PREVALENCE OF GRAM-NEGATIVE BACILLI ISOLATED FROM THE EQUIPMENT AND SURFACES IN HOSPITAL WARDS OF GOLESTAN PROVINCE, NORTH OF IRAN

Ali Asghar Ayatollahi1, Abolfazl Amini2*, Somayeh Rahimi3, Saeid Rahbar Takrami4, Reza Kazemi Darsanaki5, Muhammad Sadeqi Nezhad6

1 Laboratory Sciences Research Center, Golestan University of Medical Sciences, Gorgan, Iran
2 Student Research Committee, Golestan University of Medical Sciences, Gorgan, Iran
3 Health Center of Golestan Province, Golestan University of Medical Sciences, Gorgan, Iran
4 Young Researchers and Elites Club, Rasht Branch, Islamic Azad University, Rasht, Iran
5 Young Researchers and Elites Club, Lahijan Branch, Islamic Azad University, Lahijan, Iran
6 Department of Laboratory Sciences, Islamic Azad University, Gorgan Branch, Gorgan, Iran

Received: June 23, 2017; Accepted: July 22, 2017

Nosocomial infections are one of the most common causes of death in hospitals. This study aimed to determine the prevalence of gram-negative bacilli isolated from the equipment in hospital wards of the Golestan province, in the year 2015. In this cross-sectional study in 2015, 1980 samples from medical and nonmedical equipment and surfaces were collected from the wards of 13 teaching hospitals, in the Golestan province. Samples were inoculated into eosin methylene blue agar and blood agar culture media and isolated colonies were identified by standard biochemical tests. The obtained results were then analyzed using SPSS 22 software and $\chi^2$ test. Among 1980 isolated samples, 601 samples (30.35%) were infected with gram-negative bacilli while Enterobacter aerogenes (37.27%) was responsible for most of the contaminations. The highest rate of infection was observed in the intensive care unit (33.1%), and the highest level of contamination in the medical equipment was associated with laryngoscope and its blade (10.48%), as well as ECG sensor and its monitoring connector (6.65%). Meanwhile, phone (6.32%) and patients’ beds and linen (5.15%) had the highest level of contamination in the nonmedical equipment. Considering the high rates of gram-negative bacilli contamination in the hospital wards of the Golestan province, thorough hand washing as the main action for disinfection and sterilizing the equipment, as well as performing periodic cultivation alongside the use of standard guidelines for prevention and control of nosocomial infections, are recommended to reduce the level of contamination.

Keywords: gram-negative bacilli, nosocomial infection, hospital equipment

Introduction

Despite recent medical and technological advancements, microbial contamination in hospital settings and its consequent complications remain as a challenge in all countries. Infection prevention is an essential element of hospital management [1, 2], which requires identification of contaminations sources and attempts to effectively control the infection in hospital equipment [3]. Frequent sampling from hospital equipment along with their microbiological culture is among the most important factors for infection control in hospitals [4].

A recent study in the United States indicated that gram-negative bacilli are responsible for more than 30% of all hospital-acquired infections and Enterobacteriaceae family is the most common group of this category [5]. Majority of these are opportunistic bacteria that can lead to infection in immunocompromised patients [6]. Medical equipment and surgical instruments are associated with nosocomial infections, since pathogens can often live on surfaces for months and remain as continuous source of microorganisms’ transmission in hospital settings. Gram-negative bacilli such as Acinetobacter spp., Escherichia coli, Klebsiella, Pseudomonas aeruginosa,
Serratia marcescens, and Shigella can resist most antibiotics and survive for months on dry surfaces and wet environments as well as extreme environments compared to other bacteria. All the above factors are involved in their survival in hospitals’ sinks, baths, hot water pipes, medical supplies and equipment, leading to nosocomial infection of patients [6, 7]. It is currently not possible to completely eliminate infections, but taking appropriate measures (to determine the contamination levels of hospital equipment, using the most appropriate methods of sterilization and effective antibiotic treatment) may reduce the rate of infections, costs, and the resulting morbidity and mortality [7, 8]. Given the importance of this issue and the lack of a comprehensive study in Golestan province, North-eastern Iran, this study aimed to determine the prevalence of gram-negative bacilli isolated from the equipment in hospital wards of the Golestan province, in the year 2015.

Materials and methods

Sample collection

In this cross-sectional study, 1980 samples from medical supplies and equipment (1502) and nonmedical surfaces (478 cases) were collected from 7 different wards (operating room, intensive care unit [ICU], cardic care unit [CCU], surgical ward, pediatric ward, emergency, and internal medicine unit) of 13 teaching hospitals in the Golestan province (three hospitals in Gorgan, three in Gonbad, a hospital in Kordkoy, Bandar-Gaz, Bandar-Turkman, Aq-Qala, Aliabad, Minoodasht and Kalaleh) through census method. Contamination with gram-negative bacilli, 1–2 h after the sterilization of equipment, was the criteria for evaluating the contamination rates.

Isolation and identification

Samples from different medical and nonmedical surfaces that had contact with patients were collected using sterile swabs which had been dampened with Trypticase Soy Broth liquid medium. The samples were sent to the laboratory under sterile conditions, and after inoculation in eosin methylene blue agar and blood agar culture media for 24 to 48h, they were incubated at 37 °C and examined for growth. Identification of contaminating agents was performed by gram staining and standard biochemical tests such as indole, methyl red, voges proskauer, citrate (IMViC), triple sugar iron (TSI), oxidative fermentative (OF), oxidase, catalase, ortho-nitrophenyl-β-galactoside (ONPG), urea agar, lysine, ornithine decarboxylase, phenylalanine deaminase, and arginine hydrolyase [9, 6]. All culture media and consumables were purchased from Merck Co., Germany.

Statistical analysis

The obtained data were analyzed using SPSS software (version 22) and descriptive statistical tests. χ² analysis were performed to analyze the results and P value of less than 0.05 was considered as statistical significance level.

Results

Among 1980 samples, 601 samples (32.17%) were infected with gram-negative bacilli with the Enterobacter aerogenes (37.27%) as the most common cause of contamination (Table 1). The highest and lowest rates of infection in hospital wards were observed in the ICU (33.1%) and internal medicine unit (25.71%), respectively (Tables 2 and 3). However, this difference was not statistically significant between the hospital wards (P = 0.25).

Table 1. Prevalence of gram-negative bacilli contamination in 13 hospitals of the Golestan province

| Type of contamination     | Number of contamination (%) |
|----------------------------|-----------------------------|
| Enterobacter aerogenes     | 224 (37.27)                 |
| Serratia marcescens        | 103 (17.13)                 |
| Citrobacter spp.           | 85 (13.81)                  |
| Klebsiella spp.            | 83 (14.14)                  |
| Pseudomonas aeruginosa     | 55 (9.15)                   |
| Proteus mirabilis          | 27 (4.5)                    |
| Escherichia coli           | 18 (3)                      |
| Shigella sonnei            | 3 (0.5)                     |
| Providencia spp.           | 3 (0.5)                     |
| Total contamination        | 601 (30.35)                 |

Among the examined equipment and surfaces, the highest level of contamination in medical equipment was observed in laryngoscope and its blade (10.48%) as well as ECG sensor and its monitoring connector (6.65%). Among nonmedical equipment, phone (6.32%) and patients’ beds and bedsheet (5.15%) showed the highest levels of contamination, while no infection was reported regarding the dining table (Table 4).

The percentage of contamination among the 13 investigated hospitals was ranging between 26.36 and 37.5%. Statistical analysis showed significant correlations between the type of gram-negative bacilli and hospital wards with the rate of contamination in equipment (P < 0.05).

Discussion

The development of nosocomial infections particularly antibiotic-resistant infections has become a major problem in hospitals. Surfaces and medical equipment are suitable for colonization of microorganisms. In this study, the infection rate among the 13 investigated hospitals varied
from 26.36% to 37.5%, which indicates an alarming level of gram-negative bacilli contamination. Thus, hospitals are required to adopt specific policies for the disinfection and cleaning of at risk areas for better efficiency to avoid additional costs. Studies for determination of gram-negative bacilli infections by Amanlou in Zabul, Tohidnia in Kermanshah, and Moniri in Kashan reported 30%, 31.6%, and 65.7% infection rate, respectively, which correspond with the alarming rates found in the present study [7, 10, 11]. However, Jalalvandi in Kermanshah (5%), Bell in the United States (8.8%), and Afshar Yavari in Orumiyeh (15.15%) reported low prevalences of gram-negative bacilli contamination in hospital equipment and surfaces [12–14].

Based on the obtained results, the ICU (33.1%) had the highest and the internal medicine unit (25.71%) had the lowest infection rate of gram-negative bacilli contamination which contradicts with other studies. In 2010, Aslani et al. reported the neonatal ward with the highest infection rate (27.7%) among 137 tested samples [8]. In a ten-year

Table 2. Distribution of the participants according to the wards and gram-negative bacilli contamination

| Ward                      | Not contaminated number (%) | Contaminated number (%) | Number of contamination (%) |
|---------------------------|-----------------------------|-------------------------|----------------------------|
| Surgical ward             | 214 (67.3)                  | 104 (32.7)              | 318 (100)                  |
| Operating room            | 232 (70.5)                  | 97 (29.5)               | 329 (100)                  |
| Intensive care unit (ICU) | 198 (66.9)                  | 98 (33.1)               | 296 (100)                  |
| Cardiac care unit (CCU)   | 167 (69.0)                  | 75 (31.0)               | 242 (100)                  |
| Emergency                 | 206 (70.8)                  | 85 (29.2)               | 291 (100)                  |
| Neonatal and pediatric unit | 154 (68.8)                | 70 (31.3)               | 224 (100)                  |
| Internal medicine unit    | 208 (74.3)                  | 72 (25.7)               | 280 (100)                  |

Table 3. Prevalence of gram-negative bacilli contamination in different hospital wards

| Ward                      | E. aerogenes | S. marcescens | Klebsiella spp | Citrobacter spp | P. aeruginosa | P. mirabilis | E. coli | Sh. sonnei | Providencia spp | Number of contamination (%) |
|---------------------------|-------------|---------------|---------------|----------------|--------------|-------------|---------|------------|-------------------|-----------------------------|
| Surgical ward             | 40          | 22            | 18            | 16             | 6            | 1           | 1       | 0          | 0                 | 104 (32.7)                  |
| Operating room            | 33          | 19            | 5             | 16             | 15           | 8           | 1       | 0          | 0                 | 97 (29.5)                   |
| Intensive care unit (ICU) | 44          | 17            | 15            | 14             | 5            | 0           | 2       | 1          | 0                 | 98 (33.1)                   |
| Cardiac care unit (CCU)   | 28          | 4             | 17            | 18             | 1            | 1           | 1       | 1          | 1                 | 75 (31.0)                   |
| Emergency                 | 28          | 18            | 14            | 9              | 9            | 6           | 1       | 1          | 0                 | 85 (29.2)                   |
| Neonatal and pediatric ward | 25        | 14            | 6             | 4              | 9            | 6           | 3       | 1          | 2                 | 70 (31.3)                   |
| Internal medicine unit    | 26          | 9             | 8             | 8              | 10           | 5           | 6       | 0          | 0                 | 72 (25.7)                   |

Table 4. Prevalence of gram-negative bacilli contamination in terms of bacterial type and hospital equipment

| Equipment/supplies               | E. aerogenes | S. marcescens | Klebsiella spp | Citrobacter spp | P. aeruginosa | P. mirabilis | E. coli | Sh. sonnei | Providencia spp |
|----------------------------------|-------------|---------------|---------------|----------------|--------------|-------------|---------|------------|----------------|
| Laryngoscope and blade           | 24          | 10            | 18            | 8              | 0            | 2           | 0       | 1          | 0               |
| ECG sensors and its Monitoring connector | 10         | 8             | 6             | 4              | 6            | 0           | 3       | 0          | 0               |
| Suction                          | 8           | 16            | 0             | 6              | 7            | 1           | 0       | 0          | 0               |
| Telephone handset                 | 17          | 4             | 4             | 1              | 2            | 5           | 5       | 0          | 0               |
| Equipment/supplies                  | E. aerogenes | S. marcescens | Klebsiella spp. | Citrobacter spp. | P. aeruginosa | P. mirabilis | E. coli | Sh. sonnei | Providencia spp. |
|------------------------------------|-------------|---------------|----------------|-------------------|--------------|-------------|---------|------------|-----------------|
| Drugs’ trolley                     | 9           | 9             | 3              | 5                 | 4            | 0           | 0       | 0          | 0               |
| Patients’ beds                     | 8           | 0             | 12             | 1                 | 7            | 0           | 3       | 0          | 0               |
| Bedsheet                           | 11          | 0             | 9              | 8                 | 1            | 0           | 3       | 0          | 1               |
| Dressing trolley                   | 11          | 14            | 0              | 6                 | 0            | 0           | 0       | 1          | 0               |
| Oxygen mask                        | 8           | 5             | 6              | 0                 | 0            | 7           | 0       | 0          | 0               |
| Gan                                | 19          | 0             | 0              | 2                 | 4            | 0           | 0       | 0          | 0               |
| Infusion set                       | 12          | 4             | 0              | 5                 | 3            | 0           | 0       | 0          | 0               |
| Patient clothing                   | 3           | 7             | 0              | 9                 | 4            | 0           | 0       | 0          | 0               |
| Bagging                            | 13          | 0             | 3              | 7                 | 0            | 0           | 0       | 0          | 0               |
| Anesthetic machine                 | 1           | 4             | 0              | 1                 | 0            | 0           | 0       | 0          | 0               |
| Endotracheal tube                  | 11          | 5             | 0              | 0                 | 0            | 0           | 0       | 1          | 0               |
| Ventilator                         | 3           | 3             | 8              | 0                 | 0            | 3           | 0       | 0          | 0               |
| Bronchoscope                       | 2           | 0             | 0              | 2                 | 0            | 1           | 0       | 0          | 0               |
| Surgical instruments               | 0           | 2             | 4              | 4                 | 0            | 2           | 0       | 0          | 0               |
| Intravenous (IV)                   | 4           | 2             | 1              | 0                 | 5            | 1           | 0       | 0          | 0               |
| Endoscope                          | 2           | 0             | 0              | 3                 | 0            | 0           | 0       | 0          | 0               |
| Neonatal incubator                 | 2           | 3             | 0              | 0                 | 0            | 3           | 0       | 0          | 0               |
| Electroconvulsive                  | 12          | 0             | 2              | 1                 | 0            | 1           | 0       | 0          | 0               |
| Sialic lights                      | 3           | 1             | 1              | 2                 | 0            | 3           | 0       | 0          | 0               |
| Negatoscope                        | 2           | 0             | 0              | 1                 | 0            | 0           | 0       | 0          | 0               |
| Cardiopulmonary resuscitation (CPR) Trolley | 4           | 1             | 0              | 0                 | 0            | 0           | 0       | 0          | 0               |
| Gurney                             | 4           | 1             | 0              | 0                 | 5            | 0           | 0       | 0          | 0               |
| Colonoscope                        | 0           | 0             | 1              | 0                 | 0            | 0           | 0       | 0          | 0               |
| Nebulizers                         | 1           | 0             | 0              | 2                 | 2            | 0           | 0       | 0          | 0               |
| Cystoscope                         | 0           | 0             | 0              | 0                 | 2            | 0           | 0       | 0          | 0               |
| Cautery                            | 3           | 0             | 3              | 2                 | 0            | 1           | 0       | 0          | 0               |
| Otoscope                           | 2           | 0             | 1              | 0                 | 2            | 0           | 0       | 0          | 0               |
| Thermometer                        | 0           | 0             | 0              | 0                 | 0            | 0           | 0       | 0          | 1               |
| Oxygen flow meter                  | 3           | 1             | 0              | 1                 | 0            | 0           | 0       | 0          | 0               |
| Refrigerator door handle           | 4           | 0             | 0              | 0                 | 0            | 0           | 0       | 0          | 0               |
| Mounting sleeves                   | 1           | 0             | 0              | 1                 | 0            | 0           | 0       | 0          | 0               |
| Manometer                          | 2           | 1             | 0              | 1                 | 1            | 0           | 0       | 0          | 0               |
| Baby scales                        | 1           | 1             | 0              | 0                 | 0            | 0           | 0       | 0          | 0               |
| Wardrobe cases                     | 0           | 0             | 0              | 0                 | 0            | 0           | 0       | 0          | 1               |
| IV stand                           | 0           | 1             | 0              | 2                 | 0            | 0           | 0       | 0          | 0               |
| Echocardiogram                     | 1           | 0             | 1              | 0                 | 0            | 0           | 0       | 1          | 0               |
| Dining table                       | 0           | 0             | 0              | 0                 | 0            | 0           | 0       | 0          | 0               |

| Numbers (%)                        | 224         | 103           | 83             | 85                | 55           | 27          | 18      | 3          | 3               |
|                                   | (37.27)     | (17.13)       | (13.81)        | (14.14)           | (9.15)       | (4.5)       | (3)     | (0.5)      | (0.5)            |
study in Mashhad, Ghenaat et al. reported a higher prevalence in the internal medicine unit (44.5%) [15]. These discrepancies may be due to a number of factors including the wards’ conditions and performance of the staff. However, the results of the present study indicated higher prevalence of contamination in the surgical wards and operating rooms compared with the internal medicine unit, which further highlights the need to develop programs for prevention of infections in these wards. Nevertheless, infections in the internal medicine unit should not be neglected, since most hospitalized patients in this unit are susceptible to nosocomial infections (especially immunocompromised patients).

The highest contamination level in medical equipment was observed in the laryngoscope and its blade (10.48%), ECG sensor and its monitoring connector (6.65%), suction (6.32%), and dressing trolley (5.32%), respectively. The highest number of contamination for nonmedical equipment was associated with the phone (6.32%) and patients’ beds and bedsheet (5.15%). In Jalalvandi et al.’s study, the suction device (28.8%) and dressing trolley (23.3%), and in Aslani et al.’s study, phone (18.2%), manometer (17.5%), refrigerator door (8%), and beds (7.2%) had the highest incidents of contamination [8, 12]. Suction contamination may be due to the higher tendency of microorganisms toward horizontal surfaces particularly the surface of equipment in the surgical ward and operating room. Also, the proper cleaning of this device may be sometimes neglected due to lack of attention to the connection between suction pipe and the suction fluid reservoir.

Hands have an important role in spread of contaminations in nonmedical equipment such as phone, refrigerator, and beds. Therefore, thoroughly washing of hands should be instructed and well monitored. Moreover, contact between the staff and patients during transferring should be limited and patients’ rooms should be closed as much as possible [16]. The infection rate of gram-negative bacilli is variable in the previous studies. The highest infection among the gram-negative bacilli was related to Enterobacter (30.4%) as the most common gram-negative bacilli in 1216 tested samples [18]. Results from a study by Amanlou and colleagues revealed Klebsiella 47.2%, P. aeruginosa 27.7%, E. coli 19.4%, and Serratia 5.5% as the most prevalent gram-negative bacilli in surfaces of hospital equipment and operating rooms [10]. In a study by Afsah Yavari et al. on surgical wards’ infection in the hospitals of Urmia, Pseudomonas (60%), Klebsiella (20%), E. coli (8%), Enterobacter (8%), and Proteus (4%) were found as the most prevalent causes of gram-negative infections, respectively [14]. Tohidnia et al. also observed Klebsiella as the main gram-negative bacillus in the infection of radiology equipment (60.8%) [11]. Furthermore, E. coli was responsible for most of the contaminations as assessed by Halil and colleagues [19].

Attempts to control or prevent hospital contamination are cost-effective, considering the health problems and expenses that can be caused by nosocomial infections. It is also clear that effective contamination control policies, even in short term, has several times higher cost efficiency. Finally, it is emphasized that regular meetings and sampling result presentation to the physicians and nurses, as well as annual symposiums along with general hospital infection control policies (accurate strategies for operating rooms, ICU and even CSR and kitchen), can be very useful in further reducing contamination and nosocomial infections.

Conclusion
Bacterial infection rates with gram-negative bacilli in nonmedical and medical equipment of hospitals in the Golestan province are alarming. Proper hospital management, careful handwashing, disinfection and sterilization of the equipment, performing periodic bacterial cultures from at-risk areas and equipment, and antibiogram tests to determine the most effective antibiotics are recommended to reduce the consequent morbidity, mortality, and costs of these infections.

Funding sources
The study has been funded by the Department of Research and Technology at Golestan University of Medical Sciences, Iran (Code: 910510136).

Conflict of interest statement
The authors declare that they have no conflict of interest.

Acknowledgements
The authors would like to thank all the laboratory personnel for their assistance throughout the study.

References
1. Taheri N, Abtahi H, Amozande-Nojaveh A, Zarinfar N, Ghaznavi-Rad E: The antibiotic resistant determinant of pathogenic bacteria isolated from medical equipment and hospital environment in Valiasr Hospital, Arak, 2013. J Mazand Univ Med Sci 24(114), 60–73 (2014)
2. Khosravi A, Parhizgari N, Abbasi Montazeri E, Mozaffari A, Abbasi F: The prevalence of bacteria isolated from endotracheal tubes of patients in Golestan Hospital, Ahvaz, Iran, and determination of their antibiotic susceptibility patterns. Jundishapur J Microbiol 6(1), 67–71 (2013)
3. Muhammad UK, Isa MA, Aliyu ZM: Distribution of potential nosocomial pathogens isolated from environments of four selected hospitals in Sokoto, North Western Nigeria. J Microbiol Biotech Res 3(1), 139–143 (2013)
4. Nobahar M, Valaei AA: Survey of contamination stethoscopes as one of the factor for nosocomial infections: transmission in educational hospitals in Semnan city. Iran J Infect Dis Trop Med 8(23), 25–28 (2004)
5. Peleg AY, Hooper DC: Hospital acquired infections due to gram-negative bacteria. N Engl J Med 362(19), 1804–1813 (2010)
6. Amirmozafari N, Forouhesh Tehrani H, Mohebbi S: Survey genus and species of non-fermentative gram negative bacilli isolated from hospitalized patients. J Guilan Univ Med Sci 16(64), 67–75 (2008)
7. Moniri R, Momen Heravi M: Evaluation of bacterial contamination in medical devices and anti-bacterial resistance of isolated gram negative bacilli in Shahid Beheshti Hospital in Kashan, Iran, 2004. Feyz 9(36), 50–55 (2006)
8. Aslani Y, Saadat M, Etemadifar SH, Fazeli SM: The evaluation of different hospital equipment microbial contamination in medical training center Hajar of Shahrekord. Hamdan Nurs Midwifery Fac 17(12), 19–23 (2009)
9. Hall GS, Woods GL (2011): Medical Bacteriology. In: Henry’s Clinical Diagnosis and Management by Laboratory Methods, 22nd edn., eds. McPherson RA, Pincus MR, Saunders Elsevier, Philadelphia, pp. 1079–1115
10. Amanlou S, Farjah GH, Taghavi MR, Kolarastagh H, Jahanthigh HA, Sabouri GHR: Microbial contamination of operation rooms in Amir-Al-Momenin Hospital of Zabol, Iran. J North Khorasan Univ Med Sci 3(3), 7–14 (2011)
11. Tohidnia MR, Dezfoolianeh J, Almasi A: Bacterial contamination of radiography equipment in radiology departments of Kermanshah University of Medical Sciences (2010) J Kermanshah Univ Med Sci 16(3), 273–276 (2013)
12. Jalalvand F, Teimouri B, Sohrabi N, Fakhri M, Shahsavari S, Jafari S: Microbial contamination of operating rooms equipments in selected hospitals in Kermanshah. Iran J Infect Dis Trop Med 17(59), 49–52 (2013)
13. Bell NP, Anand A, Wanger A, Prager TC: Microbial contamination of ultrasound biomicroscopy probes: evaluation of cross-infection risk. J Cataract Refract Surg 38(1), 174–175 (2012)
14. Afshtar Yavari Sh, Diba K: The assessment of bacterial and fungal flora of operating rooms in Urmia Medical University hospitals. Urmia Med J 15(1), 33–38 (2004)
15. Gheenaat J, Sadeghian A, Ghaevini K: Surveillance of bacterial contamination in Ghaem Hospital during 10 Years (1370 to 1380). Iran J Otorhinolaryngol 16(3), 28–35 (2004)
16. Neil JA, Nye PF, Toven LA: Environmental surveillance in the operating room. AORN J 82(1), 43–50 (2005)
17. Alemu A, Misganaw D, Wondimeneh Y: Bacterial profile and their antimicrobial susceptibility patterns of computer keyboards and mice at Gondar University Hospital, Northwest Ethiopia. Biomed Biotechnol 3(1), 1–7 (2015)
18. Ensuyef S, Al-Shalchi S, Sabbar M: Microbial contamination in the operating theatre: a study in a hospital in Baghdad. East Mediterr Health J 15(1), 219–223 (2009)
19. Halil Kilic I, Ozaslan M, Karagoz ID, Zer Y, Savas E, Davutoğlu V: The role of stethoscopes in the transmission of hospital infections. Afr J Biotechnol 10(30), 5769–5772 (2011)