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RESEARCH ARTICLE

Environmental Epidemiology: a proposal to reduce nosocomial infections at third level hospitals

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Abstract

Deficient aero-microbiological environmental quality at a third level hospital constitutes one of the possibilities of presenting risks to trigger nosocomial infections, epidemiological surveillance and environmental epidemiology, both, represent real and necessary factors, towards inter hospital epidemiological surveillance which is normallycarried out at hospitals of any level. Inter hospital environmental epidemiological surveillance is a need where the monitoring of the constant inter-hospital sprays, under programmed periodicity, allowsidentifying the risks derived from the presence and distribution of aero transported micro-organisms, measuring the microbiological and aero transported volume, the knowledge of their resistance profiles against microbes and heavy metals. Monitoring inter hospital sprays and their study or surveillance intervene in guarantying the diminishment of nosocomial infections when generating strategies for controlling sanitarian hygiene and improving the quality of attention to people who are users of medical services.

Introduction

Inter hospital quality and nosocomial infections are still a serious public health problem of economic and social importance. Its clinical importance is supported on high rates of morbidity and mortality, and affect life years which become potentially lost [1-3].

It is important to point out that generally, hospitals have an epidemiology division or department and the execution of this work normally relies on medical – clinical epidemiology and thus it is known that hygienic and sanitarian measures of the hospital standard cares of the health professionals, their education for health and the same entitled population accounted, the flow of the patients, among other factors which intervene in the generation of a characteristic inter hospital environment makes environmental epidemiology and inter hospital environmental epidemiological surveillance acquire a value of use that at the same time determines strategies or specific actions that help diminish nosocomial infections.

It is important to establish that when microorganisms face stressful environments, on their struggle for surviving, they synthetize a type of proteins denominated compatible solutes, which allow them to resist osmotic stress to which they are submitted and in a way those increase their capacity of virulence and become more virulent[4]. In reference to O.R a clean atmosphere is required in order to avoid further infections after the surgical intervention [5] and on the same way, the microbiological control on areas of pharmaceutics production [6].

It has been demonstrated that the concentration of $1x10^3$bacteria high negative/m^3in the environment cause inflammatory effect of the mucus membranes,

which represents a concentration of 0.1 mg/$m^3$of endotoxin [4,7].

In reference to the recuperation of bacteria by cubic meter, it is known that if one cultivation box that contains TSA Trypticase soy agar is exposed for 15 minutes and impact them only 1 UFC/m^3. , a presence of at least 38 UFC/$m^3$is required.

For example, if we multiply the number of impacted UFC in the cultivate box by the factor 38, we will obtain an approximate estimation of the bacteria concentration for cubic meter [4-6]. Then, under this estimation, it is possible to calculate the quantity of bacteria at which hospitalized people are exposed in a controlled but contaminated area [6], in the case of a hospital, a pharmacy or any other area of the hospital.

Environmental monitoring of sprays generated at the hospital represent a useful methodology to evaluate the environmental impact of the air, it is defined as the recollection, analysis and systematic evaluation of environmental samples, such as air, water or aliments looking for microbiological contamination [8].

It's important to point out that regarding the collection of environmental samples and in reference to the sampling of microorganisms, diverse ways to obtain the samples from the environmental air exist, highlighting the sediment ones, in the petri box with TSA Trypticase soy agar for 20 minutes exposition for O.R or in TSA Trypticase soy agar for 15 minutes exposition for controlled areas as the best way for microbial recuperation [6].

Through this methodology it has been possible to recuperate entire bacteria from sprays which in a particular way showed patters of resistance to antimicrobial and to heavy metal and which due to their genotypic characteristics show incremented virulence[9], so the presence of this type of microorganisms could represent risks for health. It is known that bio sprays could impact human health [9,10].

Other sampling methods are known, among them, one of the most important which could allow estimating the risk derived from exposition to microorganisms is (MA) MonitorAnderssen; this represents a mechanical technique in 15 minutes of exposition in agar, malt extract and Trypticase soy agar [4].

In addition, an alternative method has been known, in case of not being supplied with the MA. The aero bio collector "air IDEAL ^{TM}" serves to conduct this type of samples and research projects and which allows environmental and microbiological monitoring and which operates according to the impact principle under the norm ISO/DIS 14698-, taking air 100 lt/min with an impact speed of <20 m/sec.It collects particles whose diameter oscillates between 3 and 10 µm, it is compatible with the sampling of 65/70 y de 90 mm Rodac boxes [11]. It´s is important for hospitals to havethese supplies. Up to the moment, the environmental inter hospital monitoring are conducted collocating a Rodac box in the exits of the air conditioning and in the superficies without being able to say the volume of exposition.

Nosocomial infection rates at third level hospitals maintain an average of 4.8/100 egresses at a national level, according to the data base RHOVE in 2008, same that varies according to the site of infection [11]. This leads to considerate the important development of the inter hospital environmental epidemiological surveillance, in other words, of applied environmental epidemiology and in interaction with medical- clinical epidemiology that allows evaluating inter hospital risks and trying to combat damage and prejudices that generate nosocomial infections.

Justification

One of the unprotected factors, merely at a hospital level, has to do with the environmental health of the hospital environment; the lack of tracking from epidemiological surveillance and the lack of standardized patters concerning the management of the environmental quality make necessary that the third level of attention has patters and comparable parameters, evaluated from environmental sciences, where the quality of the hygienic inter hospital services could be effectively sustained and a positive impact that promotes the increase of the academic capability of the people in charge of executing epidemiological surveillance, not only medical-clinical, but also of risk evaluation from the inter hospital environmental epidemiology, above all in what concerns a hospital of third level, where epidemiological surveillance is required in a constant- permanent and important basis.

It is known that when bacteria live in spaces where the concentration of contaminating agents, included antibiotics, they are marinated in constant aggressiveness, they can produce some protein substances known as compatible solutes, that on one side allows them to survive in those environments and at the same time causes stress to which they are submitted in a way, this facilitates their most virulent action, virulence which they express when they find a guest that gives them accommodation and that provides the nutritional conditions to cause illness, this most of all derived if their viability is more effective, even in human beings concerning the cultivation means as in the blood agar, 110 agar, staphylococcus, where apparently are captured and don't grow, this means they are not viable, or better said, capable of being cultivated.

Although (Joames, M. Almazán, M. 1993) has already pointed out that the best cultivation mean for the bacterial recoverability proceeding from air is the TSA Trypticase soy agar, reason for which this substance is proposed when conducting this type of epidemiological surveillance. Through constant monitoring, this project will employ TSA [6].

Antibiotics as well as other contaminated substances from the inter hospital environment represent a source of exposition for bacteria, meaning that an environment charged of medicine and chemical substances are provoked aggressiveness, to which bacteria react generating resistance profiles and at the same time increasing their virulence [21]. The bacteria located in contaminated environments and with specific resistance profiles mean their usefulness as bio indicators of microbiological quality [12]. This will allow preventing and designing strategies to avoid the beginning or development of nosocomial infections and even of epidemic outbreaks.

Conducting a reach project of this size at an inter hospital level supports the academic basis yet incipient to effect epidemic surveillance, considering the environment supported by the aerobiological methodology or environmental epidemiology, methodology that deserves a transcendental collaboration to the environmental epidemiology; in that way it could be possible to obtain the collection and register of risk factors in a systematized and constant way. Their collection in the data base would facilitate the opportune analysis, with the finality that this allows qualifying and quantifying the inter hospital environment and pursuing standards of environmental quality. At the same time, this project will allow to interpret a subjective reality up to the moment concerning the collect of inter hospital microorganisms as a model of inter hospital environmental epidemiological surveillance, that at its time could affect diminishing nosocomial infections and economic costs for such health services.

Conducting scientific research projects at the third level of attention, would allow to finally count with a technical- scientific methodology to point out aerobiological quality of the hospitalization services, through the attention that environmental sciences represent at an inter hospital level, where evaluation of knowledge is applied through the health personnel and the users, the monitoring of hygienic - sanitary applied measures and their correction, if necessary, including the actions of the cleaning personnel of the hospital by orientating them and keeping control of the chemicals the employees use every day.

Environmental monitoring results to be an effective methodology to determine the aerobiological aero transported quality; resistance profiles to antibiotics and the microbiological recuperation for their study from the perspective of their cellular viability, as well as the existent correlations between these types of microorganisms and nosocomial infections.

2.1. The challenge towards this research project.

It is known $1x10^3$that bacillary morphological bacteriain the air of controlled areas represent a risk for human health, that these bacteria get stressed and synthetize protein to survive in adverse conditions, but also that this situation allows them to be more virulent, modifying their metabolism and their form even back to favorable conditions [13-16]. Those adverse conditions could occur in the community or in the hospital, though *E. coli* y *K. pneumonia* strains, which produce beta-lactamase, have been isolated with more prevalence of inter hospital strains rather than community ones [17].

The air does not include the aero transportation of microorganisms not only transmitters of respiratory diseases, but of a wide variety of microorganisms between which are the saprophytes and aerolite products, fragments of cellular membranes, scourges and genetic material, metabolites, volatile organic compounds, endotoxins and mycotoxins, in the internal air can contain microorganisms that affect the human health and the environment, associated with bio sprays.

In order to consider the environmental quality, bio sprays can contain particles between

0.5-30 µm diameter, the concentration of microorganisms located in bio sprays varies depending on the dissipation and deposition, they are associated with particles depending of the size, density, humidity, temperature, when they are extreme they intervene as environmental factors and favor the variety of microorganisms, fungus, bacteria, virus, amoeba cysts among other agents.

During their transportation, microorganisms get stressed and die, but the one that survive generate adverse damages in human health, the agents get installed in the human gest through exposition mechanisms and entrances as indigestion, inhalation and contact through the skin, are the main roots of exposition for the human.

Human beings inhale approximately 10 m^3 per day and can give room in their alveoli for particles of 1 to 2 µm diameter; as a result of this they will present adverse health status, such as, severe infections, asthma, hypersensitiveness, pneumonia and other associated with the exposition to bio sprays [18-20].

For thequantitativecollection of bio sprays sampled, there are three the methods mainly implemented: impact, liquid mean, filtration by gravity; to conduct

studies of microscopy biochemical, immune essays and PCR. [7-10,20].

The challenge consists on looking for answers to unknowns as following:

What is the microbiologicalaero transported quality in the hospitalization services, as well as their correlation with the incidence of etiologic incidence of etiological agents related to nosocomial infections and their main risks factors identified in a third level hospital?

For instance:

Has the maintaining and cleaning personnel or the person in charge of carrying out the application of hygienic- sanitarian measures received training on the usefulness of chemicals and inter hospital cleaning processes?

2.2. Objective:

One of the fundamental objectives to carry out this type of investigation are mainly: determining the variability of inter hospital aero microbiological recuperation and its correlation with the incidence of etiological agents related to nosocomial infections, as well as their main risks factors identified though the standardized environmental epidemiological surveillance system

Proposal for the persistence of nosocomial infections

The proposal is to carry out research projects from the epidemiology and their design starting from a longitudinal descriptive study, which through sampling of air in cultivate boxes added with TSA Trypticase soy agar, exposed for 15 minutes in an open box, surveillance of the environmental aero microbiological quality, standardizing sampling methods, as well as proposing sampling of the air of the hospital rooms by means of a sampler that simulates the functioning of the respiratory system of humans denominated as sampler Andersen (MA) and in another sampler of air, as it is air sampler IDEAL ^{TM}and analyzing the collected information concerning nosocomial infections, microbial viability, invasive treatments, characteristics related to the etiologic agent: the microbial recovery , frequency of nosocomial infection, as well as etiological agent and resistance and sensitiveness to antimicrobial, resistance profiles to heavy metals as well as exploring in the health personnel the incidence of respiratory infections. It is fundamental to execute the environmental epidemiology in all the hospitals, obviously that the best quality of inter hospital attention and were we less expect to find the experience of suffering a nosocomial infection.

Material and Methods

We performed a quantitative study, observational retrospective longitudinal descriptive analyzed the information obtained from September 2010 to August 2011, in 135 patients. For it was necessary to include the following variables: age, gender, where they received care service, location of infection, reason for admission, if surgery was performed and the particular information in addition to the following risk factors, mechanical ventilation catheter Central, peripheral catheter, urinary catheter, surgical wound, orogastric, nasogastric tube, parenteral nutrition, blood transfusion, blood line and finally characteristics related to the etiologic agent: the frequency of nosocomial infection and resistance and antimicrobial susceptibility .

Results

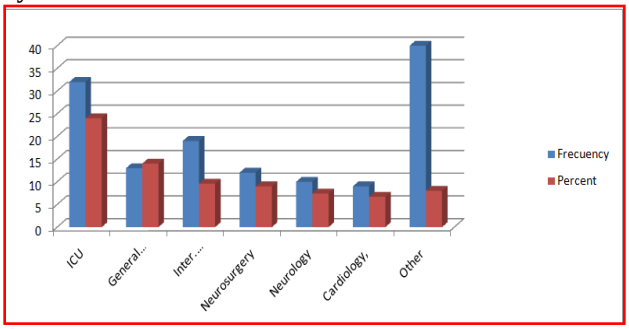
The results make reference to 135 patients attending the Regional hospital of high specialty in which they presented at least one of a total of 209 nosocomial infections, corresponding to 60% male and 40% female, average age of patients with nosocomial infection was 52 years, with 20-30 days of hospital stay after detection, cultivation and detection resolution or specific event runs on average in the three days subsequent to the onset of symptoms.

The service of UTI, Internal Medicine, General Surgery, Neurology and Cardiology among others accumulate most hospital stay and where less manifest this type of infection is the Dermatology (Figure 1).Leading cause of deathhighlightsthedeathfrom sepsis and septic shock (Figure 2). According to the site of infection, there weremore frequently detected: pneumonia, urinary tract infection and bacteremia-septicemia (Figure 3) and pollution degree surgeries "polluted and dirty" associated with nosocomial infection. Risk factors are most often associated, mechanical ventilation, central and peripheral catheter, as well as nasogastric among others (Figure 4). The results suggest the likelihood of correlation between the track location with the type of infection risk factor also was found that synergism in the risk of developing a nosocomial infection more dependent increase in risk factors. The highest frequency of nosocomial infection was detected in the surgery called tracheostomy, other known as N / A which means no invasive or minor surgery. (Figure.5).

It was found that there is no specific cause of income associated with the feasibility of acquiring a nosocomial infection, but it is worth noting that submission surgery increases the chance of infection nosocomial risk, the most common etiologic agents were *Pseudomonas aeruginosa, Escherichia coli,*

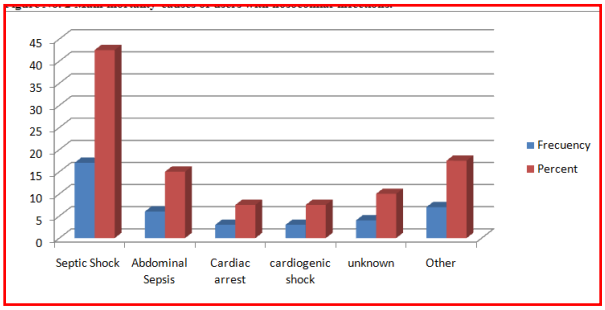
Candida albicans, *Staphylococcus aureus*, among others (Table 1, 2). Antimicrobialstogreaterresistancewasdetectedwere: ampicillin, cefazolin, cefepimeamongothers (Table 3, 4).

Figure No.1 Frequency of nosocomial infections by services.



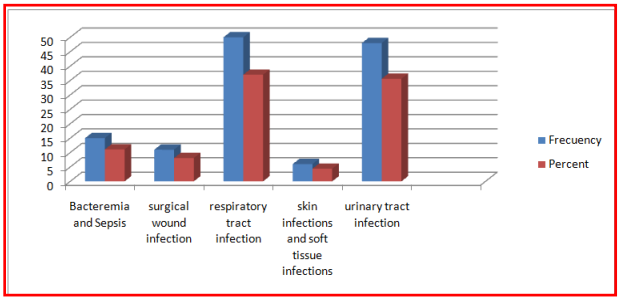
Source: Archive of the Epidemiological surveillance Tertiary Hospital Division, 2011

Figure No. 2 Main mortality causes of users with nosocomial infections.



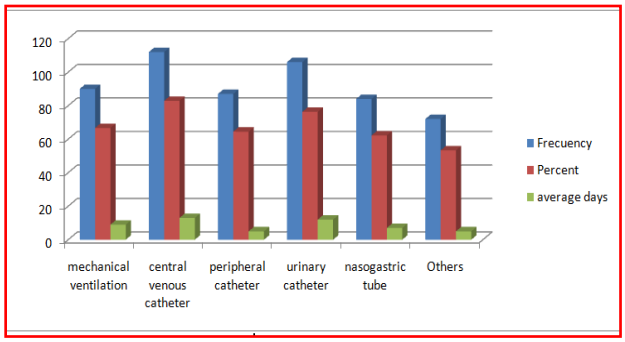
Source: Archive of the Epidemiological surveillance Tertiary Hospital Division, 2011

Figure No. 3 Placement of the nosocomial infection



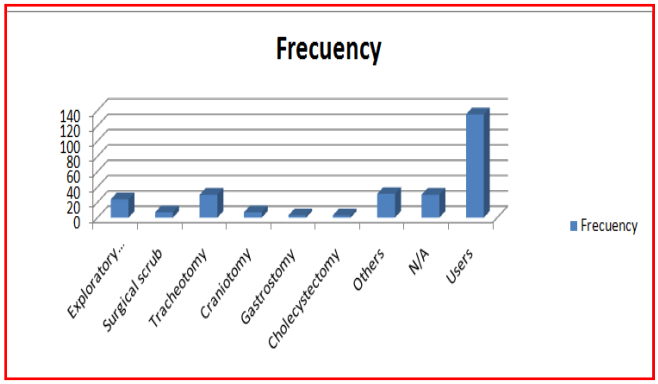
Source: Archive of the Epidemiological surveillance Tertiary Hospital Division, 2011

Figure No. 4 Mainriskfactorsonuserswith nosocomial infections



Source: Archive of the Epidemiological surveillance Tertiary Hospital Division, 2011

Figure No.5 Frequency of surgeries of users with nosocomial infections.



Source: Archive of the Epidemiological surveillance Tertiary Hospital Division2011

Table No. 2 Main attack rates of agent-patient with nosocomial infections.

Microorganism	Frequency	Rate	%
Pseudomonaaeuroginosa	**34**	**0.25**	**25.18**
Escherichiacoli	**25**	**0.18**	**18.51**
Candidaalbicans	**25**	**0.18**	**18.51**
Staphylococusaureus	**20**	**0.14**	**14.81**
Acinetobacterbaumani	**13**	**0.09**	**9.62**
Candidaglabrata	**12**	**0.08**	**8.88**
Klebsiellapneumoniae	**11**	**0.08**	**8.14**
Enterococusfaecales	**10**	**0.07**	**7.40**
Enterobactercloacae	**9**	**0.06**	**6.66**
S. maltophila	**7**	**0.05**	**5.18**
Total Number of patients	**135**		

Source: Archive of the Epidemiological Surveillance Tertiary Hospital Division, 2011.

Table No. 1 Distribution of the frequency of Etiologic agents present on nosocomial infections

Microorganism	Frequency	%
Pseudomonaaeuroginosa	34	16.26
Escherichiacoli	25	11.96
Candidaalbicans	25	11.96
Staphylococusaureus	20	9.56
Acinetobacterbaumani	13	6.22
Candidaglabrata	12,	5.74
Klebsiellapneumoniae	11	5.26
Enterococusfaecales	10	4.78
Enterobactercloacae	9	4.30
Stenotrophomonasmaltophila	7	3.34
Klebsiellaoxytoca	3	1.43
Trichosporomasahi	3	1.43
Pseudomonastutzeri	3	1.43
Acinetobacterhaemolitycus	3	1.43
Enterobacteraerogenes	2	0.95
Candidatropicalis	2	0.95
Stephanesascusciteri	2	0.95
Candidaguillermandii	2	0.95
Serratiamercens	2	0.95
Morganellamorgani	2	0.95
Candidadubliniensis	2	0.95
Staphylococushominis	2	0.95
Cryptococolaurenti	2	0.95
Routellaplanticola	2	0.95
Enterobacterasburriae	1	0.47
Pediococcuspentusaceus	1	0.47
Corinebacteriumangcolatum	1	0.47
Proteusmirabilis	1	0.47
Entrococcusfaecium	1	0.47
Candidafamata	1	0.47
Proteuspenneri	1	0.47
Stenotrophomonas aeuroginosa	1	0.47
Achromobacterdentrificans	1	0.47
Staphylococusahemoliticus	1	0.47
Providenciareftgeri	1	0.47
Total	209	100

Source: Archive of the Epidemiological Surveillance Tertiary Hospital Division, 2011

Table No. 3 Main antimicrobial which showed resistance to nosocomial infections.

Antimicrobial	Frequency	%
Ampicilina	76	56.2
Cefazolin	49	42.9
Ceftriaxona	42	36.2
Cefepime	27	20
Aztreonam	25	18.5

Source: Archive of the Epidemiological Surveillance Divisiontertiary hospital, 2011.

Table No. 4 Main medicines towhichpatientsshowedsensitivityto nosocomial infections.

Antimicrobial	Frequency	%
Imipenem	31	23
Meropenem	28	20.7
Amikacina	26	19.3
Ertapenem	24	17.8
Anfotericina B	23	17
Fluconazol	22	16.3

Source: Archive of the Epidemiological Surveillance Divisiontertiaryhospital, 2011.

Discussion

(Paluchowska P, et al, 2012) in department of anesthesiology and intensive care (59%) and unit of internal medicine (11%) were the main source of multidrug-resistant strains of P. aeruginosa. Pathogens were mainly isolated from clinical specimens collected from the respiratory tract (61%), urine (15%) and wound swabs (13%). Seven (15.2%) strains of P. aeruginosa produced the metallo-beta-lactamases [22]. These results agree with those obtained in a tertiary hospital in Mexico, Especially regarding the most frequently detected strain, ie, *Pseudomonaaeruginosa*, with the hospital and their multiresistant ability to antibiotics.26 (figure 1,2). Aptly, there is agreementon the following: "The bacterium which belongs to alert pathogens is an important cause of many severe and difficult to treat infections which greatly increase the morbidity and mortality among hospitalized patients worldwide. Epidemiological studies and detection of local resistance patterns can provide useful information which can be used in the development of strategies to combat the rising tide of microbial antibiotic resistance"[23].

The purpose of microbial monitoring of the inanimate environment surrounding a patient can be two-fold;

to monitor hygiene standards and also to examine for the presence of specific nosocomial pathogens which may be the source of an outbreak. While both purposes involve routine culture of microorganisms, the methods used for each can differ in order to provide optimal results.Detect the presence or absence of multi-resistant nosocomial pathogens for infection control surveillance is simply transcendent. For this reason, it is important to detect nosocomial pathogens in the inanimate environment in the clinical setting.Microbial monitoring of the environment can involve the use of variety of methods but their monitoring allows the implementation of prevention, control of infections, cleaning and disinfection regimens [24].Microbiological monitoring is a useful tool for assessment of the contamination of operating theatres in order to improve air quality [25].

A research study (Sexton JD, et al, 2011) states that recent scientific literature suggests that portable steam systems are capable of rapid, chemical-free surface disinfection in controlled laboratory studies. This study evaluated the efficacy of a portable steam system in a hospital setting. The study was carried out in 8 occupied rooms of a long-term care wing of a hospital. Remarkably, the steam device consistently reduced total microbial and pathogen loads on hospital surfaces, decreased the detection in most instances. Treatment reduced the presence of total coliforms on surfaces from 83% (40/48) to 13% (6/48). As a conclusion, the steam system reduced bacterial levels by 90% and reduced pathogen levels on most surfaces below the detection limit. The steam system provides the means to reduce levels of microorganisms on hospital surfaces without the drawbacks associated to chemicals, and may decrease the risk of cross-contamination [26]. This establishes strategies from environmental monitoring in the hospital with the aim of reducing nosocomial infections. Therefore, we strongly emphasize on the use of the proposed environmental epidemiology plan.

Finally, we agree that the exposed-plate method was found to capture microorganisms efficiently with little variation in duplicate samples, suggesting their use in hospitals for preliminary assessment of indoor air quality and determining pathogenic microorganisms due to particle fall-out.[32] Therefore, this method is feasible for environmental monitoring. It is not expensive and is efficient to collect environmental microorganisms on hospital environments.

The next study indicates the importance of environmental epidemiology in the hospital. It is important to point out the resistance mechanisms of microorganisms which even the chemicals used for cleaning of the hospital environments develop. In the study by Oie S. (2012) describes the following: a 76-year-old male patient developed pneumonia due to Burkholderiacepacia whilst being in an intensive care unit at a Japanese university hospital. During the subsequent environmental investigation to find the source, B. cepacia with an identical DNA type was found in his denture storage solution. Open packets of unwoven rayon cloths soaked in 0.2% alkyldiaminoethylglycine hydrochloride, used for environmental cleaning, were shown to be contaminated with B. cepacia, Alcaligenesxylosoxidans, Pseudomonas fluorescens and Pseudomonas aeruginosa [27]. It requires anticipating such events, so environmental monitoring is important in chemical samples which vary according to the needs. The custodial staff recommends that you use security measures to avoid exposure to agents or nosocomial strains of microorganisms. The increase of antimicrobial resistance is a growing threat that requires the establishment of monitoring trends and directs ongoing action strategies in hospitals in order to reduce the impact on health and economy of society suffering from nosocomial infection or who dies as a result of this and increases the social cost and family impact.

It is important to point out that the presence of enterobacteria captured from aerosols, based on their profiles and antimicrobial resistance in heavy metals represent useful bio-indicators of environmental impact [9,12]. Particularly, when detected in people who come from contexts where the human population is exposed to aerosols we could also point out that those are bio-indicators that have an impact on human health. A previous retrospective study after building a database allows identifying the variability of microorganisms detected in nosocomial infection, antibiotics whose strength and sensitivity were detected besides their risk factors and their impact on the public health of the users [26,28]. This makes the implementation of the proposal emergent and transcendent in the sense of implementing and executing hospital environmental epidemiology, a situation that could assist on strongly decreasing nosocomial infections.The air transport of virulent microbiological agents, as well as the density of antibiotics and resistant bacteria may enhance the adverse effects on public health and environmental surroundings, hence the importance of considering the implementation of inter hospital epidemiology.

Conclusion

Every hospital requires the intervention of a department of division of epidemiology, not only clinical epidemiology but environmental inter hospital epidemiology. Inter hospital environmental epidemiological surveillance intervenes in diminishing the nosocomial infections and implies and means that epidemiological surveillance requires of taking samples and environmental monitoring to describe and identify the risks of inter hospital sprays.

Inter hospital environmental epidemiology through methodology and research actions and standardized monitoring allow the execution of hygienic-sanitarian measures. Train the health professional on the hand wash and on the exhaustive care concerning the transportation of their clothes, their working area and other spaces inside and outside the hospital.

The increase in antimicrobial resistance is a growing threat that requires the establishment of monitoring trends on antimicrobial resistance and directs ongoing action strategies in hospitals in order to reduce the impact on health and economy of society suffering from nosocomial infection or who die as a result of this which increases the social cost and family impact. Adverse effects on public health and environmental surroundings, hence the importance of considering the implementation of interhospital epidemiology.

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