procedures.

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The universal practice of preoperative hand antisepsis, colloquially known as scrubbing, has changed little since Semmelweis and Carter introduced the practice of scrubbing with chlorinated lime solution in 1847, thereby diminishing the incidence of puerperal sepsis.<sup>1</sup> The safety and efficacy of alcohol-based (ie, waterless) scrub technique, which requires no water for preoperative hand antisepsis, are well established in the literature.<sup>2-6</sup> Waterless scrub solutions containing chlorhexidine gluconate as the primary active ingredient are prevalent at scrub sinks in American hospitals alongside traditional aqueous scrub solutions designed to be used with running water.

A Cochrane Review investigation found no major differences in efficacy between chlorhexidine gluconate-based alcohol scrubs and traditional aqueous scrubs.<sup>7</sup> The studies in the review used surgical site infections and bacterial colony

forming units taken from swabs of surgeons' hands as the outcome variables. Some studies have suggested that waterless scrubbing is more efficacious than traditional water-based procedures.<sup>3,8-13</sup>

Routine use of waterless scrub solutions for surgical hand antisepsis was endorsed in a joint compendium published by the Society for Health and Epidemiology of America, the American Hospital Association, the Infectious Diseases Society of America, and the Joint Commission.<sup>14</sup> The World Health Organization (WHO) declared waterless chlorhexidine gluconate-based hand rubs more effective than water-based scrubs and recommended their incorporation into daily practice.<sup>15</sup> Despite these endorsements, traditional running water scrub remains the standard preoperative routine in many institutions, at least for the first scrub of the day for each staff member.

Wormer et al<sup>16</sup> described the environmental and financial outcomes that environmentally focused initiatives can have on a tertiary surgical center in North Carolina. They predicted that \$2000 and 2.7 million L of water could be saved per year across their institution by shifting to waterless scrub, an average of \$57 and 77 143 L of water per OR per year. The estimate by Wormer et al<sup>16</sup> was based solely on municipal water and sewage cost and water consumption per surgical procedure. Other studies have tracked the water used by surgeons at scrub sinks in surgical preparation, suggesting that unnecessary water use, primarily caused by allowing the water to run throughout the scrub process, is common practice.<sup>17,18</sup>

The savings in water and the environmental impetus for conservation of water may be sufficient justification for shifting to this modern, safe, and effective technology. To our knowledge, our study is the first to use materials and personnel costs to detail the savings available to modern health care facilities associated with a conversion to waterless hand antisepsis, based on real-world experience at a major academic institution.

## Methods

Data collection was conducted at the Anne Bates Leach Eye Center at the Bascom Palmer Eye Institute, University of Miami Miller School of Medicine (BPEI), Miami, Florida. The study was performed from January 5 to March 1, 2019. Because no human participants were involved, the study was considered exempt from approval by the University of Miami Institutional Review Boards.

The WHO defines a standard preoperative aqueous scrub as 2 minutes of scrubbing with soap and 1 minute of running water per hand, amounting to 2 minutes of continuous water use per scrub.<sup>15</sup> We tested the flow rate of industry-standard scrub sinks by running water in the sinks for 2 minutes in accordance with the WHO standard. The water produced in that time was collected in a receptacle and weighed. The volume of water was calculated using a standard density of 0.997 g/mL. This procedure was performed 3 times at each of BPEI's 8 operating room scrub sinks and the mean was determined.

We conducted a review of accounting records associated with the purchase of alcohol-based scrub solutions, aqueous scrub solutions, standard scrub brushes, chlorhexidine gluconate-impregnated wet-scrub brushes, and nail picks. At BPEI, the alcohol-based surgical scrub used is an ethyl alcohol-based hand rub (active ingredient, chlorhexidine gluconate, 1%; Avagard; 3M) and the aqueous solution is a surgical soap (Tri-septin; Becton Dickinson). Estimated surgical volume was based on actual 5-year experience spanning 12 135 procedures in 2014 to 13 623 procedures in 2018. The cost of water per gallon was calculated based on a review of invoices from the Miami-Dade Water and Sewage Company between November 2017 and January 2019. These data were used to identify the institutional consumable cost per scrub and cost per year for the different procedures based on product costs as well as the volume of water consumption per year.

## Key Points

**Question** Are potential financial savings achievable by exclusive use of alcohol-based hand scrub for surgical preparation at a large ophthalmic surgical hospital?

**Findings** In this economic evaluation conducted at a surgical eye hospital, water savings amounted to 61 631 L per operating room per year after sole use of alcohol-based hand scrub was initiated. The savings from adopting waterless scrub technique could be between \$280 000 and \$348 000 per operating room per year.

**Meaning** These data suggest that eliminating water from presurgical hand preparation could save modern health care facilities millions of dollars per year and potentially conserve valuable water resources, although potential savings regarding the water used to prepare and distribute alcohol-based hand scrubs for surgical preparation were not calculated.

Personnel time savings and OR facility time savings were calculated based on a review of United States and WHO standards for time consumed by waterless scrub techniques vs traditional running-water scrubs.<sup>14</sup> Time savings were converted into costs, based on the results of an accounting analysis performed by internal audit at the institution to determine the cost of a minute of OR time at BPEI. This study followed the Consolidated Health Economic Evaluation Reporting Standards (CHEERS) reporting guideline for economic evaluations.

## Results

Scrub sinks in the BPEI OR consumed an average of 15.9 L of water in a 2-minute period. A 5-year review of surgeries performed at BPEI revealed an average of 12 921 surgical procedures with an average of 3 scrubbed personnel per procedure. Surgical volume increased every year at BPEI for the past 5 years, with 13 623 surgical procedures performed in 2018. Based on these data, 616 313 L (162 813 gallons) of water per year would be consumed, an average of 61 631 L per OR per year, if every surgical procedure used wet scrub for surgical hand antisepsis. A total of 15.9 L of water would be used for each scrub, with 47.7 L used per procedure.

A review of water bills from Miami-Dade Water and Sewage between November 2017 and January 2019 documented a mean (SD) of \$0.45 (\$0.02) per liter of water, including runoff and sewage charges. This cost translates to \$277 per OR per year in actual water and sewer charges.

The cost of alcohol-based surgical scrub is \$30.16 per 500-mL container. The manufacturer recommends 6 mL for each scrub, allowing for 83 procedures per container; the total cost per scrub is \$0.36. Aqueous soap is purchased for \$18.41 per container and the company recommends 14 mL of solution per procedure. The cost of aqueous soap per procedure can be projected as \$0.33. Chlorhexidine gluconate-impregnated scrub brushes used at many sinks were found to cost \$0.43 per unit.

The consumables cost per year for alcohol-based surgical scrub for 1 staff member for every surgical procedure at BPEI

**Table 1. Cost Comparison of Alcohol-Based Surgical Scrub vs Wet Scrub Using Soap Dispenser and Preimpregnated Scrub Brushes**

Variable	Cost, \$		
	Waterless	Wet Scrub	
		Without PISB	With PISB
<b>Materials</b>			
Alcohol-based surgical scrub	0.36	NA	NA
Aqueous soap	NA	0.330	NA
PISB	NA	NA	0.430
Scrub brush	NA	0.260	NA
Pick	NA	0.050	NA
Water <sup>a</sup>	NA	0.071	0.071
<b>Cost</b>			
Per staff member	0.36	0.711	0.501
Per staff member per year <sup>b</sup>	4650	9190	6470
Waterless	NA	4540	1820

Abbreviations: NA, not applicable; PISB, preimpregnated scrub brushes.

<sup>a</sup> The cost of water was calculated based on a measurement of 15.9 L consumed per staff member per scrub at a cost of \$0.45 per liter.

<sup>b</sup> Using an average of 12 921 surgical procedures per year between 2013 and 2018 at Bascom Palmer Eye Institute.

**Table 2. Comparison of the Cost of OR Time Between Alcohol-Based Surgical Scrub and Standard 5- and 6-Minute Wet Scrubs<sup>a</sup>**

Variable	Procedure Time, Cost, \$		
	Alcohol, 40-70 s	Standard, 6 min	Standard, 5 min
\$/Procedure	\$48.58	\$318	\$265
\$/y	\$627 725.82	\$4 108 751	\$3 423 959
\$/OR/y	\$62 772.58	\$410 875.08	\$342 395.90
Difference	NA	\$348 102	\$279 623

Abbreviation: OR, operating room.

<sup>a</sup> OR costs at Bascom Palmer Eye Institute: \$53 per minute.

in a year was projected to be \$4650. In contrast, the consumable cost of wet scrubs using dispensers and scrub brushes projects to \$9190 using the dispensers and \$6470 using the chlorhexidine gluconate-impregnated scrub brushes (Table 1). At BPEI, the average scrub team comprises 3 personnel and the cost can be averaged over 10 ORs. Overall, a shift to waterless scrub was associated with a supplies cost savings of \$1360 per OR per year if dispensers are used and \$548 if chlorhexidine gluconate-impregnated brushes are used by a 3-member scrub team. In total, scrub materials alone could account for \$4534 per scrubbed staff member per year.

Operating room time costs BPEI \$53 per minute based on an audited contribution margin analysis conducted between 2017 and 2018. The analysis included all hospital and professional charges, both direct and indirect, for each case. The WHO prescribes between 40 and 70 seconds for a waterless scrub procedure and 6 minutes for a traditional scrub with soap and water.<sup>15</sup> A 5-minute scrub time is standard in the United States and therefore was incorporated into this analysis as well. The annual surgical volume at BPEI was averaged across 10 ORs to identify the yearly cost of OR time per OR. If every surgical procedure at BPEI over the past 5 years had been prepared with a traditional 5-minute aqueous scrub, the cost of OR time per room would have been \$279 623 more than if every procedure had included alcohol-based rubs. If the same surgical volume was prepared using the WHO standard 6-minute scrub time, the additional cost would be \$348 102 per OR per year (Table 2).

## Discussion

A conversion from traditional water-based preoperative hand antisepsis to waterless, alcohol-based techniques has the potential to save a modern US health care institution \$281 323 per OR per year with a surgical volume similar to that of BPEI. Although there are environmental imperatives for saving water, by far the largest component of actual cost savings is attributable to the lower costs of supplies and the savings in chargeable OR time associated with waterless scrub techniques. The institution studied is a high-volume, hospital-based ophthalmologic facility that typically has 3 scrubbed staff members per surgical case. However, many institutions focused on other forms of surgery may have many more scrubbed staff members per surgical case with staff scrubbing in and out over the course of a complex procedure.

Surgical handwashing would account for 616 313 L of water consumption per year in the absence of waterless alternatives at our institution. The Centers for Disease Control and Prevention reported that, in 2010, there were 30.194 million surgical procedures performed in the United States.<sup>19</sup> At this surgical volume and with an average of a 3-person scrub team, the quantity of water would be 1.44 billion L. At institutions with higher surgical volume or in specialties requiring more scrubbed personnel per operation, water consumption will increase proportionately. However, in regions where water resources are scarce, the quantity of water consumed

through the use of traditional scrub techniques is even more precious.

The cost savings associated with alcohol-based scrub supplies vs traditional water-based scrub supplies far exceeds the cost savings attributable to the water itself. The price per scrub for alcohol-based surgical scrub was two-thirds the price of a traditional wet scrub using a chlorhexidine gluconate-impregnated scrub brush and less than half that of a wet scrub using a soap dispenser and scrub brushes. Materials alone were projected to result in a potential \$4534 in annual savings per staff member by eliminating wet scrub and adopting a waterless product. This value should increase if the number of surgical procedures continues to increase at BPEI.

The largest component of savings, however, is the savings in OR personnel costs and OR time associated with a shift to waterless scrub. The audited cost at BPEI of \$53 per minute is consistent with previous studies that have estimated OR costs. A study reported in 2005 surveyed 100 US hospitals and found an average cost of \$62 per minute.<sup>20</sup> A study conducted in California surveyed 302 facilities and found an average of \$37 per minute for OR costs.<sup>21</sup> Based on BPEI's cost structure, a standard 6-minute wet scrub costs an extra \$348 102 per OR per year. Even with a 5-minute scrub, which is standard practice at many institutions, the cost is an extra \$279 623 (Table 2). Those costs extrapolate to \$3.48 million for 6-minute scrubs and \$2.8 million for 5-minute scrubs at BPEI, which has 10 ORs.

The implications of this study go beyond the OR. Although the institution chosen for this study is located in a region that has adequate fresh water for its current needs, there are regions of the world where the use of water must be strictly rationed, and water used in a health care facility restricts the availability of water for other purposes. West and coworkers<sup>22</sup> have shown that the key to trachoma control is daily face washing, which requires an allocation of water in regions where water is scarce. In such regions, the actual cost of water is higher than the 1.7 cents per gallon in Miami.

Switching to a waterless scrub in surgical and medical settings frees scarce resources for sanitation and drinking while reducing the financial burden on health systems. The cost of hand sanitation is \$0.36 per person for surgical preparation. Waterless scrubs could be made available at low cost to areas with scarce water provisions to help prevent the spread of common pathogens and perhaps facilitate better surgical care. According to a WHO report, 2.1 billion people live without access to safe drinking water and approximately 4.4 billion people live without access to adequate sanitation.<sup>23</sup> Access to clean water is a large obstacle to improving health outcomes in impoverished regions. Conserving water in the OR will help to alleviate the burden of health care on public water stores.

Waterless scrub also has major implications for environmental conservation efforts. Antibacterial agents used in hand soaps immediately enter the sewer system and pass through a sewage treatment plant to enter rivers and coastal waters. In doing so, they create a toxic environment for aquatic life, which is of growing concern worldwide.<sup>24</sup> Alcohol-based scrubs, on the other hand, do not enter the ecosystem, except to the ex-

tent that residues are later washed off the skin during casual handwashing, bathing, or swimming.

### Limitations

This analysis, as with any economic model, has several limitations. Water use assumptions are based on WHO surgical scrub time recommendations and not on actual staff behavior. We did not analyze manufacturing or distribution demands for water in our analysis of water consumption. However, both alcohol-based and water-based scrubs require water for their production.<sup>25</sup> Indeed, production of iodinated soaps requires double-boiler evaporation and produces a smaller quantity of sterilizing solution per milliliter of water than the manufacturing process for alcohol-based surgical scrub.<sup>26,27</sup> These similarities in manufacturing procedures suggest that water conservation in hospitals is akin to environmental savings, but further studies are needed to evaluate any differences.

It is likely that many surgeons do not follow the scrub time guidelines set out by the WHO precisely, with an unknown effect on hand sterility or ultimate effect on patients. Moreover, Prabhu et al<sup>18</sup> showed that surgical personnel often leave water running unnecessarily during the scrub procedures instead of opening the faucet only at the beginning and end of each hand rinsing.

### Conclusion

The model presented herein provides a baseline for the environmental cost demanded by the regulations in place when hospitals and staff choose traditional wet scrubs in favor of alternatives. Flow rates of sinks, municipal water costs, and surgical volumes will vary between institutions. Analyses at similar institutions to quantify water costs and consumption in addition to spending on scrub products would help to correct for this limitation but were outside the scope of this investigation. BPEI is a specialty surgical center at which most ORs are not used on nights and weekends. Hospitals with longer OR hours and higher surgical volume will have a larger environmental footprint as well as higher potential financial incentive to switch to waterless scrub. There are many factors that could contribute to even greater savings that are not included in this analysis. An institutional shift to exclusively waterless scrubs would reduce water consumption in hospitals and surgical centers, conserve staff time associated with more time-consuming aqueous scrub techniques, conserve space costs and expense associated with building and maintaining surgical scrub sinks, and save costs associated with the ongoing purchase of supplies associated with water-based scrub techniques.

Waterless hand antisepsis is now well established as equal to or superior to traditional running-water scrubs in safety and efficacy. Our study suggests that the actual cost saving in water alone is eclipsed by savings in supplies as well as staff and facilities resources. These data may help health care facilities to become more environmentally responsible and financially savvy.

## ARTICLE INFORMATION

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