

Commentary

Critical analysis of common canister programs: a review of cross-functional considerations and health system economics

Trent Larson

Banner Health, Mesa, AZ, USA

Ravindra Gudavalli Dean Prater

Banner Health MD Anderson Cancer Center, Gilbert, AZ, USA

Scott Sutton

The Microbiology Network Inc., North Chili, NY, USA

Address for correspondence:

Trent Larson PharmD BCPS, Banner Desert Medical Center, 1400 S. Dobson Road, Mesa, AZ 85202, USA.
trent.larson@bannerhealth.com

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Abstract

Respiratory inhalers constitute a large percentage of hospital pharmacy expenditures. Metered-dose inhaler (MDI) canisters usually contain enough medication to last 2 to 4 weeks, while the average hospital stay for acute hospitalizations of respiratory illnesses is only 4–5 days. Hospital pharmacies are often unable to operationalize relabeling of inhalers at discharge to meet regulatory requirements. This dilemma produces drug wastage. The common canister (CC) approach is a method some hospitals implemented in an effort to minimize the costs associated with this issue. The CC program uses a shared inhaler, an individual one-way valve holding chamber, and a cleaning protocol. This approach has been the subject of considerable controversy. Proponents of the CC approach reported considerable cost savings to their institutions. Opponents of the CC approach are not convinced the benefits outweigh even a minimal risk of cross-contamination since adherence to protocols for hand washing and disinfection of the MDI device cannot be guaranteed to be 100% (pathogens from contaminated devices can enter the respiratory tract through inhalation). Other cost containment strategies, such as unit dose nebulizers, may be useful to realize similar reductions in pharmacy drug costs while minimizing the risks of nosocomial infections and their associated medical costs. The CC strategy may be appropriate for some hospital pharmacies that face budget constraints, but a full evaluation of the risks, benefits, and potential costs should guide those who make hospital policy decisions.

Introduction

Over 1 million hospitalizations occur each year in the US due to an acute exacerbation of chronic obstructive pulmonary disease (AECOPD) alone, aside from other respiratory disease. Short-acting and long-acting bronchodilators, anticholinergics, and corticosteroids are typically administered to these patients during their inpatient stay and are delivered via metered dose inhalers (MDIs), dry powder inhalers (DPIs), or nebulizers. When used by a single patient, at FDA-approved dosing, MDI canisters typically contain enough medication to last 14 to 28 days¹. However, the average length of hospital stay for AECOPD is only 4 to 5 days^{1,2}. Many hospital pharmacies don't have the ability to operationalize relabeling procedures for inhalers at discharge to meet state-by-state regulatory requirements. Therefore, hospital pharmacies often see a significant amount of these canisters returned to the pharmacy, which then must be disposed of (i.e., pharmacy medical waste). This leads to questions as to the disposition of the remaining medication and the cost of waste. Respiratory inhalers account for a large portion of expenditures in hospital pharmacies and drug wastage within this category can lead to high cost burdens³.

From the authors' perspective, at one of our larger system facilities (549 beds), a 1 week internal evaluation of patient-specific medication use (albuterol,

ipratropium, tiotropium, fluticasone, albuterol/ipratropium, and fluticasone/salmeterol) administered via MDI or dry powder inhaler (DPI) found that only 11.3% of the total drug available in the inhalers (i.e., those devices returned to the pharmacy for disposal at discharge) was utilized. The other 88.7% was discarded. To put this in perspective, using internal acquisition cost data, the discarded drug was equivalent to \$270,108 annualized. The average length of stay for these patients was 5.04 days. This degree of wastage has been recently reproduced by Sakaan and colleagues at the University of Tennessee who found that 87% of the total MDI or DPI doses dispensed were wasted costing the hospital approximately \$86,973⁴.

The common canister (CC) approach is a method some hospitals have adopted in an effort to minimize medication-related waste and associated costs. Adopters of the CC approach have been able to realize considerable cost savings to their institutions by minimizing waste^{3,5}. A study conducted at a 250-bed hospital in Sellersville, PA found savings of about \$75,000 in 1 year by switching to a CC protocol¹. Ehlers *et al.*⁶ conducted a study that reported a 58.3% overall decrease in MDI usage with the CC approach and saved approximately \$69,000/year using the protocol. Liou and colleagues⁷ achieved an 80% decrease in usage and a corresponding drug savings of \$130,000 over approximately 6 months. The University of Colorado Hospital reduced usage of MDIs 43% and achieved a cost savings of \$303,000 in 1 year, although an additional respiratory therapist needed to be hired to support the program⁸. Supporters of the CC approach suggest that staff efficiency is increased with one canister for many patients resulting in fewer treatment delays, respiratory therapy can reinforce improved inhaler technique, and cross-contamination is unlikely if the proper disinfection method is followed^{3,5,8}.

It is important to note that the CC protocol is not typically used for patients in isolation and is rarely used for those on mechanical ventilation⁵. Other populations that should likely be considered for exclusion are those who have undergone transplant, the immunocompromised, or those with cystic fibrosis⁸. These patients may be at an increased risk of contracting healthcare-associated infections (HCAI). For instance, patients on ventilators have been shown to have an increased risk of contracting ventilator-associated pneumonia simply from alcohol-free mouthwash⁹.

The CC approach was first described in the late 1990s but has been the subject of considerable controversy since¹⁰⁻¹². Unfortunately, well designed and published studies showing the benefits and risk of cross-contamination of the CC program are lacking³. Further, methodologically rigorous studies supporting a causal inference (or lack thereof) have not been available to date. Based on the available literature, cross-contamination rates may be as

high as 5%¹. Several factors need to be considered before a hospital can implement a CC protocol.

Literature review of common canister protocols and potential colonization

The most recent review by Neel and Tauman³ outlined 10 infection risk studies conducted using the CC protocol^{11,13-18}. One of these studies found cross-contamination with potentially pathogenic bacteria typically found in the respiratory tract¹⁸. Some of the studies found positive culture results grew coagulase-negative *Staphylococcus*^{13,17}, *Enterococcus*¹¹, and common hospital environmental contaminants, while another reported the presence of Enterobacteriaceae¹⁸.

The investigators from these 10 studies as well as Neel *et al.*³ considered the CC program to be safe if a multidisciplinary-developed protocol was precisely followed at all times. However, this evidence is relatively weak as it comes from conference posters and papers, not peer-reviewed publications¹⁹. The primary question of inferring a causal link between CC and hospital-acquired pneumonia (HAP) is therefore neither substantiated nor refuted to date.

While not the CC protocol per se, Liou and colleagues⁷ conducted a study at the Saint Elizabeth Regional Medical Center that evaluated the safety of recycled MDIs. The facility had implemented a rigorous MDI cleaning procedure, which involved spraying the MDI mouthpiece with compressed air, cleaning the entire MDI with 70% isopropyl alcohol, and allowing to air dry before returning it to the pharmacy stock. The investigators conducted bacterial tests of at least 10% of MDIs from three categories each month: prior to pharmacy cleaning (17 MDIs), after pharmacy cleaning (33 MDIs), and new/unused control (33 MDIs). A secondary evaluation was performed using artificially contaminated MDIs (*Pseudomonas aeruginosa*, methicillin-resistant *Staphylococcus aureus* (MRSA), *Stenotrophomonas maltophilia*, and *Haemophilus influenzae*) that had been subjected to the institutional cleaning procedures. The samples were cultured for 48 hours. No bacterial growth was noted on any of the MDIs from any of the three categories. However, the authors acknowledged their swab culture method had a sensitivity of 0.01 mL (<100 colony-forming units [CFU]/mL) and was not designed to detect fungal, viral, or slow-growing bacterial pathogens. This limited the ability of the study to assess the risk of cross-contamination from those organisms. Despite these limitations, the authors concluded their strict quality control program and rigorous cleaning procedures were effective. However, their admission that viral spread could not be detected is in reality another important issue that should be raised. The authors of this paper are

unaware of any CC data that addresses viral cross-contamination.

A study is currently being conducted to compare the CC protocol with the use of individual MDIs on infection rates (pneumonia) in patients on mechanical ventilation²⁰. The Association for Professionals in Infection Control and Epidemiology (APIC) has put their MDI Common Canister Protocol initiative on hold pending the publication of relevant studies.

Practical considerations

The authors of this paper are aware of at least two separate institutions using the CC protocol where respiratory therapists have placed an isolation patient's inhaler back into the automated medication dispensing machine for reuse instead of pulling it out of circulation (personal communication). In one of those instances, involving an MRSA isolation patient, the canister was subsequently administered to other patients for approximately 24 hours before this issue was discovered. At that point, several patients had to be isolated and monitored. No observed cross-infections were noted, but this was still considered costly. A third reported inadvertent CC administration in a bone marrow transplant unit that should have been excluded. Additionally, respiratory therapists have been known to carry CC MDIs in the pockets of their lab coats instead of placing them back in the automated medication dispensing machine as per protocol. It is these 'breaks' in protocol that are concerning and raise the valid question as to whether healthcare professionals can be trusted to routinely follow the infection control protocols that are put in place to protect patients.

Hospitals may need to plan for the following: are there contingency plans in place for patients who receive the CC protocol after microbiological cultures from previous patients are determined positive? Are these patients then put in isolation? More importantly, what is the true risk of transmission of various organisms when a common canister is used on a patient in whom it took 48 hours or more to culture positive and subsequently become 'isolated'?

Regulatory considerations

The CC protocol is a subset of concurrent therapy. In respiratory therapy, concurrent therapy occurs when one therapist administers treatments utilizing small volume nebulizers (SVNs), metered dose inhalers MDIs, or intermittent positive pressure treatments to multiple patients simultaneously. The Joint Commission (TJC) considers concurrent therapy/CC to be "a problem"²¹. According to TJC, if concurrent therapy is to be considered there must be a clear indication for it and a policy and procedure

in place to govern its application. Policies for the administration of concurrent therapy need to include consideration of the assessment for appropriateness (including frequency) of the order, patient's location within the facility, cognitive status, understanding of therapeutic goals, coordination, attitude, tolerance of the therapy, and ability to cooperate with the therapy. The Tennessee Board of Respiratory Care, for example, discourages the use of concurrent therapy/CC. According to their position statement, "patient safety is the primary reason for respiratory therapists not to deliver care via concurrent therapy without a thorough patient assessment. Indiscriminate use of concurrent therapy may lead to declines in quality and may jeopardize patient safety"²¹.

Cross-contamination risk

There could be serious cross-contamination risk if the protocol for disinfecting the nozzle is not followed 100% of the time⁵. Pathogens can enter the lower respiratory tract through the inhalation of aerosols generated by contaminated respiratory-therapy equipment^{22,23}. Nosocomial infections (e.g., hospital-acquired pneumonia [HAP], healthcare-associated pneumonia [HCAP]) are some of the most serious patient safety issues facing the healthcare system today²⁴.

The risk of hospital-acquired infections could be mitigated by good hand washing along with wiping down the canisters with alcohol swabs. However, if members of the staff are not compliant with hand hygiene between patients, one should consider how compliant they will be with cleaning the mouthpiece after every patient use⁵. It is apparent that healthcare practitioners do not follow the appropriate procedures at all times⁵. This issue was also suggested from a study on the contamination of glucose test strips²⁵. Covert observation studies show that hand hygiene protocol adherence varies widely from 5% to 89% and is generally poor^{26,27}. The World Health Organization (WHO) estimates the overall average at 38.7%²⁶. Risk factors for non-adherence to hand washing procedures include: observed factors such as working in intensive care (duration of contact with patient ≤ 2 min); self-reported factors such as skin irritation and dryness, being too busy; perceived barriers including the fact that their institution did not put a high priority on hand washing²⁶.

To underscore this importance, hand hygiene failure is the leading cause of HCAs and the spread of multidrug resistant organisms²⁶. Contaminated healthcare workers' hands contribute significantly to endemic HCAs and outbreaks of HCAs²⁶. The duration of hand washing episodes varies widely among healthcare workers (e.g., from 6 to 30 seconds)²⁶. Numerous hospital-based studies have evaluated the impact of hand hygiene on the risk of developing

HCAIs²⁶. Most of these have demonstrated a correlation between the improvement in hand hygiene practices and reduced infection and cross-contamination rates. Won *et al.*²⁸ found respiratory tract infection rates decreased in their neonatal intensive care unit from 3.35 to 1.06 per 1000 patient days as a result of a campaign to increase hand-washing awareness ($p = 0.002$). In addition, a significant correlation was found between nosocomial infection of the respiratory tract and hand washing compliance ($r = -0.385$; $p = 0.014$).

WHO cites the prevalence of HCAIs at approximately 4.5% in the US²⁶. A recent CDC study of 11,282 patients found pneumonia and surgical site infections to be the most common HCAIs in the US, each accounting for 21.8% of the total number of infections²⁹. In addition, device-associated infections (such as ventilator-associated pneumonia, central-catheter-associated bloodstream infections, catheter-associated urinary tract infections), which have previously been the focus of programs to prevent HCAIs, accounted for 25.6% of HCAIs. Therefore, a 5% rate of cross-contamination may be unacceptable due to the high volume use of MDIs and the frequency of repeated exposures for patients who use the devices as part of a CC program.

Contamination risk of other medical devices

Focusing on contamination of spacer devices, bacterial contamination was reported in 22 reservoirs (35.5%) and 16 masks (25.8%) from spacer devices used by 62 asthmatic children³⁰. The investigators isolated *Pseudomonas aeruginosa* from 21.0% of the reservoirs and 14.5% of the masks, *Klebsiella pneumoniae* from 6.5% and 4.8%, and *Staphylococcus aureus* from 9.7% and 8.1%, respectively. Another report from the Netherlands, on spacers of 64 children, found that 24 (38%) had become contaminated with *Bacillus* sp. and *Pseudomonas aeruginosa*³¹. Interestingly, spacers, cleaned according to the national guidelines, were just as contaminated as those that were not. De Vries and colleagues³² evaluated the growth of several respiratory pathogens on spacer devices. Common respiratory pathogens and *Candida albicans* were applied to three different spacer devices (18 total devices) and to Petri dishes in the presence or absence of corticosteroids. After 24 hours of culture 39% had *S. aureus*, 67% had *P. aeruginosa*, and 28% had *C. albicans*. In addition, the authors found that colonization of metal spacers was lower than that of polyethylene or polycarbonate spacers. It must be noted that these spacers were artificially inoculated with large numbers of microorganisms, but the study clearly shows the potential for spacers to

support microbial survival and potentially even support microbial growth.

One of the difficulties of these types of studies is the establishment of a causal relationship. While one can show these devices are capable of serving as fomites, and they do become contaminated in use, to date one is not able to demonstrate the use of a contaminated CC resulting in illness. Exposing patients in need of nebulizers or medical devices and diagnostics to deliberately contaminated devices to monitor rates of infection is not an ethically acceptable study. Therefore, all such studies have a significant number of assumptions incumbent in the design. A major assumption in all such studies is that if the device is demonstrated to be capable of serving as a fomite, then it must be assumed that illness can result from repeated exposure to that risk. Support for this assumption in other related situations can be cited.

From a broader perspective, the cross contamination of medical devices has been observed in other disease states. The Infection Control Recommendation for Patients with Cystic Fibrosis points out that respiratory therapy devices are potential vehicles for the transmission of infectious organisms from patient to patient³³. Aitken and colleagues³⁴ study assessed the potential risk of pathogenic growth (*P. aeruginosa*, *S. aureus*, MRSA, *Candida*, *Aspergillus*, *Burkholderia*, *Stenotrophomonas*, as well as some species of yeasts and coliform bacteria) in 85 mannitol inhalers of 34 cystic fibrosis patients after 1 week of twice daily use. Growth was detected in one device from each of three patients. However, none of these patients experienced pulmonary exacerbations during the 6 month study period. A letter to the editor described a small pilot study of 31 devices (including 28 MDIs)³⁵. Eighteen of the culture samples showed no growth, while seven showed upper respiratory tract flora, six grew coagulase-negative *Staphylococci*, and one grew *Staphylococcus aureus*. The investigators suggested that these results demonstrated that common respiratory tract pathogens typically do not colonize the device mouthpieces, but based on these results colonization can still occur.

A recent FDA drug safety communication has officially addressed the potential cross contamination issue of another shared medical device. In an attempt to minimize the risk of spreading infections via shared multi-dose diabetes pens, which were originally intended for single patient use, on February 25, 2015 the FDA announced that it now requires label warnings prohibiting the sharing of these devices even if the needle is changed out. The safety alert makes the following statement that “no confirmed cases of actual infection transmission have been reported, but sources of infection are often difficult to identify and may go unreported”⁴⁸. This is analogous to the potential patient safety issues that accompany CC especially if breaches in the infection control protocol occur.

Nosocomial pneumonia and potential costs

Bacteria from contaminated devices can enter the respiratory tract through inhalation³⁶. In recent years, pneumonia has been cited as the second most common nosocomial infection (accounting for 14% to 20% of all nosocomial infections), after urinary tract infections^{36–38}. Pneumonia has the potential to prolong hospital stays by 4 to 9 days and it is associated with the highest mortality rates (20% to 50%) of any type of nosocomial infection^{36–38}. These rates can spike even higher when the infection is caused by high-risk pathogens^{39,40}.

A study published in 2014 by the CDC²⁹ involved surveys that were conducted in 183 hospitals (patient data from 2011). Of 11,282 patients in the study, 452 (4%) had one or more HCAs. Of the 504 such infections, the most common types were *pneumonia* (21.8%) and surgical-site infections (21.8%). Overall, device-associated infections (e.g., ventilator-associated pneumonia, etc.) accounted for 25.6% of such infections. Interestingly device-associated infections have historically been the focus of HCAI prevention programs. These data highlight the prevalence of nosocomial pneumonia within HCAs.

Any apparent cost savings from the CC protocol may be lost if infection occurs. A CDC study estimated \$35.7 billion to \$45 billion in 2007 as the overall annual direct medical costs of HCAs to US hospitals⁴¹. One case of HAP was estimated to cost \$46,400. This expense could easily offset any cost savings from the CC protocol, depending on how many cases occurred⁴². It is clear that HAP is responsible for considerable economic losses to healthcare institutions.

Potential cost of cross-contamination versus alternative methods of drug delivery

To the best of the authors' knowledge, there are no published economic evaluations establishing the cost consequences of the common canister approach. Using Chronic Obstructive Pulmonary Disease (COPD) as an example, comparing the common canister (CC) approach to nebulization, the impact of the CC protocol can be estimated using a simple economic model (personal communication). From the published literature, the average length of stay for a hospitalized acute exacerbation of COPD patient is 4 to 5 days. Because most canisters have a 30 day drug supply and these may be the best to use as common canisters, each canister would be used by a maximum of seven patients. In this scenario, the average per patient cost with the common canister would be between \$25 and \$30 (at a canister cost of \$150 and a spacer cost of

\$5). It is assumed that each patient would receive an individual spacer. A nebulized drug, such as arformoterol, is available in unit dose formulation. The cost of treatment per patient during hospitalization is estimated at \$58.32 (8 units of drug). Since hospitals are equipped with nebulizer devices, a separate nebulizer device cost is not applicable. Based on the previous literature^{1,11,13–18} and expert opinion, conservatively there may be a 2% incremental cross-contamination risk with the use of the common canister approach.

Assuming costs for respiratory therapists, nurses, etc. are similar between the two treatments, the cost savings per patient with the CC protocol compared with the nebulized agent would be \$31.32 (using CC cost of \$27). However, when estimating the impact of one additional hospital day due to cross-contamination per 1000 hospitalizations (20 hospital days × \$1700 as average DRG for hospital day⁴³ = \$34,000), the model demonstrates an actual net loss of \$2680 using the CC protocol.

$$\begin{aligned} & \$31,320(\$31.32 \times 1000) - \$34,000(20 \times \$1700) \\ & = -\$2680 \end{aligned}$$

In order to achieve a net cost savings with the CC approach, the incremental nosocomial infection rate using this model would need to be <1%. Considering the generally poor compliance regarding hand hygiene and other aseptic procedures, can this rate be consistently achieved without other effects on efficiency and costs?

Alternative approaches to pharmacy cost reductions and preserving patient safety

Clinicians need to consider that the financial impact of the common canister program vs. optional drug delivery methods will vary depending on which inhaler is being evaluated. The albuterol/ipratropium (100 µg/20 µg) MDI is a good example. Depending on an institution's

Table 1. Comparative drug/supply costs of nebulized albuterol/ipratropium vs. common canister^a.

Cost Considerations	Nebulization	Common Canister
Alb/Ipr ^b	\$4.32	\$29.33
One-way valved spacer device ^c	N/A	\$4.81
Standard Neb tubing/mask ^d	\$0.81	N/A ^e
Breath-Activated Neb (BAN) tubing/mask ^d	\$2.86	N/A ^e

^aAssumes 4 day length of stay, QID dosing; internal acquisition prices as of 19 January 2015.

^bSVN (3 mg/0.5 mg) \$0.27/dose; Combivent Respimat (100 µg albuterol/20 µg ipratropium bromide) MDI, 120 inhalations per canister, \$220/MDI or \$1.83/dose.

^cRespironics Optichamber; assumes one spacer per patient per admit.

^dSVN tubing: assumes one tubing set used per patient per admit.

^eAssumes no concomitant respiratory meds delivered via nebulization.

Table 2. Common canister checklist: suggested considerations for evaluation and implementation^{3,7}.

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- ✓ Full analysis comparing all respiratory medication administration models to optimize patient safety and cost savings for an institution and/or health system
 - ✓ Inhaler formulary review to determine inclusion, canister size to be stocked, and any necessary therapeutic interchanges (i.e., dry powder inhalers cannot be used in CC protocol)
 - ✓ Determine information technology (IT) process to allow for appropriate 'per-puff' or 'individual canister' patient charges
 - ✓ One-way spacer device selection
 - ✓ Inhaler storage options
 - ✓ Dose tracking mechanism if needed (i.e., Inhaler Mate, PuffMinder DOSE, etc.)
 - ✓ Determine patients to be excluded from CC (considerations include isolation, mechanically ventilated, transplant, immunocompromised/neutropenic, and cystic fibrosis patients)
 - ✓ Initial and revolving education of pharmacy, nursing, respiratory therapy, and physician staff with particular emphasis on respiratory infection control protocols to capture new respiratory employees and assure 100% compliance
 - ✓ Policy to address concurrent therapy
 - ✓ Once monthly random cultures of CC MDI mouthpieces to test for cross-contamination
 - ✓ Ongoing infection control department monitoring of institutional nosocomial and MRSA infection rates post-implementation to compare against baseline
 - ✓ Monitoring system in place to detect potential spread of infection from delayed isolation patients who had canisters used on other patients
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contract pricing the cost of this inhaler can be approximately \$220 for a 120 dose canister or \$1.83 per inhalation. Using the standard recommended dosage regimen of one inhalation four times daily (QID), direct drug costs will be \$7.33/day utilizing CC. Contrast this to the option of nebulized generic albuterol/ipratropium (3 mg/0.5 mg), which can cost as little as \$0.27/unit to an institution or ~\$1/day using equivalent QID dosing (86% lower). Patient-specific SVN tubing (standard or breath-activated) is generally less expensive than spacer devices and can also be used the length of the entire admission unless soiled (Table 1)^{44,45}. Respiratory therapists should be involved in the drug delivery process regardless of which system is used (CC vs. SVN); so staffing costs are assumed to be similar, although that may be disputed. Using the patient-specific SVN approach, however, can minimize the cross-contamination risks and also capture the patient populations that should be excluded in any CC program.

Methods to reduce pharmacy costs not associated with an increased risk of nosocomial pneumonia infection similar to the above illustration have been proposed by others. The pharmacy department at East Orange General Hospital evaluated alternatives for long acting beta agonist/corticosteroid (LABA/Cort) MDIs⁴⁶. This facility had a large elderly population with difficulties self-administering MDIs. Arformoterol and budesonide (AFOR/BUD; both available in a nebulized solution form) were selected as the alternative to LABA/Cort MDIs. The nebulizers were

available in unit doses, stocked in the institution's automated dispensing cabinet, and supplied as 7 day containers that were dispensed by the hospital's pharmacy. Even though the *daily* cost of AFOR/BUD was greater than that for LABA/Cort MDIs (\$21.00/day vs. \$10.00 to \$12.50/day, respectively) the overall cost savings to the institution were \$18,418/year (a 48% cost reduction) after making the therapeutic substitution. Cost savings were attributed to the elimination of both waste and lost inhalers. No treatment failures or serious adverse events (AEs) were reported in the 1.5 years since the substitution had been implemented.

After reviewing several alternative products, pharmacists at an Ascension hospital in Detroit switched from MDIs to a multiuse nebulizer⁴⁷. As a result of this change, the average cost per patient dropped from \$191 with MDIs to \$46 with the nebulizer. The cost savings between \$870,000 and \$1.7 million are predicted based on a 50% to 100% system-wide conversion (Ascension Health) to the new nebulizers.

Conclusions

The common canister strategy may be appropriate for hospital pharmacies to cut costs, but full evaluation of the risks, benefits, and potential costs of healthcare-associated pneumonia should guide hospital decision makers. Table 2 offers considerations when evaluating the CC protocol. Patient safety must always be the most important concern. Cross-contamination risk aside, recent issues with emerging infectious diseases (e.g. Ebola) provide a reason for further pause as even less is known regarding the risk of potential viral spread. Other cost containment tactics may be useful to realize similar reductions in pharmacy costs while minimizing nosocomial infections. For patients who would benefit most from nebulized therapy, cost savings of similar magnitudes could be realized without the associated risks⁴⁷.

Transparency

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Declaration of financial/other relationships

T.L., R.G., and D.P. have disclosed that they have no significant relationships with or financial interests in any commercial companies related to this study or article. S.S. has disclosed that he has been a consultant to Sunovion Pharmaceuticals.

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