

Effect of Tissue Paper versus Air Dryer for Drying Hands on Skin Inhabited Bacteria in Obstetrical Wards

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Abstract

Background: Transmission of bacteria commonly occurs from wet skin than from dry skin. Thus, nurses and midwives are considered front-line conquerors who need to wash their hands too often, for infection prevention and control. This study **aims** to compare the effect of tissue paper versus air dryer for drying hands on skin inhabited bacteria in obstetrical wards. **Study design:** Comparative study was used between the two method of drying hand. The number and types of bacteria covering the nurses' hands were determined before and after hand hygiene using the two drying techniques for all nurses on duty in the ante, intra, and post-natal wards. **Sampling:** A purposive sample of all nurses (30) who are working in the (ante, intra, and postnatal) maternity wards of El-Nada maternity hospital, Egypt was recruited. **Tools:** Three tools were used for data collection. Tool I was occupational and demographic questionnaire. Tool II an observational checklist to assess the way and the time of drying hand used in each group. Tool III: Microbiological assessment tool to assess and compare pathogenic bacteria in each group. **Results:** Using air dryers for at least 45 seconds resulted to fewer transient and resident bacteria remained on the skin ($P < 0.001$) compared with those found after drying hand using tissue paper. **Conclusion and Recommendations:** Hands dried by air dryer harbors fewer viable bacteria than the hands dried with tissue paper. Air dryers are recommended to reduce resident and transient hand bacteria.

Keywords: Midwife, Routine Hand Hygiene, Jet Air Dryers, Resident Bacteria, Microbiology.

Introduction

Midwives use infection prevention and control as a crucial life-saving skill in tackling the issue of maternal mortality (Robinson-Bassey & Onyeabara, 2016). Hand hygiene is recognized as the simplest and the most efficient method in reducing infection transmission (Hammer Schmidt & Manser, 2019). There is a there is lack of knowledge on infection prevention and control education for nursing and midwifery students, especially in clinical settings (Ward, Deborah, 2015).

The hand hygiene practice and its effect on illnesses are issues of growing importance (Borchgrevink, Cha, & Kim, 2013; Rabbi, & Dey, 2013; Hirai et al., 2016). Scheithauer, Batzer, Dangel, Passweg, and Widmer, (2017) reported high workload is a commonly self-reported reason of compliance with hand hygiene but was often seen unsatisfactory. Despite the fact that hand hygiene is widely recognized as the most important method for avoiding and decreasing healthcare-associated infections (HCAIs), it is also a crucial aspect for patient and

practitioner safety. An improved hand hygiene is as an important and fundamental public health measure for controlling the spread of infection (Gammon & Hunt, 2019).

Broadly, there is a much emphasis on the documentation correct methods of handwashing (Centers for Disease Control and Prevention, 2019), but a less concern the methods of hand drying (Kimmitt & Redway, 2016; Wilcox, Best, & Parnell, 2017). The efficiency of hand drying is as important in preventing microorganisms' transmission. Patrick, Findon, & Miller, 1997 noted that inadequately dried hands, are more likely to transmit microorganisms than those that are carefully dried.

Hand drying is an important part of the hand hygiene process. Hand drying after washing should be addressed as an important aspect of hand hygiene and infection prevention procedures. Hand drying is important because it not only removes moisture from the hands but also involves mechanical friction, which minimizes bacterial load and consequently

microorganism spread (**Gammon & Hunt, 2019**).

Nonetheless, hand drying is a much-neglected aspect of hand hygiene as evidenced by the limited studies relating to the options for hand drying, the efficacy of different methods of hand drying in reducing contamination, amount of consequential microorganisms transmission into the clinical environment, the efficacy, frequency, and compliance of drying by healthcare practitioners and the consequences of wet hands for the healthcare practitioner (**Hirai et al., 2016; Suen, Lung, Boost, Au-Yeung, & Siu, 2019**).

Methods of hand drying vary widely and include paper towels, warm air dryers, or jet air dryers either singly or in combination. Drying with paper towels may remove remaining microorganisms through friction by wicking away moisture into the absorbent material. Warm air dryers evaporate moisture and remove some microorganisms during hand rubbing, although this process is time consuming, with hands consequently remaining damp. Newer jet air dryers rely on the passage of high speed, usually unheated, air to dry hands without rubbing, typically in 15 seconds. The selection of a drying method may depend upon a number of factors including practicality, space availability, cost, or personal preference (**Wilcox et al., 2017; Peate, & Wild, 2018**).

The benefits of machine hand dryers against paper towels for hand drying after washing were reported by a study of **Best et al., 2018**. Using towels tissue may have undesirable effects on waste disposal and environmental sanitation in health care institutions (**Joseph, Baah, Jahanfar, & Dubey, 2015**). Another study by **Best, Parnell, & Wilcox, 2014** found air bacterial counts in a hand dried through jet air dryer to be significantly higher, next to the use of paper towels. Infection prevention considerations may influence the choice of hand drying method, but the evidence is weak to make informed decisions.

Significance of the study

Maternal infections is a life-threatening episodes that occur as a result of an infection during pregnancy, during or after childbirth, or during an abortion (**Bonet et al., 2018**). Pregnancy-related infections are the third most common direct cause of maternal death

worldwide. Physiologic changes of pregnancy overlap with dysregulated host response to infection and additional challenge the identification of infections during pregnancy, labour and early puerperium (**Bauer, et al., 2014**).

A midwife has a crucial role in preventing and controlling infection. Nurses and midwives are considered front-line conquerors who deserve appreciation and protection for their vital role in infection prevention and control. Handwashing does not only protect nurses from getting sick, but it also reduces the risk of infecting others (**Malliarou, 2017**). **Maheshwari, 2014** highlighted the importance of reinforced training on hand hygiene practices among the health care workers greatly contribute to behavioral change that lead to minimizing nosocomial infections.

However, scientific evidence associated with hand hygiene compliance among healthcare professionals, information about knowledge level and hand hygiene behavior is relatively limited (**Szilágyi et al., 2013; Kingston, Slevin, O'Connell, & Dunne, 2017**). Many studies have evaluated hand hygiene behavior which focus on handwashing compliance, but the importance of hand drying is often ignored (**Borchgrevink et al., 2013; Rabbi, & Dey, 2013; Tao, Cheng, Lu, Hu, & Chen, 2013; Hirai et al., 2016**).

Careful hand drying is integral to the process of hand hygiene, which aims to optimize the removal of potentially pathogenic microorganisms. Ineffective hand drying results in wet hands which increases the risk of cross-infection, occupational contact dermatitis for healthcare practitioners, harm to patients, and environmental contamination (**Gammon & Hunt, 2019**). Consequently dry hands spread bacteria less than wet hands by thousand times. Is important that drying process resulted in not contaminated hands (**Redway & Fawdar, 2008; Alharbi et al., 2016**).

Healthcare-associated infections (HCAIs) and antimicrobial resistance are significant threats to public health. Preserving public health especially among vulnerable groups as pregnant women through infection prevention remains vital aspects of public health maintenance. Patients are becoming increasingly susceptible to HCAIs and resistant organisms as a result of healthcare treatments and interventions increasing complexity (**Burnett, 2018**).

The WHO, 2019 reported that HCAs occur in 7 and 10 out of every 100 hospitalized patients in high-income countries and low- and middle-income countries, respectively. Hospital-acquired infections are a major cause of morbidity and mortality among hospitalized patients. It is also associated with a substantial economic burden due to longer hospital stays and additional antibiotic costs (Luangasanatip et al., 2018). Since hand hygiene is a single important step of infection control and a key measure to prevent healthcare-associated infection (Wetzker et al., 2016).

Aim of the Study

This study aims to determine the effect of tissue paper versus air dryer for drying hands on skin inhabited bacteria in obstetrical wards.

Operational Definition

In this study, skin inhabited bacteria is defined as the types and number of bacteria that covering nurses' hands were measured by using a microbiological assessment tool to assess pathogenic bacteria in each group.

Research Hypotheses

There is difference between hand dryers and tissue paper when used to dry hands after routine handwashing in relation to the number of hand bacteria that remained on the skin.

Subjects and Method

Research Design

Comparative study was used between the two method of drying hand to reach the aim of the study.

Study Setting

The study was conducted in the maternity wards (ante, intra, and post-natal) at El-Nada maternity hospital in Egypt. El-Nada Hospital is the first private hospital that serves as the hub for women and children's care in Cairo and Giza. It provides obstetrical care, counseling, maternal-fetal services, and diagnostic testing for pregnant women. It also provides gynecological care for women.

Study subjects

A purposive sample of 30 nurses working in ante, intra, and post-natal wards of El-Nada Hospital from April to July 2019. All nurses had at least 3 years' experience in working in maternity hospitals, had short cut nail, wore no jewelry - not even wedding ring, and had intact non-inflamed skin. As the two-group pretest-posttest quasi-experimental design was used. The number and types of bacteria covering nurses' hands were determined before and after hand hygiene using the two drying techniques for all nurses on duty.

Data Collection Tools:

There were three tools used for data collection:

Tool I: Occupational and demographic data collection tool

This tool was designed by the researchers to collect data about age, gender, residence, level of education and years of experience.

Tool II: Observational checklist

The researchers designed an observational checklist to assess and observe the way and the time of drying hand used in each group. Whether, they used paper towels to dry hands, which measuring 100 mm × 200 mm, sterilized in an autoclave for 15 min before use; or, if they used hand dryer specified voltage 220 VAC with a related frequency of 50 Hz and related power of 1500 W to dry their hands.

Tool III: Microbiological assessment tool:

The researchers collected swabs to assess and compare pathogenic bacteria in each group. The samples were taken from the dominant hands, specifically from the palm region of the hand, in between fingers and the nails of the fingers. The specimens were then sent immediately to the laboratory for culture. In the cultivation process, the following were strictly followed: Plates were incubated at 37°C under aerobic conditions, then Colony-Forming Units (CFUs) were counted after 48 hours. Potential transient pathogenic bacteria were identified using standard microbiological techniques (Gram staining biochemical tests) and Phoenix reading using Phoenix machine.

Pilot study:

A pilot study was conducted on five nurses before the study officially started. This was done to ensure the validity and reliability of the tools used. Statistics for the results were done and included in the study sample.

Research Process:

Three phases were performed to fulfill the research aim, namely, the preparatory, implementation, and outcome phases.

Preparatory phase

A review of the literature was used to design the data collection tool. Five experts were provided the generated content of tool to test its validity, and they were asked to share their thoughts and ideas on the tool's content. The text was changed in accordance with the recommendations of the experts.

Implementation phase

All inclusion criteria are guaranteed by the researchers. Occupational and demographic data (gender, age, educational level, and side of dominant hand) and information about hand drying habits were obtained. Hands of the nurse participants were washed using the ordinary soap liquid in the hospital and were dried by either paper tissues or jet air dryer. Hand washing was done according to routine protocol approved by the infection control committee of the hospital which is derived from the infection control policy and procedure book of the Egyptian ministry of health protocols.

Nurses were used tissue papers as a method of drying and also used the jet air dryers in another shift. A sample was derived from the jet dryer filter before starting using it and at the end of the experiment to validate the possibility to retrieve microorganisms in the filter. Two samples were derived from each nurse first participant: one before performing hand washing and the other was taken immediately after drying hands either using paper tissue or jet dryers as a drying method. Hand washing checklist was filled-up by the researchers during the procedure and the time taken for drying hands either by using air dryers or tissue paper were also recorded.



The researchers review the steps of drawing samples with the microbiologist before starting to take specimens. The samples were taken from the dominant hands from the palm region of the hand, in between fingers and from the nails of the fingers and then sent immediately to the laboratory for culture. In the cultivation process the following steps were strictly followed: plates were incubated at 37°C under aerobic conditions, and CFUs were counted after 48 hours. The maximum count was 300 CFUS; beyond this figure, it was considered too many to count. Potential transient pathogenic bacteria were identified using standard microbiological techniques (Gram staining biochemical tests) and Phoenix reading using Phoenix machine.

Outcome Phase

A comprehensive report about the cultivation results was submitted to the medical director of the hospital for interpretation of the results and decided for actions according to hospital policy.

Ethical Considerations

This study was approved by the Research Ethics Committee of Nursing Faculty in Misr University for sciences and technology, and the approval letter came from the director of el-nada maternity hospital. Comprehensive description of the purpose of the study was explained to the nurses and an informed consent to participate in the study was obtained.

Limitations of the study

The presence of the hospital (the place of research setting) in a remote area resulted in a shortage in the number of nurses, which led to a small sample size.

Statistical analysis

Descriptive statistics was conducted for both drying methods for all nurses in the study

group. The experiment focused on the difference between the two drying methods in relation to number of bacteria found after hand washing. Analysis using SPSS version 24 was done and statistical significance deference at $P < 0.05$ was considered. Frequency and percentage used to present the study data. The Chi-square test of independence is used to decide if the research idea is plausible or not.

Results

Table 1 revealed that 83.3% of the study sample were aged less than thirty years old, and 76.7% of the study sample passed technical education in nursing. Concerning the place of residence, 70% of the study sample lived in urban areas, 80% of them had 3-6 experience years in maternity wards, and 90% attended training courses about hand hygiene.

Table 2 showed that 66.7% took 10–20 seconds to dry their hands using tissue papers and 63.3% of them took the same time to dry

with air dryer. Also, there was no statistical difference between the two methods time of drying ($P = 0.09$).

Table 3 illustrated that only 16.7% of nurses their hands were not harbor any bacteria before washing hands and reached to (53.3%) their hands were not harbor any bacteria after drying using tissue paper. On the other hand, 26.7 % of nurses their hands harbor no bacteria before washing hands and reached to more than three quarters of them (76.7%) their hands harbor no bacteria after drying using air dryer.

Table 4 showed that the microbiology results after both drying hands with tissue paper and air dryer. The table highlighted that the number of microorganisms found is less when hands dried by using air dryer than that found after drying hands using paper tissues, with statistically significance difference was found ($P=0.000$).

Table 1. Distribution of the study sample according to their occupational and demographic characteristics

| | | |
|--|----|-------|
| Age group | | |
| >30 | 25 | 83.3 |
| 30–40 | 5 | 16.7 |
| Total | 30 | 100.0 |
| Education | | |
| Technical | 23 | 76.7 |
| High Education | 7 | 23.3 |
| Total | 30 | 100.0 |
| Residence | | |
| Rural | 9 | 30.0 |
| Urban | 21 | 70.0 |
| Total | 30 | 100.0 |
| Years of experience in maternity wards | | |
| < 3 | 2 | 20.0 |
| 3–6 | 28 | 80.0 |
| Total | 30 | 100.0 |
| Attendance of training courses about hand hygiene | | |
| No | 3 | 10.0 |
| Yes | 27 | 90.0 |
| Total | 30 | 100.0 |

Table 2. Number and percentage distribution of the study sample in relation to time taken to dry hands using both tissue and dryer

| Time by seconds | Time taken to dry hands using tissue paper | | Time taken to dry hands using dryer | |
|-----------------|--|------|-------------------------------------|------|
| | No | % | No | % |
| 5-10 seconds | 0 | 0 | 0 | 0 |
| 11-15 seconds | 9 | 30.0 | 2 | 6.7 |
| 21-25 seconds | 11 | 36.6 | 15 | 50.0 |
| 26-30 seconds | 2 | 6.7 | 2 | 6.7 |
| 31-35 seconds | 5 | 16.7 | 1 | 3.3 |
| 36-40 seconds | 1 | 3.3 | 7 | 23.3 |
| 41-45 seconds | 2 | 6.7 | 2 | 6.7 |

Table 3. Microbiological findings before and after washing hands and drying with either air dryer or tissue paper.

| Microbiological findings | Drying with tissue paper | | | | Drying with air dryer | | | |
|--------------------------|--------------------------|------|--------------|------|-----------------------|------|--------------|------|
| | Before washing | | After drying | | Before washing | | After drying | |
| | No | % | No | % | No | % | No | % |
| Gram positive | 21 | 70.0 | 8 | 26.7 | 13 | 43.3 | 4 | 13.3 |
| Gram negative | 4 | 13.3 | 6 | 20.0 | 9 | 30.0 | 3 | 10.0 |
| Free | 5 | 16.7 | 16 | 53.3 | 8 | 26.7 | 23 | 76.7 |

Table 4. Comparison between microbiology results after both drying hands with tissue paper and air dryer.

| Microorganisms found | After drying with tissue paper | | | | After drying with air dryer | | | |
|----------------------|--------------------------------|------|------|---------|-----------------------------|------|--------|---------|
| | No. | % | Chi | P value | No. | % | Chi | P value |
| Gram positive | 8 | 26.7 | .061 | 5.600 | 4 | 13.3 | 25.400 | 0.000 |
| Gram negative | 6 | 20.0 | | | 3 | 10.0 | | |
| Free | 16 | 53.3 | | | 23 | 76.7 | | |

0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 10.0.

Discussion

Effective hand hygiene is important in preventing disease transmission in the clinical setting and community. The transmission of bacteria is more likely to occur from wet skin than from dry skin; therefore, the proper drying of hands after washing should be an integral part of the hand hygiene process in health care. Evidence suggests that wet or inadequately dried hands can transmit skin organisms, thus contributing to the spread of potential pathogens (Pitt, Crockett, and Andreou, 2018). However, self-reported practice on hand drying methods indicated that additional education was needed (Suen, So, Yeung, Lo, and Lam, 2019).

This study compared the effect of drying hands after hand hygiene using tissue paper and air dryers on decreasing bacteria inhabiting the skin among nurses in obstetrical wards. The findings of this study were discussed in the frame of reference of the following hypothesis: Hand dryers produce the same effects of tissue paper

when used to dry hands after routine hand washing in maternity departments. Our findings revealed that nearly two third of nurses were drying their hands for 10-20 seconds. This limited time most probably due to the nature of maternity hospitals which push nurses to make every skill in a hurry way. Similarly, Redway & Fawdar (2008) study aimed to compare the drying efficacy of different hand drying methods found that, the most of studied sample dried hand for 10-20 seconds. This findings as health care workers are always hasty.

In our study, more than half of nurse's hands harbor no bacteria after drying using tissue paper, while four fifth of them no longer harbor any bacteria after drying using air dryer. These findings highlight the effectiveness of the air dryer method. Controversially, Huang, Ma, & Stack, (2012) conducted an Australian study, which aimed to systematically review the hygienic efficacy of different hand drying methods, and found that most studies revealed that paper towels can dry hands efficiently,

remove bacteria effectively, and cause less contamination of the washroom environment.

Also, **Pitt, Crockett, and Andreou, (2018)** study aimed to compare the drying efficacy of using paper towels, warm air dryers, and jet air dryers, who reported that paper towels were more effective at drying hands than WADs and JADs, they are more likely to be used appropriately and lead to minimal dispersal of microorganisms from wet hands. The reasons for this are because they provide an effective means to dry hands in microbiological terms and drying is likely to be carried out properly without need for special instructions. In addition, using hand towels can be seen as wasteful (even when the paper is recycled) and air dryer in particular have been shown to have a lower carbon footprint. Also, an air dryer was available and newly used at the hospital and may be preferred in a healthcare setting.

The current study reported that, there was a remarkable decrease in resident bacteria after drying using tissue paper, or after drying using air dryer. Likewise, **Redway & Fawdar (2008)** reported a noteworthy decrease of bacteria when using paper towels and air dryer compared to when using hot air dryers; the latter generally led to an increase in bacterial numbers.

Regarding the percentage of microbiological results after using drying hands methods either with tissue paper or with air dryer among the studied nurses, the current study revealed that the air dryer method for hands drying was significantly less in the percentage of microorganisms than that found after drying hands with paper tissues technique. These findings are congruent with **Mutters & Warnes (2018)** in their German study aimed to compare the efficacy of drying washed hands with a jet air dryer and paper towels to remove transient bacterial contamination, which found significantly fewer transient and residential bacteria remained on the skin among healthcare workers, if hands were dried with a jet air dryer compared to paper towels.

From a hygiene standpoint, washed hands should be dried to reduce cross infection. Air dryer is for use in locations in which hygiene is utmost, such as hospitals and clinics. Also, it decreases the cost and the contamination of the environment.

Implications on nursing practice

Hands dried by air dryer help maternity nurses reduce the number of hand bacteria that remained on the skin. In addition, using paper tissues to dry hands after washing instead of using dryers increases the cost burden that can be directed to other purposes that raise the level of health services provided.

Conclusions

Hands dried by air dryer harbor fewer viable bacteria than hands dried with tissue paper in maternity departments. Hence, these findings supported the main hypotheses of the study that “There is difference between hand dryers and tissue paper when used to dry hands after routine handwashing in relation to the number of hand bacteria that remained on the skin.”

Recommendations

Considering the positive effect of dryer harbor, the following are recommended:

- Air dryers is recommended to reduce number of hand bacteria that remained on the skin.
- Further studies should be considered on large scale of health care providers regarding the choice of hand-drying method carefully.

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References

- Alharbi, S. A., Salmen, S. H., Chinnathambi, A., Alharbi, N. S., Zayed, M. E., Al-Johny, B. O., & Wainwright, M. (2016).** Assessment of the bacterial contamination of hand air dryer in washrooms. *Saudi Journal of Biological Sciences*, 23(2), 268–271. doi: 10.1016/j.sjbs.2015.06.020
- Bauer M.E., et al. (2014).** Maternal physiologic parameters in relationship to systemic inflammatory response syndrome criteria: a systematic review and meta-analysis. *Obstet*

- Gynecol.;124(3):535–541. Doi: 10. 1097/AOG. 0000000000000423
- Best, E. L., Parnell, P., & Wilcox, M. H. (2014).** Microbiological comparison of hand-drying methods: the potential for contamination of the environment, user, and bystander. *Journal of Hospital Infection*, 88(4), 199–206. DOI: 10. 1016/j. jhin. 2014. 08.002
- Best, E., Parnell, P., Couturier, J., Barbut, F., Le Bozec, A., Arnoldo, L., ... & Wilcox, M. H. (2018).** Environmental contamination by bacteria in hospital washrooms according to hand-drying method: a multi-centre study. *Journal of Hospital Infection*, 100(4), 469–475. DOI: 10.1016/j.jhin.2018.07.002
- Bonet, M., Souza, J. P., Abalos, E., Fawole, B., Knight, M., Kouanda, S., ... & Metin Gülmezoglu, A. (2018).** The global maternal sepsis study and awareness campaign (GLOSS): study protocol. *Reproductive health*, 15(1), 1–17. DOI: 10.1186/s12978-017-0437-8 1/2018/30
- Borchgrevink, C. P., Cha, J., & Kim, S. (2013).** Hand washing practices in a college town environment. *Journal of Environmental Health*, 75(8), 18–25.
- Burnett, E. (2018).** Effective infection prevention and control: the nurse's role. *Nursing Standard*, 33(4), 68. DOI:10.7748/ns.2018.e11171
- Centers for Disease Control and Prevention (CDC). (2019).** When and how to wash your hands. CDC24/7: saving lives, protecting people. Retrieved from <https://www.cdc.gov/handwashing/when-how-handwashing.html>
- Gammon, J., & Hunt, J. (2019).** The neglected element of hand hygiene-significance of hand drying, efficiency of different methods and clinical implication: a review. *Journal of infection prevention*, 20(2), 66–74. DOI: 10.1177/1757177418815549
- Gwarzo, G. D. (2018).** Hand hygiene practice among healthcare workers in a public hospital in North-Western Nigeria. *Nigerian Journal of Basic and Clinical Sciences*, 15(2), 109. DOI: 10. 4103/ njbcs. njbcs_40_17
- Hammer Schmidt, J., & Manser, T. (2019).** Nurses' knowledge, behaviour and compliance concerning hand hygiene in nursing homes: a cross-sectional mixed-methods study. *BMC Health Services Research*, 19(1). doi:10.1186/s12913-019-4347-z
- Hirai, M., Graham, J. P., Mattson, K. D., Kelsey, A., Mukherji, S., & Cronin, A. A. (2016).** Exploring determinants of handwashing with soap in Indonesia: a quantitative analysis. *International Journal of Environmental Research and Public Health*, 13(9), 868. DOI: 10. 3390/ijerph13090868
- Huang, C., Ma, W., & Stack, S. (2012).** The hygienic efficacy of different hand-drying methods: a review of the evidence. *Mayo Clinic Proceedings*, 87(8), 791–798. doi:10.1016/j.mayocp.2012.02.019
- Joseph, T., Baah, K., Jahanfar, A., & Dubey, B. (2015).** A comparative life cycle assessment of conventional hand dryer and roll paper towel as hand drying methods. *Science of the Total Environment*, 515,516, 109–117. DOI: 10. 1016/j. scitotenv.2015.01.112
- Kimmitt, P. T., & Redway, K. F. (2016).** Evaluation of the potential for virus dispersal during hand drying: a comparison of three methods. *Journal of Applied Microbiology*, 120(2), 478–486. doi: 10.1111/jam.13014
- Kingston, L. M., Slevin, B. L., O'Connell, N. H., & Dunne, C. P. (2017).** Hand hygiene: attitudes and practices of nurses, a comparison between 2007 and 2015. *American Journal of Infection Control*, 45(12), 1300–1307. doi:10.1016/j.ajic.2017.08.040
- Luangasanatip, N., Hongsuwan, M., Lubell, Y., Limmathurotsakul, D., Srisamang, P., Day, N. P. J., ... & Cooper, B. S. (2018).** Cost-effectiveness of interventions to improve hand hygiene in healthcare workers in middle-income hospital settings: a model-based analysis. *Journal of Hospital Infection*, 100(2),165–175. DOI: 10. 1016/j. jhin.2018.05.007

- Maheshwari, V., Kaore, N. C., Ramnani, V. K., Gupta, S. K., Borle, A., & Kaushal, R (2014).** A study to assess knowledge and attitude regarding hand hygiene amongst residents and nursing staff in a tertiary health care setting of Bhopal City. *Journal of Clinical and Diagnostic Research: JCDR*, 8(8), DC04. DOI: 10.7860/JCDR/2014/8510.4696
- Malliarou, M. (2017).** Hand hygiene of nurses and patient safety. *International Journal of Nursing and Clinical Practices*, 4 (1), 217. DOI: 10.15344/2394-4978/2017/217
- Mutters, R., & Warnes, S. L. (2019).** The method used to dry washed hands affects the number and type of transient and residential bacteria remaining on the skin. *Journal of Hospital Infection*, 101(4), 408-413. DOI: 10.1016/j.jhin.2018.12.005
- Patrick, D. R., Findon, G., & Miller, T. E. (1997).** Residual moisture determines the level of touch-contact-associated bacterial transfer following hand washing. *Epidemiology and Infection*, 119 (3), 319-325. DOI: 10.1017/S0950268897008261
- Peate, I., & Wild, K. (2018).** *Nursing practice: knowledge and care*. Chapter 18, The Principles of Infection Control. 2nd edn. John Wiley & Sons. pp.313-331.
- Pitt, S. J., Crockett, S. L., & Andreou, G. M. (2018).** The contribution of hand drying in prevention of transmission of microorganisms: comparison of the efficacy of three hand drying methods in the removal and distribution of microorganisms. *Journal of Infection Prevention*. 19(6), 310-317. doi:10.1177/1757177418789485
- Rabbi, S. E., & Dey, N. C. (2013).** Exploring the gap between hand washing knowledge and practices in Bangladesh: a cross-sectional comparative study. *BMC Public Health*, 13(1), 1-7. DOI: 10.1186/1471-2458-13-89
- Redway, K., & Fawdar, S., (2008).** A comparative study of three different hand drying methods: paper towel, warm air dryer, jet air dryer. *European Tissue Symposium (ETS)*. pp. 2–34.
- Robinson-Bassey, G. C., & Onyeabara, C. N. (2016).** Infection prevention and control lifesaving skills: practice among midwives in University of Port Harcourt Teaching Hospital Rivers State. *Obstetrics and Gynecology International Journal*, 4(4), 00119. DOI: 10.15406/ogij.2016.04.00119
- Say L, et al. (2014).** Global causes of maternal death: a WHO systematic analysis. *Lancet Glob Health*. ;2(6):e323–e333. Doi: 10.1016/S2214-109X(14)70227-X.
- Scheithauer, S., Batzer, B., Dangel, M., Passweg, J., & Widmer, A. (2017).** Workload even affects hand hygiene in a highly trained and well-staffed setting: a prospective 365/7/24 observational study. *Journal of Hospital Infection*, 97(1), 11-16.
- Suen, L. K. P., Lung, V. Y. T., Boost, M. V., Au-Yeung, C. H., & Siu, G. K. H. (2019).** Microbiological evaluation of different hand drying methods for removing bacteria from washed hands. *Scientific Reports*, 9(1), 1-7. DOI:10.1038/s41598-019-50239-4
- Suen, L. K. P., So, Z. Y. Y., Yeung, S. K. W., Lo, K. Y. K., & Lam, S. C. (2019).** Epidemiological investigation on hand hygiene knowledge and behaviour: a cross-sectional study on gender disparity. *BMC Public Health*, 19(1), 1-14. Doi: 10.1186/s12889-019-6705-5
- Szilágyi, L., Haidegger, T., Lehotsky, Á., Nagy, M., Csonka, E. A., Sun, X., ... Fisher, D. (2013).** A large-scale assessment of hand hygiene quality and the effectiveness of the “WHO 6-steps.” *BMC Infectious Diseases*, 13(1). doi:10.1186/1471-2334-13-249
- Tao, S. Y., Cheng, Y. L., Lu, Y., Hu, Y. H., & Chen, D. F. (2013).** Handwashing behaviour among Chinese adults: a cross-sectional study in five provinces. *Public Health*, 127(7), 620-628. doi: 10.1016/j.puhe.2013.03.005
- Ward, D. (2015).** *The infection prevention and control education of nursing and midwifery students*. The University of Manchester (United Kingdom).

Wetzker, W., Bunte-Schönberger, K., Walter, J., Pilarski, G., Gastmeier, P., & Reichardt, C. (2016). Compliance with hand hygiene: reference data from the national hand hygiene campaign in Germany. *Journal of Hospital Infection*, 92(4), 328–331. doi: 10. 1016/ j. jhin. 2016. 01.022

Wilcox, M. H., Best, E. L., & Parnell, P. (2017). Pilot study to determine whether microbial contamination levels in hospital washrooms are associated with hand-drying method. *Journal of Hospital Infection*, 97(2), 201-203. DOI: 10. 1016/ j. jhin. 2017.07.007

World Health Organization. (2019). Patient Safety, Key facts. Retrieved from <https://www.who.int/news-room/fact-sheets/detail/patient-safety>