

## Air conditioning systems and nosocomial infections in Mosul hospitals

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### ABSTRACT

**Background:** Nosocomial infections (NIs) have proven to be persistent and sometimes complicated problem. More than one third of all nosocomial infections possibly involve airborne transmission. The aim of this study is to estimate the types of bacteria that could be present in air-conditioning systems of some hospitals and their antibiotic sensitivity profile.

**Materials and methods:** Swab samples were taken from air-conditioning system filters and rendered for bacterial identification and evaluation of their antibiotic susceptibility.

**Results:** The results showed twenty isolates from three different hospitals. Ibn Sina showed 16 isolates (5 *S. aureus*; 3 *S. epidermidis*; 4 *S. saprophyticus*; 1 *E. coli*; 1 *Proteus mirabilis*; 1 *Klebsiella pneumoniae* and 1 *Pseudomonas aeruginosa*), Ibn Al-Atheer hospital showed only 2 isolates (1 *S. aureus*, and 1 *Streptococcus*) and Al-Jumhori hospital showed only 2 isolates (1 *S. aureus*, and 1 *S. saprophyticus*); most of this isolates are resistant to the antibiotics used in this study.

**Conclusion:** there are a risky bacteria located in air conditioners especially indoor conventional systems more than the hospital designed systems and still both represent a susceptible source for nosocomial infection.

**Keywords:** nosocomial, air-conditioning systems, airborne infection

### الخلاصة

**الخلفية:** أثبتت العديد من الدراسات بان الإصابة المكتسبة من المستشفى هي إصابة طويلة الأمد و قد تكون مشكلة معقدة. أكثر من ثلث الإصابات المكتسبة من المستشفى هي إصابات مكتسبة من جو المستشفى (الهواء المحيط بالمريض).

الهدف من هذه الدراسة هو لتقييم أنواع البكتيريا التي قد تكون موجودة في أنظمة تكييف الهواء في المستشفيات المختارة ومدى حساسية هذه البكتيريا لعدة أنواع من المضادات الحيوية.

**طريقة العمل:** تم اخذ مسحات من مرشحات (فلتر) مكيفات الهواء الموجودة في المستشفيات و تم إخضاع هذه المسحات للاختبارات البكتيرية للتعرف على نوع البكتيريا و لتقييم حساسيتها للمضادات الحيوية.

**النتائج:** أظهرت نتائج الدراسة وجود عشرين عزلة بكتيرية من المستشفيات الثلاث المختارة و كانت متوزعة كالتالي: مستشفى ابن سينا التعليمي العام اظهر 16 عزلة من مختلف الردهات (خمس المكورات العنقودية الذهبية، ثلاث من المكورات العنقودية الفضية، أربع من العنقوديات الحمضيات، عزلة واحدة من عصيات أي كولاي و عزلة واحدة من البروتيويس و عزلة واحدة من الكليسيلا و عزلة واحدة من السيدوموناس ابروجينوزا) بينما كانت هناك عزلتان فقط من مستشفى ابن الأثير التعليمي للأطفال و هما (عزلة واحدة من المكورات العنقودية الذهبية و عزلة واحدة من المكورات العنقودية الفضية) و اظهر مستشفى الزهراوي التعليمي للجراحة عزلتين فقط و هما ( عزلة واحدة للمكورات العنقودية الذهبية و عزلة واحدة للعنقوديات الحمضيات)، معظم هذه العزلات أظهرت مقاومة للمضادات الحيوية المستعملة في هذه الدراسة.

**الاستنتاج:** هناك العديد من البكتيريا الخطيرة موجودة في أنظمة التكييف و خاصة النوع التقليدي أكثر من المكيفات المخصصة للمستشفيات، و مع ذلك كلاهما يمثل مصدر خطر للإصابة المكتسبة من المستشفى.

Nosocomial infections (NIs) are those that acquired in a hospital setting, the associated infections occur after 48 hours of ICU admission or within 48 hours after transfer from an ICU, and these infections are not present at admission. Two million people become ill each year as a result of hospital acquired infections, and contributed to the death of nearly 10,000 hospital patients per year.

Ninety percent of the NIs caused by bacteria whereas mycobacterial, viral, fungal, or protozoal agents are less commonly involved. *Klebsiella pneumoniae*, *Staphylococcus aureus*, *Escherichia coli*, *Proteus mirabilis*, and *Pseudomonas aeruginosa* are among the most common causative agents of NIs. Large use of broad spectrum antibiotics in hospital environment promoted emergence of a newer organisms such as *acinetobacter baumannii*, *Sternotrophomonas maltophilia* and *Burkholdereria cepaci*.

If transmission by direct contact predominates as many experts suggest, then surface disinfection technologies should have a major impact in reducing infection rates. But with more than a third of all nosocomial infections possibly involving airborne transmission at some point, the combination of surface and air disinfection should produce optimum results.

Airborne transmitted nosocomial infections is estimated between 10-16% of total ICU nosocomial infections, the total number of airborne viable particles in this critical areas, seems to be a significant risk factor for the development of nosocomial infections in immune compromised patients.

Airborne transmission is the transfer of particles measures  $\leq 5 \mu\text{m}$  or less in size into the air, either as airborne droplets or dust particles containing the infectious microorganisms that can be produced by coughing, sneezing, talking or procedures such as bronchoscopy or suction. These particles can remain in the air for several hours; and can be spread widely within a room or over longer distance. Special air handling and ventilation are needed to prevent airborne transmission. Each nosocomial infection adds 2-10 days to the affected patient's time in the hospital, increasing morbidity and mortality of hospitalized patients especially the ones admitted in an intensive care units.

Many researchers determined that the reservoir of the deadly pathogen was the air conditioning systems and although many measures were taken to control the out breaks but it did never ended until the air conditionings system were sterilized and controlled.

This study aimed to find the type of pathogens that could be present in air conditioning systems in three hospitals in Mosul city, and to detect the antibiotic sensitivity profile of these pathogens.

### Materials and methods

Swabs were taken from the inner filters of the air conditioning systems of three hospitals in Mosul city, represented as general hospital (Ibn Sina), pediatric hospital (Ibn Al-Atheer) and surgical hospital (Al-Jumhori). Swabs are commercially available type Citotest transport swab, totally 18 swabs were used.

Samples were collected in autumn 2008. Two weeks after the maintenance period for the air conditioning systems i.e. annual washing and cleaning, and the swab samples were taken from surgery, burns, pediatric yards, respiratory care unit (RCU), cardiac care unit (CCU), central laboratories, ECHO imaging room and artificial kidney yards and from the central units on the hospital roof.

The samples were analyzed in microbiology laboratory in the College of Pharmacy, University of Mosul. Swabs were inoculated in blood and MacConkey agar then isolated colonies were subcultured in nutrient agar slants, then isolated for pure cultures. identification of the pure cultures was conducted by using morphological study by Gram stain, colony morphology on selective medias, and biochemical tests, which included Indole test, Voges-Proskauer test, citrate test, urease test, and sugar fermentation tests. The identified bacteria were rendered for antibiotics

sensitivity test, five antibiotics were used: cefotaxime 30 µg, rifampicin 30 µg, cefadroxil 30 µg, tetracycline 30 µg and ciprofloxacin 30 µg as standard disks for antibiotic sensitivity testing<sup>10</sup> using the Bauer's standard disk diffusion method<sup>11</sup>.

### Results

The total isolates from the three hospitals revealed that there were twenty active isolates from different yards of these hospitals.

Ibn Sina hospital revealed the largest number of isolates, from many different yards and departments totally sixteen isolates; while Ibn Al-Atheer pediatric hospital and Al-Jumhori surgical hospital revealed two isolates each only.

Ibn Sina hospital revealed five isolates of *Staphylococcus aureus*, seven coagulase negative *Staphylococcus* (CNS), one *Klebsiella pneumoniae*, one *Escherichia coli*, one *Proteus mirabilis* and one *Pseudomonas aeruginosa* as shown:

Table 1. Types of isolated bacteria and location in Ibn-Sina general hospital

Culture results/ yards	Gram –ve bacilli	Gram +ve cocci	No growth/yard
Bacteriology lab. No. (%)	1 (0%)	1 (6.25%)	
ECHO room No. (%)	1 (0%)	2 (12.5%)	
Emergency pediatric room 1 No. (%)	1 (0%)	2 (12.5%)	
Emergency pediatric room 2 No. (%)	1 (0%)	3 (18.75%)	
Artificial kidney No. (%)	1 (0%)	1 (6.25%)	
RCU 1 No. (%)	1 (0%)	1 (0%)	No growth
RCU 2 No. (%)	2 (12.5%)	1 (0%)	
Pediatric yard No. (%)	1 (0%)	1 (0%)	No growth
Operation room No. (%)	2 (12.5%)	3 (18.75%)	
Total No. (%)	11 (50%)	12 (50%)	

Ibn Al-Atheer pediatric hospital revealed one *Staphylococcus aureus* and one *diplococcus* as shown in Table 2.

Table 2. Types of isolated bacteria and location in Ibn Al-Atheer pediatric hospital

Culture results/ yards	Gram –ve bacilli	Gram +ve cocci	No growth/yard
Suction Fan	1 (0%)	1 (0%)	No growth
Central unit	1 (0%)	1 (50%)	
Central unit	1 (0%)	1 (50%)	
Total No. (%)	1 (0%)	2 (100%)	

While Al-Jumhuri surgical hospital revealed two isolates one *Staphylococcus aureus* and one

*Staphylococcus saprophyticus* (CNS) as shown in Table 3.

Table 3. Types of isolated bacteria and location in Al-Jumhori hospital

Culture results/ yards	Gram –ve bacilli	Gram +ve cocci	No growth/yard
Central unit female surgery 1 <sup>st</sup> yard	00(0%)	00(0%)	No growth
Central unit female surgery 2 <sup>nd</sup> yard	00(0%)	1(50.0%)	
Central unit female renal ICU	00(0%)	1(50.0%)	
Central unit male renal ICU	00(0%)	00(0%)	No growth
Female renal surgery yard	00(0%)	00(0%)	No growth
Male burn yard	00(0%)	00(0%)	No growth
Female burn yard	00(0%)	00(0%)	No growth
<b>Total No. (%)</b>	0(0%)	2(100%)	

The type of isolated bacteria and there percentage is listed in table 4, 5 and 6:

Table 4. The type and percentage of bacteria isolated in Ibn-Sina hospital

Bacteria isolated	No. of isolates	Percentage %
<i>S. aureus</i>	5	31.25%
<i>S. epidermidis</i> and <i>S. saprophyticus</i> Coagulase negative <i>staphylococcus</i> (CNS)	7	43.75%
<i>E. coli</i>	1	6.25%
<i>K. pneumoniae</i>	1	6.25%
<i>P. mirabilis</i>	1	6.25%
<i>Ps. aeruginosa</i>	1	6.25%
Total	16	100%

Table 5. The type and percentage of bacteria isolated in Ibn-AlAtheer hospital

Bacteria isolated	No. of isolates	Percentage %
<i>S.aureus</i>	1	50%
<i>S. epidermidis</i> and <i>S. saprophyticus</i> Coagulase negative <i>staphylococcus</i> (CNS)	1	50%
Total	2	100%

Table 6. The type and percentage of bacteria isolated in Al-Jumhori hospital

Bacteria isolated	No. of isolates	Percentage %
<i>S.aureus</i>	1	50%
<i>S. epidermidis</i> and <i>S. saprophyticus</i> Coagulase negative <i>staphylococcus</i> (CNS)	1	50%
Total	2	100%

Antibiotic sensitivity profile for these isolates showed in table 7, 8 and 9 as follow:

Table V. Ibn Sina general hospital isolates culture and sensitivity results as Sensitive / Total isolates (sensitive %)

Bacteria	Antibiotic				
	Cefotaxime	Rifampicine	Cefadroxil	Tetracycline	Ciprofloxacin
<i>S. aureus</i>	1/5 (20%)	3/5 (60%)	1/5 (20%)	1/5 (20%)	1/5 (20%)
<i>S. epidermidis</i>	1/3 (33.3%)	1/3 (33.3%)	1/3 (33.3%)	1/3 (33.3%)	1/3 (33.3%)
<i>S. saprophyticus</i>	1/2 (50%)	2/2 (100%)	1/2 (50%)	1/2 (50%)	2/2 (100%)
<i>E. coli</i>	1/1 (100%)	1/1 (100%)	1/1 (100%)	1/1 (100%)	1/1 (100%)
<i>K. pneumoniae</i>	1/1 (100%)	1/1 (100%)	1/1 (100%)	1/1 (100%)	1/1 (100%)
<i>P. mirabilis</i>	1/1 (100%)	1/1 (100%)	1/1 (100%)	1/1 (100%)	1/1 (100%)
<i>Ps. aeruginosa</i>	1/1 (100%)	1/1 (100%)	1/1 (100%)	N/D*	1/1 (100%)

\*N/D: Not Determined

Table A. Ibn Al-Atheer isolates culture and sensitivity results as Sensitive / Total isolates (sensitive %)

Bacteria/antibiotic	Cefotaxime	Rifampicine	Cefadroxil	Tetracycline	Ciprofloxacin
<i>S. aureus</i>	1/1 (100%)	1/1 (100%)	1/1 (100%)	1/1 (100%)	1/1 (100%)
<i>Diplococcus</i>	1/1 (100%)	1/1 (100%)	1/1 (100%)	1/1 (100%)	1/1 (100%)

Table 9. Al-Jumhori isolates culture and sensitivity results as Sensitive / Total isolates (sensitive %)

Bacteria/antibiotic	Cefotaxime	Rifampicine	Cefadroxil	Tetracycline	Ciprofloxacin
<i>S. aureus</i>	1/1 (100%)	1/1 (100%)	1/1 (100%)	1/1 (100%)	1/1 (100%)
<i>S. saprophyticus</i>	1/1 (100%)	1/1 (100%)	1/1 (100%)	1/1 (100%)	1/1 (100%)

### Discussion

The results showed many types of bacteria isolated from the three selected hospitals, all these bacteria are well known cause of worldwide nosocomial infections (especially pneumonia)<sup>14</sup>.

As shown in the results, interestingly there were many isolates from Ibn Sina hospital in comparison to so fewer isolates from Ibn Al-Atheer pediatric hospital and Al-Jumhori surgical hospital, and this variation could be explained on the basis of the type of air-conditioning systems that are used in these hospitals

Both Al-Jumhori and Ibn Al-Atheer hospitals use central units placed on the hospital roof with propelling system through specific filters and there are other separated suction systems that moves air from inside to outside the hospital. While in Ibn-Sina general hospital uses split unit air-conditioners or window air-conditioners in each room and it is well known the air conditioning system for such devices is via in-room air circulation (especially in split units system), i.e. there is no fresh filtered air pushed from outside to inside the hospital, but the in-hospital contaminated air is sucked by indoor split unit, recirculate it again into the hospital with a very high chance for

the microbes to be settled in the dust filter and colonized there due to humidity and re spread again to cause infection to the next patients in that yard.

The distribution of bacteria through out the yards of the three hospitals may be related to the type of patients in each yard and/ or the type of treatment provided in that yard.

*Staphylococcus* species localized almost in all yards because it is considered as global first suspect in causing nosocomial infection even the commensal species like *S. epidermidis* or *S. saprophyticus*<sup>14</sup>. Other types of bacteria like *Klebsiella pneumonia* and *Pseudomonas aeruginosa* located in RCU mostly due to the in-patients who carry this bacteria and contaminating the ventilators or aspiration systems, such result is in agreement with Akash Deep *et al*<sup>15,16</sup> and also established as a fact<sup>17,18</sup>

On the other hand the *E.coli* and *proteus mirabilis* which are members of *Enterobacteriaceae* are considered as major causative bacteria for NIs in abdominal operation rooms<sup>17,18</sup>. This is also documented in this study, whereas these bacteria were isolated from the air-conditioning system of the operation room from the general hospital which use the in-door split unit system.



Many reports emphasized the importance of airborne nosocomial infections as one of the major sources of total nosocomial infection<sup>5</sup>, and so fine dust or droplets generated by cough or speaking can cause spreading of bacteria which can remain viable in air for several hours until it could find a suitable host<sup>6,7</sup>, which is usually human (patient or working personnel) or suitable media to grow like air conditioners filter.

The culture and sensitivity test showed that almost all the isolated bacteria are highly resistant to most of the antibiotics used in this study, especially those which are highly prescribed in hospital (like cefotaxime), and there was one risky isolate (*S.aureus*) from artificial kidney yard showed no inhibition zone for all antibiotics used in this study.

*E.coli*, *Klebsiella pneumoniae* and *pseudomonas aeruginosa* resistance pattern is comparable to the pattern of Akash Deep *et al*<sup>8</sup>, and so as the pattern of *S. aureus* which showed high resistance to almost all antibiotics used in this study, where 2 isolates out of 5 were totally resistant to all antibiotics in this study.

In conclusion hospital air conditioning systems can carry and spread risky types of bacteria that could cause higher morbidity and mortality to many patients.

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