

Bacterial Colonization of Home Nebulizers Used by Children With Recurrent Wheeze

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Objective: To look for bacterial colonization of parts of home nebulizers used for children with recurrent wheeze and asthma. **Methods:** Children aged 1 mo-12 y, using home nebulizers for recurrent cough and wheeze were enrolled from May to October, 2019. Caregivers were administered a structured questionnaire by a single researcher, during their hospital visit, to elicit information on their nebulizer cleaning practices. Samples were taken from nebulizer medicine chamber and tubing for bacterial culture and sensitivity. **Results:** Bacterial growth was observed in 17 culture samples obtained from medicine chamber and/or tubing of nebulizers used by 12 (20.3%) out of the 59 enrolled children. The bacteria isolated were *Klebsiella pneumoniae*, *Pseudomonas aeruginosa* and *Staphylococcus aureus* (Methicillin resistant *S. aureus* and Coagulase negative staphylococci) and these were resistant to many of the commonly used antimicrobials. Almost 20% parents had never cleaned the nebulizers. Diluent re-use was significantly associated with bacterial colonization of nebulizer parts [AOR (95% CI) 20.6 (2.26-188.5); $P=0.007$]. **Conclusion:** Home nebulizers, if not cleaned properly as per set protocols, may get colonized with potentially harmful bacteria. There is a need to increase awareness about their proper use amongst parents of children with recurrent wheeze.

Keywords: Asthma, Contamination, Domiciliary, Infection.

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The home use of nebulizer has expanded in recent times from indications of chronic respiratory diseases like cystic fibrosis to more common conditions like asthma and recurrent wheezing in infants and toddlers [1]. However, not enough evidence is available for their safety for home use. Being medical devices, their use is covered under Infection Prevention and Control guidelines, which recommend that cleaning of these devices should involve removal of drug residues, dirt, and microbes [2]. Protocols have been formulated and published by various professional organizations for the proper use of these devices [2,3]. However, there are inconsistencies amongst the guidelines published. Another challenge is lack of awareness regarding the existence of these protocols amongst manufacturers, health personnel and users. Moreover, much of the home use in otherwise healthy children is based on over-the-counter purchase of these devices [4], so caregivers may not be receiving any instructions on proper usage and maintenance of these devices, setting the stage for colonization with potentially harmful microbes. It has been shown that in the hospital setting, bacterial contamination of nebulizers is clearly associated with nosocomial pneumonia [5-8]. Also, inhalation of aerosols contaminated with gram-negative bacteria generated from home use nebulizers in cystic fibrosis

patients have been shown to act as primary route of bacterial colonization of lung [9-11]. Studies in adult COPD (chronic obstructive pulmonary disease) patients using domiciliary nebulizers have shown a high prevalence of bacterial contamination which was difficult to eradicate with the recommended washing methods, possibly due to formation of biofilms, and a higher probability of exacerbations in patients using contaminated nebulizers [12].

Invited Commentary: Pages 365-66.

In children, most of the research work on colonization of home nebulizers has been done in patients of cystic fibrosis; whereas, almost 50% of children under six years suffer from at least one episode of wheeze [13]. As use of domiciliary nebulizers in this group of children is common [4], we conducted this study to ascertain their safety so that remedial measures can be undertaken.

METHODS

This descriptive study was conducted in the outpatient department of a tertiary care hospital after approval by institutional ethics committee. Between May to October, 2019, caregivers of children aged one month to 12 years presenting with history of recurrent cough, wheeze and asthma were asked about use of home nebulization. Eligible

children were enrolled after taking parental consent. Patients diagnosed as cystic fibrosis, primary ciliary dyskinesia, immunodeficiency disorders and those who had been diagnosed to have pneumonia within last four weeks were excluded from the study. Caregivers of all enrolled children were asked to bring their devices along with tubing and medicine chamber at next visit. The equipment was examined for visible dirt and moisture; samples were collected from the nebulization chamber by rotating a swab moistened with sterile saline, and from tubing by flushing it with saline collected in sterile container. The collected samples were sent immediately to the microbiology laboratory. These were processed as per standard protocol on liquid medium, Brain heart infusion broth (BHIB) and solid medium, blood agar and MacConkey agar. All the cultures were incubated at 37°C for 24 hours. BHIB was observed for turbidity next day and if turbid, sub-culturing was done on solid media. All the isolates obtained were identified as per micro-biological techniques. The antibiotic sensitivity was done as per CLSI (Clinical and Laboratory Standards Institute) guidelines [14]. The parents were administered a questionnaire on device cleaning and maintenance procedures being followed by them.

Considering the expected contamination rate as 65%, similar to a previous study [15], assuming 95% confidence interval and 13% deviation for absolute precision, sample size of 52 was determined.

Statistical analysis: Comparison of various parameters between devices colonized and those not colonized with bacteria was done with Chi-square or Fisher exact test for categorical variables. Significance was defined as *P* value <0.05. Analysis was done using Stata/MP 14.0 software.

RESULTS

A total of 59 patients (66% boys) were enrolled in this study, majority (72.8%) of whom were younger than 6 years [median (IQR) age, 80 (55-108) months] (**Table I**). All enrolled patients were using jet nebulizers, 38.9% for more than a year. At least one previous episode of fever and fast breathing with wheeze was reported by 21 (35.6%), of which 10 required hospitalizations, but it was unclear whether the episodes qualified as pneumonia or just a viral infection associated with wheeze. Eleven (19%) parents used nebulizers on advice of friends/family, while the rest were advised by a doctor; out of which only 15 (31.2%) received cleaning instructions from the advising physician.

Reuse of the same medicine bottle beyond one day was seen in 12 (20.3%) patients and never in 42 (71.3%). Out of these, five had re-used the bottle during the same episode of wheezy illness while the remaining had reused the bottle opened for the previous episode. Normal saline was used as

diluent for medications by 25 patients, while one used tap water. Most of those who cleaned the nebulizer (*n*=12), used water alone or soap and water to wash the tubing and chamber.

Out of a total of 118 samples, 17 had positive bacterial culture from 12 (20.3%) nebulization sets (6 samples from medicine chamber, 11 from nebulizer tubing). We found a predominance of gram-negative bacteria on culture, out of which the most frequent isolates were *Klebsiella pneumoniae* (*n*=6/17) and *Pseudomonas aeruginosa* (*n*=5/17). Most isolates were resistant to third generation cephalosporins while being sensitive to amikacin, piperacillin-tazobactam and imipenem. Other isolates included *Staphylococcus aureus*, Methicillin resistant

Table I Characteristics of Children With Recurrent Wheeze Using Home Nebulizers (N=59)

Characteristic	No. (%)
Father's education (below 10th standard)	7 (12)
Mother's education (below 10th standard)	11 (19)
<i>Child nebulized by</i>	
Mother	35 (59)
Father	7 (12)
Both parents	10 (17)
Relative	7 (12)
<i>Nebulizer use advised by</i>	
Doctor	48 (81)
Friends and relatives	11 (19)
Read the instruction manual	17 (28.8)
<i>Re-use of diluent bottle, ^an=25</i>	
Never	8 (32)
Beyond 1 day	17 (68)
<i>Re-use of syringe, ^bn=18</i>	
Never	1 (5.6)
Within same day	1 (5.6)
Beyond 1 day	16 (88.9)
<i>Cleaning of nebulizer</i>	
After every use	32 (54.3)
Occasionally	15 (25.4)
Never	12 (20.3)
<i>Part of nebulizer cleaned, n=47</i>	
Only mask	21 (44.7)
Mask and medicine chamber	15 (31.9)
Mask, medicine chamber, tubing	11 (23.4)
<i>Drying the tube after use</i>	
After every use	39 (66)
Sometimes	13 (22.2)
Never	7 (11.8)
<i>Handwashing before nebulization</i>	
Before every use	46 (78)
Sometimes	12 (20.3)
Never	1 (1.7)

^aNone reused diluent within the same day; ^bonly 18 used syringes.

S. aureus, Coagulase negative staphylococci and *Citrobacter koseri*.

The only significant associations of colonization of nebulizer device were found with 'past history of fever with fast breathing' and diluent re-use on univariate analysis, and only diluent re-use [AOR (95% CI) 20.6 (2.26-188.5); $P=0.007$] on multivariate analysis.

DISCUSSION

It was observed that a high proportion of nebulizer devices used for home nebulization in healthy children with recurrent wheeze were colonized with potentially pathogenic bacteria, most of which were resistant to several commonly used antimicrobials. The spectrum included organisms usually associated with nosocomial infections, despite only domiciliary use of these devices.

The current study is one of the first attempts to learn about the nebulizer use and cleaning practices in otherwise healthy children in our country. The limitation of the study is that we have only looked for bacterial colonization, whereas fungi may also colonize the damp parts of the device. Another limitation is that this study does not conclusively tell us whether colonization of the device resulted in colonization of the patients' respiratory passages or in increased risk of respiratory infections.

High rates of bacterial colonization of home nebulizer devices have been reported earlier. Barnes, et al. [16] observed bacterial contamination in 35% home nebulization units, while Cohen, et al. [15] reported a rate of over 65%, figures much higher than the 20% rate observed by us, but with a similar spectrum of microbes being isolated. Both studies had few differences which could have accounted for a higher colonization rate reported by them, like composition of patient population and sites of sampling for culture.

A nebulizer generates very small particles (1-3 microns) which reach the terminal bronchioles and alveoli and may cause delivery of microbes to distal airways, if the device is contaminated. In children, this may result in respiratory infections due to an immature immune system. Whether this risk is real, needs to be evaluated by well-designed studies on this aspect, but more important is the need to generate awareness about balanced decision regarding the appropriate home-use device, and proper use and care of the nebulizers used at home.

Ethics clearance: IEC, GMCH, Chandigarh; No. GMCH/IEC/2019/348, dated May 29, 2019.

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