Miami-Dade County Health Department

Investigation of *Pseudomonas aeruginosa* Cases at Miami Children's Hospital

Principal Investigator

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Background

On March 16, 2009 the Miami-Dade County Health Department (MDCHD), Office of Epidemiology, Disease Control and Immunization Services (OEDC-IS), was contacted by the Director of Infection Control at Miami Children's Hospital regarding two patients in the Neonatal Intensive Care Unit (NICU) who had recently expired and a third patient that was doing poorly. One of the patients (Baby A) expired from multiple factors, among them was sepsis due to *Pseudomonas aeruginosa*. This was confirmed by endotracheal aspirate culture. The second patient who expired (Baby B) also had sepsis as a contributing cause of death, but all cultures were still pending. The third patient (Baby C) was ill and sepsis was among the multiple diagnoses being considered while culture results were still pending. Over the following days, culture results became available indicating that all three patients had *Pseudomonas aeruginosa* infections. Based on these findings, the MDCHD decided to initiate an investigation and a meeting was held with officials from Miami Children's Hospital (MCH). At this meeting, hospital officials provided further details on the three cases and discussed measures that had been taken to prevent further infections. Several initial suggestions were made by the MDCHD and a follow-up meeting was scheduled with additional officials from both the MDCHD and MCH.

Miami Children's Hospital is a 289-bed tertiary care hospital exclusively for children. As such, it does not have any obstetric delivery services so all patients in their Neonatal Intensive Care Unit (NICU) are transferred from other hospitals. MCH provides specialty care to very sick, extremely premature, and immunocompromised patients that not many other facilities are able to care for. They receive patients from a very wide catchment area including Central and South America, the Caribbean, and the entire South Florida region. There is only one other facility in the South Florida area (Jackson Memorial Hospital) that has similar specialty care capabilities as MCH.

Pseudomonas aeruginosa is a ubiquitous gram-negative bacillus that is found in soil and water that can thrive in adverse conditions and can colonize many natural and artificial environments. Because it thrives on moist surfaces, *Pseudomonas* can be found on medical equipment and is a common cause of hospital acquired infections [Muscarella]. An opportunistic pathogen of immunocompromised individuals, *P. aeruginosa* typically infects the pulmonary tract, urinary tract, burns, wounds, and also causes blood infections. It has been found to be the most frequent colonizer of medical devices (e.g. ventilators, catheters, etc.). One in ten hospital-acquired infections (HAI's) is from *P. aeruginosa*. Many hospital acquired infections with *Pseudomonas spp*. involve organisms resistant to multiple antibiotics [Hota]. Several outbreaks in neonatal intensive care units have been reported in the literature [Foca]. In past outbreaks at other facilities, implicated sources of infection with *P. aeruginosa* have included health care workers [Moolenaar, Zawacki], medical equipment, and environmental surfaces and water sources [Aumeran, Hota]. Airway colonization with *P. aeruginosa* has been frequently observed in very low birth-weight infants on mechanical ventilation [Cordero]. Outbreaks or clusters of invasive infections with *P. aeruginosa* should be reported by hospitals to the MDCHD so that possible sources can be investigated.

Investigation Methods

The investigation involved several components including 1) review of medical records for the infected patients; 2) surveillance cultures collected on all patients present on the NICU with cohort analysis of factors associated with colonization; 3) site visits to assess infection control and patient care procedures on the NICU; 4) site visits by environmental health staff to review facility maintenance procedures with MCH engineers; 5) collection of environmental samples from the NICU, other areas of the hospital, and the water system surrounding the hospital; and 6) laboratory analysis of collected specimens. Specific methodological details regarding each aspect of the investigation are provided below.

1) Complete medical records for Babies A, B, and C were reviewed.

2) Surveillance cultures were obtained for all patients (N=36) present in the NICU as of March 16, 2009. Specimens were obtained from blood, endotracheal aspirates, or rectal, nasal or eye swabs. All specimens were tested for bacterial growth at the Mayo reference laboratory and the Florida Department of Health, Bureau of Laboratories-Jacksonville. Medical records were reviewed for all patients present on the unit and data were abstracted to a standard form and entered into a data base through an abbreviated chart review. Data elements collected included factors related to the children's birth and delivery, underlying medical conditions, and medical care received at MCH. Factors were compared between children colonized and not-colonized with *P. aeruginosa* as indicated by surveillance culture. Univariate and multivariate logistic regression was used to generate odds-ratios with 95% confidence intervals for factors associated with colonization.

3) Site visits were performed on March 18, March 23, and April 1, to observe infection control and patient care procedures on the NICU.

4) Environmental assessments of the various systems within the hospital were performed, with particular emphasis on plumbing and HVAC (Heating, Ventilation, Air-Conditioning) systems. Included in these evaluations were discussions of maintenance schedules and procedures that were followed during maintenance. Construction activity is on-going at MCH, for expansion and updating of older systems. Therefore MDCHD Division of Environmental Health (DEH) staff also reviewed policies and procedures related to stopping and re-starting various systems including the plumbing and HVAC systems.

5) DEH collected environmental samples from various sites within the NICU. This included water samples from sinks located on the NICU, and requested MCH staff to sample the bottled water and betadine solution used in patient care. Tests were performed on collected specimens to assess the presence of fecal coliforms and *P. aeruginosa* from various sources within the hospital. Bacterial cultures of water samples from the same locations were repeated after MCH took certain corrective environmental measures. DEH also measured chlorine residuals from the water system, both within and around the hospital, to assess disinfectant levels at various locations.

6) Laboratory testing for bacteria was performed by the Florida Department of Health, Bureau of Laboratories-Jacksonville. Earlier test results performed by Mayo Reference Laboratories were later confirmed by the state laboratory. Bacterial isolates of *P. aeruginosa* obtained from human and environmental sources at MCH were tested for antibiotic resistance and analyzed by Pulsed-Field Gel Electrophoresis (PFGE) to identify common pulsetypes (strains) of *P. aeruginosa*.

Results

Medical Record Review of Infected Patients

As previously noted, a total of three patients (A, B, and C) on the NICU had invasive infections with *P. aeruginosa* in March 2009; two of these children died and the other recovered. A brief synopsis of the clinical history of each patient is provided in Table 1 and the text below.

Table 1. Characteristics of NICU patients with invasive *P. aeruginosa* infections

Pt	Sex	DOB	Birth Hosp	Gestation age (wks)	Birth weight	Surgery	Vent	Rm	Culture date	Outcome
A	M	3/7/09	Lawnwood	31	1.43 kg	Y	Y	2	3/14	died (3/14/09)
B	F	2/22/09	Lawnwood	24	0.62 kg	Y	Y	2	3/14	died (3/15/09)
C	M	2/4/09	Mercy	25	0.65 kg	Y	Y	2	3/15	survived

Baby A was delivered on March 7, 2009 by cesarean section, at Lawnwood Hospital in St. Lucie County and was transferred to MCH the same day by air ambulance. The child was born 7 weeks premature with corresponding low birth weight. The child did not require mechanical ventilation on admission to MCH but received oxygen via nasal cannula. The child underwent a surgical procedure in the operating room at MCH on March 9, to repair a tracheoesophageal fistula. During this procedure the child was placed on mechanical ventilation which was discontinued after surgery. The patient died on March 14. Also on March 14, an endotracheal aspirate specimen was obtained for culture, which was positive for *P. aeruginosa* on March 16. This isolate was later determined to be pulsetype III.

Baby B was delivered on February 22, 2009 by cesarean section, at Lawnwood Hospital in St. Lucie County and was transferred to MCH the following day by air ambulance. The child was born 14 weeks premature and weighed 0.62 kg. The child was on mechanical ventilation when admitted to MCH and remained ventilator dependent throughout her hospitalization. On March 9, the child underwent a surgical procedure in the NICU to repair a patent ductus arteriosus (PDA). On March 14, rectal swab and endotracheal aspirate specimens were obtained for culture which were positive for *P. aeruginosa* on March 15. This isolate was later determined to be pulsetype II. The patient died on March 15.

Baby C was born on February 4, 2009 at Mercy Hospital in Miami, and transferred to MCH the same day by ground ambulance. The child was born 13 weeks premature and weighed 0.65 kg. The child was on mechanical ventilation when admitted to MCH. On February 16, the child underwent a surgical procedure in the NICU to repair a PDA. On March 15, blood specimens were obtained for culture which were positive for *P. aeruginosa* on March 18. This isolate was later determined to be pulsetype I. The patient was treated with antibiotics and recovered from

his sepsis syndrome. Due to the child's extreme prematurity, he remained hospitalized at MCH through May 2009.

The NICU at MCH has a capacity of approximately 40 beds, arranged in 5 separate rooms with 8 beds per room. All three infected babies were cared for in room 2 on the NICU. Both Baby A and B were born at Lawnwood Hospital and transferred to MCH by air ambulance. Record review of laboratory data from Lawnwood Hospital conducted by the St. Lucie County Health Department, indicated nothing out of the ordinary occurring at Lawnwood Hospital near the time of the infants' births. Review of the air ambulance service used to transfer these patients was also unremarkable.

Colonization Study

On March 16, 2009, the MCH Infection Control staff collected specimens from all patients that occupied the NICU that day. Of the 36 patients, without invasive infections, for whom surveillance cultures were obtained, 11 patients showed evidence of colonization with *Pseudomonas aeruginosa* and 25 patients did not. Various clinical parameters were compared between colonized and non-colonized patients and results are presented in Table 2 and Table 3. None of the patients with invasive infections (Baby A, B, and C) are included in this analysis.

Table 2. Comparison of categorical variables for colonized and non-colonized patients

Risk Factor	Colonized (N=11)	Not Colonized (N=25)	Rate (%)	Relative Risk (95% CI)	p-value*
female	3	9	25.0	1.0	
male	8	16	33.3	1.13 (0.73 – 1.73)	0.71
Ground transfer	9	16	36.0	1.0	
Air transfer	2	9	18.2	0.51 (0.13 – 1.96)	0.43
Vaginal delivery	4	12	25.0	1.0	
Caesarian	7	13	35.0	1.40 (0.50 – 3.95)	0.72
Singleton	5	22	18.5	1.0	
Multiple birth	6	3	66.7	3.60 (1.44 – 8.99)	0.01
No anomaly	4	4	5.0	1.0	
Birth anomaly	7	21	25.0	0.50 (0.19 – 1.28)	0.21
No vent on admission	1	11	8.33	1.0	
Vent on admission	10	14	41.67	5.00 (0.72 – 34.63)	0.06
No vent @ MCH	0	9	0.0	1.0	
Vent @ MCH	11	16	40.7	8.21 (0.53 – 126.9)	0.03
No surgery	11	22	33.3	1.0	
Surgery	0	3	0	0.37 (0.02 – 5.15)	0.54
No nasal cannula	8	17	32.0	1.0	
Nasal cannula	3	8	27.3	0.85 (0.28 – 2.62)	1.0

No incubator	10	16	38.5	1.0	
Incubator	1	7	12.5	0.33 (0.05 – 2.17)	0.23
Room 2, 4 or 5	2	14	0.13	1.0	
Room 1 or 3	9	11	0.45	3.6 (0.90 – 14.37)	0.07

*Fischer's exact test

Table 3. Comparison of mean values for colonized and non-colonized patients

	Colonized	**Non-colonized**	**p-value***
Gestational age (weeks)	30.36	32.2	0.41
Birth weight (kg)	1.52	1.95	0.29
Admission weight (kg)	1.93	2.25	0.50
Hospital duration (days)	65.9	52.4	0.62
Ventilator duration (days)	41.8	20.3	0.01

* t-test

In logistic regression analysis, the single factor most strongly associated with colonization was number of days on a ventilator. The parameter estimate of the odds ratio for each successive day of ventilator dependence was 1.07 [95% CI (1.02-1.12)]. When multivariate models were fitted to the data, the only other variable associated with colonization that resulted in a better fit to the data was being in room 1 or 3. When presence in room 1 or 3 was added to the model, the parameter estimate for the odds ratio for the association between duration of ventilator dependence in days and colonization was 1.095 [(1.026-1.169)]. Further multivariate analyses were limited by the small number of patients in the analysis.

Observations of Patient Care and Infection Control Practice

Site visits to MCH and observation of the NICU revealed no obvious deficiencies in patient care or breaches in standard clinical infection control practices. In general, the infection control staff at MCH maintained appropriate documentation, responded to the index cases quickly and aggressively, and notified the MDCHD as appropriate. A walk through of the NICU by County and State Health Department officials demonstrated a sink in room 2 that, when used, generated an excess amount of "splash" that landed on environmental surfaces adjacent to patient care areas. This raises the possibility of contamination from a sink to patient care areas or equipment that could be used for patient care. Past studies of *Pseudomonas* outbreaks in NICUs have suggested that the combination of biofilm build up in plumbing systems, combined with splash from sinks in improperly designed rooms can result in contamination of patient care areas and result in *P. aeruginosa* infections in premature neonates [Hota].

Environmental Inspection and Assessment

During discussions with MCH engineers, hospital staff indicated that the facility flushes water lines when there are any pressure problems or when repairs are done within the property. The staff also indicated that all of the water mains and meters have recently been fitted with backflow prevention devices and that any new equipment that is installed is also fitted with backflow prevention devices. They are currently in the process of retrofitting backflow prevention devices on all existing equipment and plumbing. Maintenance responds to leaks and any other problems when there are complaints. The facility has chillers, boilers and cooling towers on site.

MCH engineering staff indicated that there are currently no policies or procedures in place for routine inspection and testing of the hospital plumbing system. The facility also does not systematically flush their system and the hospital does not utilize Miami-Dade County's chlorine purge program. The Miami-Dade County chlorine purge program occurs twice per year and is intended to treat any potential biofilm build-up in plumbing systems by changing from chloramine (ammonia and chlorine) to free chlorine for a two week period. During this period all hospitals are notified and encouraged to flush their systems in order to receive the full benefit.

The air conditioning/HVAC systems and maintenance programs were also discussed with the engineering staff. The filters are changed monthly and visual inspections are done on a regular basis to ensure that they are in proper working condition and clean. No deficiencies were noted by MDCHD DEH staff related to the air conditioning/HVAC systems.

Environmental Sampling

Water samples were taken by MDCHD Department of Environmental Health staff on Thursday, March 26, 2009, to test for any microbial organisms present in the water in the NICU area. A total of 22 water samples were taken from various sinks in the 5 NICU rooms, from parent sinks, from a teaching room sink, a bathroom sink, the nurse's station sink, the breast pump room sink, and from a shower head located on the floor above the NICU. All 22 tests came back negative for fecal coliform which is a microbial indicator mandated by the Florida Safe Drinking Water Act and the Federal Drinking Water Act to test microbial drinking water quality.

Five of these water samples were tested for chlorine residuals with all testing at 0.7 parts per million (ppm). Compliance was met (0.6 ppm minimum or greater is required by Chapter 62-555 FAC). However, our records indicate that an average of 2.5 ppm or greater of chlorine residual has been maintained in the potable water distribution system around the hospital. The source of this data is the monthly microbial water testing results reported by the Miami-Dade Water and Sewer Department (WASD). In addition, staff from MDWASD and MDCHD performed joint chlorine readings from fire hydrants around the hospital on April 23, 2009. All readings were in the range of 2.5 to 3.2 ppm (See Attachment 1, Environmental report).

The microbial culture plates were incubated longer to test for the presence of other organisms using coliform selective media (MFC). Isolates from this media were then identified using the clinical lab protocols which included growth on MacConkey Agar and 5% Sheep Blood Agar and additional tests with a final identification using API 20 E Biochemical testing kits. These test results showed 4 tests confirmed positive for *Pseudomonas aeruginosa* , 7 tests presumptive for *Pseudomonas aeruginosa,* 1 test positive for *Vibrio metschnikovii,* and 9 tests resulting in non-fermentor gram negative growth (no further work up needed). Fifty (50%) percent of the samples tested positive or presumptive for *Pseudomonas aeruginosa.* All positive *Pseudomonas aeruginosa* results grew on MFC within 24 to 48 hours so there was no need to isolate organisms from the heterotrophic plate count (HPC) since the organisms grew on the MFC plates. Positive results were sent to FDOH Laboratories for pulsetyping (PFGE). Pulsetype I, which was found in Baby C, matched a pulsetype from a water sample taken from the sink in the same unit and adjacent to where Baby C was placed in the unit.

On Monday, May 11, 2009, a new round of samples was taken. This sampling effort was intended to measure the effectiveness of the work that had been completed by hospital staff and to confirm some of the earlier results especially the results of the sample that had been taken from the NICU room 2 right sink (sample #455). A total of eight (8) samples were taken at seven (7) locations in the NICU area and one sample from the shower head on the third floor. Chlorine residual readings were also taken. All eight (8) samples were negative for fecal coliform and the chlorine residual ranged from 2.2 ppm to 2.6 ppm which definitely indicated an improvement related to the flushing of the water lines. Two of the eight samples tested positive for *Pseudomonas aeruginosa* after 24 to 48 hours of extended incubation on the MFC media. This showed a reduction to 25% positive results of samples as compared to 50% positives from the initial sampling. This improvement might be related to the purging of the plumbing system by hospital staff. The two samples that were positive were again from room 2 in the NICU (R sink, sample # 682 and L sink, sample # 681) and were sent for PFGE (Pulsed-Field Gel Electrophoresis) analysis to the Bureau of laboratories in Jacksonville. The results of the PFGE analysis showed a matching pulsetype X for the left sink and a new pulsetype XXIII for the right sink. This may indicate a problem that is limited to room 2 in the NICU and may require further investigation of the plumbing system within the unit. In light of these results, on May 18, 2009 the MDCHD made a recommendation to MCH to close room 2 of the NICU until an engineering evaluation and additional microbial testing has been completed. (See Environmental report) This evaluation should include clearance sampling that attests to the sanitation quality of the potable water in the related plumbing system. The MCH agreed to this recommendation.

Additional Laboratory Analysis

PFGE analysis of all *P. aeruginosa* isolates obtained from the three (3) patients with invasive infections, the eleven (11) colonized patients, and twenty six (26) positive environmental samples yielded twenty three (23) separate pulsetypes (Table 4). Common PFGE pulsetypes (Roman numerals) are an indication of a common source of contamination or infection and each Roman numeral represents a distinct bacterial DNA fingerprint. There were three groups of related pulsetypes that involved patients. One group (pulsetype I) included Baby C and a faucet located adjacent to the bed that was occupied by Baby C in room 2. The second group (pulsetype III) included Baby A and a group of colonized triplets that had been in room 3, adjacent to room 2. The third grouping (pulsetype V) included two colonized patients who had both been admitted after the deaths of Baby A and B, and who both occupied room 5. There were also six (6) groupings of PFGE pulsetypes among the environmental samples but no other PFGE patterns from environmental samples matched any other patient patterns. All isolates of *P.aeruginosa* tested were sensitive to common antibiotics and no drug resistant isolates were detected.

Table 4. PFGE pulsetype results for patient and environmental samples

Source	Pulsetype
Baby C	I
water isolate from room 2	I
Baby B	II
Baby A	III
Colonized triplet	III
Colonized triplet	III
Colonized triplet	III
Colonized patient	IV
Colonized patient	V
Colonized patient	V
Colonized patient	VI
Colonized patient	VII
Colonized patient	VIII
Ceiling Tile #1	IX
Ceiling Tile #2	IX
NICU room 2 sink	X
NICU room 2 sink	X
water isolate	X
Faucet room 1 pod	XI
Faucet room 2 left	XI
water isolate	XI
water isolate	XI
water isolate	XI
water isolate	XI
Faucet room 4 (27)	XII
Sink room 4 (27)	XII
water isolate	XII
water isolate	XII
water isolate	XII
Room 3 faucet left	XIII
Room 3 faucet left	XIV
Faucet room 3 right	XVI
water isolate	XVI
Faucet Satellite (amb POST-OP)	XVII
Sink Satellite (amb POST OP)	XVIII
Sink Stepdown PICU	XIX
Sink 269	XX
Staff Bathroom Sink	XXI
water isolate	XXII
water isolate	XXII
water isolate	XXIII

Conclusions

Laboratory results indicate 23 different pulsetypes (strains) of *P. aeruginosa* identified between patients A, B, C, the colonized patients, and the environmental samples, suggesting no single common source was responsible for the observed findings. These findings argue against a common source cause such as a medical device or colonized health care worker. Patients A, B, and C all occupied room 2. There were no pulsetype matches found between environmental sources and either of the two (2) patients that died. The single pulsetype match observed between a human and an environmental sample was found between Baby C and a water sample taken from the sink in room 2. Both this and one other sink in room 2 remained positive for *P. aeruginosa* after corrective environmental actions had been taken by the hospital. This suggests a possible biofilm contamination or other plumbing problem with the two (2) sinks in room 2. Based on preliminary results from this investigation and the recommendations of MDCHD, MCH has closed room 2 and is taking further corrective action.

Overall, 26 of 94 environmental samples taken on the unit were positive for *P.aeruginosa.* This finding is difficult to interpret since no comparative sampling is available from other hospitals. *Pseudomonas* is known to be ubiquitous in the environment so finding it in 28% of specimens would not necessarily be surprising. MDCHD is not aware of any studies examining the prevalence of *Pseudomonas* in hospitals by random environmental sampling. A literature search was conducted and no data could be found on random environmental sampling for *P. aeruginosa* in hospital settings.

Water testing conducted on March 25, 2009, showed a chlorine residual level of 0.7 ppm, which is compliant with regulatory limits, but lower than the 2.53 ppm level detected in the area surrounding the hospital. These levels were measured approximately 10 days after the deaths of Baby A and Baby B, however, so it is impossible to know the chlorine residual levels at the time of their infections. There are no water readings, within the hospital, available for the period of early to mid-March, 2009. The lack of hospital policies or procedures for the routine inspection or flushing of the plumbing system, combined with the relatively low disinfectant residual levels of chlorine raise the possibility of biofilm build-up in the system with possible contamination of the water supply.

MDCHD found no evidence to suggest that specific patient care practices or procedures were associated with infection or colonization with *P. aeruginosa*. The small number of infected patients (N=3) precluded a comprehensive assessment of risk factors, due to the small sample size. The three (3) patients treated for infections with *P. aeruginosa* were all at high risk for opportunistic infection with hospital acquired pathogens such as *Pseudomonas*. All three (3) patients were born severely premature with very low birth weights, and two of the three were on ventilators for extended time periods. Ventilator use is a known risk factor for hospital acquired infections with *Pseudomonas*. For the colonization survey of all patients on the unit, risk factors associated with colonization were consistent with known risk factors for *Pseudomonas* identified in previous studies. These include a generally fragile state of health and reduced immune competence as indicated by low gestational age and low birth weight, as well as extensive periods of ventilator support [Cordero]. Other than ventilator dependence, no specific health care workers, procedures, devices, medical products or equipment, were associated with

colonization. Comparative data regarding colonization with *Pseudomonas* in other institutions is also scarce. In a study published in 2000, a similar hospital conducted surveillance cultures and found that 22% of patients were colonized with *Pseudomonas* [Foca, M]. Anecdotal data from a similar NICU at a hospital in western Florida, suggested a colonization rate of 10-25% of NICU patients. Therefore the 30% colonization rate MDCHD observed in the MCH NICU is only slightly higher than colonization rates reported at similar institutions. Further conclusions regarding risk factors for colonization at MCH were also somewhat limited by the relatively small sample size of patients on the NICU.

In conclusion, MDCHD found no causal association between infection with *Pseudomonas* and any of the factors MDCHD investigated. The root cause of the three (3) invasive infections appears most likely to be related to environmental factors and less likely to be related to patient care or practice of infection control precautions. MCH infection control practices appear to be adequate and consistent with current standards. *Pseudomonas aeruginosa* is a common bacteria and is found throughout our environment so it is not unusual to see hospital acquired infections (HAI) caused by *P. aeruginosa.* The fact that these infections occurred in extremely high risk, immunocompromised patients is consistent with past reports in the literature [Foca]. The MCH staff was very proactive in its efforts to identify the cause and to prevent further infections. No additional *Pseudomonas* infections have occurred on admitted children at MCH to date. The MDCHD has identified areas where environmental practices at MCH can be improved (see recommendations below and Environmental Report).

Recommendations

Based on the findings from this investigation, MDCHD makes the following recommendations to MCH:

A) Internal backflow prevention control

1. Inventory all systems, ensuring they all have approved backflow prevention devices (fire lines, irrigation lines, chiller water lines, boilers, etc.).
2. Create a schedule to routinely test all backflow prevention devices.
3. Conduct tests at least once per year by Certified Tester and retain documentation.

B) Point of use devices

1. Create a schedule, per manufacturer's specifications, to maintain and /or change water filters.
2. Provide a maintenance schedule for sterile filtration stations.

C) General plumbing operation and maintenance

1. Create on-site water mains flushing procedures to coincide with the Utility yearly flushing (annual chlorine purge) schedule.
2. Identify all dead ends within the plumbing system.

3. Conduct routine checks of all systems and visual inspections as well as responding to complaints.
4. Routinely monitor chlorine residual levels inside the buildings with the emphasis on areas with low water use, critical care areas and at the meter locations. Record the results. Chlorine levels in the plumbing system should be equal to the levels provided by the county water system. Note, attached is the Cl2 readings collected on April 27, 2009 by the MCH engineering staff. Readings indicate that the hospital's flushing effort was effective (Attachment 4 in Environmental Report).
5. Conduct monthly standard HPC (Heterotrophic Plate Count) analysis throughout the water plumbing system. HPC analyses are a good tool for monitoring water quality. This is especially true if a monitoring program with regular frequency is established. This will yield trend data and allow for establishment of a designation of what can be considered a "normal" count. Any deviation from this figure is suggestive of prudent investigation. Although no enforceable standard currently exists for HPC, USEPA sets acceptable HPC levels in drinking water at less than 500 CFU/mL Internally, in the hospital's potable water system, HPC levels should be at the same levels (<50 CFU) normally found in WASD's water distribution system. WASD is the hospital's water supplier.
6. All sinks located within critical care areas must be re-evaluated to minimize water splashing to the adjacent areas.
7. Provide training to the MCH's engineering and plumbing staff, using as a reference the CDC document "Guidelines for Environmental Infection Control in Health-Care Facilities."
8. Consider an active and supplemental disinfection of the hospital potable water systems such as Chlorine dioxide (ClO_2) as an alternative supplemental disinfectant This method will provide added protection to the hospital's water systems from biofilm buildup, and opportunistic waterborne pathogens.

D) Heating, Ventilation, Air Conditioning (HVAC) System

1. Create procedures for filter replacements and cleaning.
2. Perform sanitary surveys of fresh air intakes at least once per year to ensure minimum impact from any possible sources of pollution, including fugitive dust from construction sites, obnoxious odors, etc.
3. Ensure all systems are working properly.
4. Verify that cooling towers meet the proper setback distance from fresh air intakes.
5. Clean and disinfect tower trays routinely with adequate disinfectant residuals.

E) Construction:

1. Ensure all proper permits are obtained.
2. Minimize fugitive dust from construction sites.

F) Sink "Splash"

1. Install plastic or plexiglass "Splash Guards" at the sinks in the NICU to minimize water splash onto surrounding environmental surfaces adjacent to patient care areas.
2. Clean these splash guards as per NICU protocol when sinks and surrounding areas are cleaned.
3. Establish a buffer zone of at least 3 (three) feet surrounding the sinks where no equipment is placed or stored, especially any equipment dedicated to patient care use.
4. If none of the above measures seem to work, then consider relocating the sinks to an area of the unit away from patient care areas and equipment used for that purpose to minimize splash that could possibly contaminate sensitive surfaces and equipment.

G) Sharing of Report

1. A copy of this report has been shared with the Agency for Health Care Administration (AHCA).
2. A copy of this report has been shared with Miami Children's Hospital.

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