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RESEARCH ARTICLE

Unique Motivational Initiative to Avoid Misuse of Used ETO Gas Cartridges in a Healthcare Institution and Enhance Revenue Generation Out of Waste

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ABSTRACT

Background: The Central Sterile Services Department (CSSD) is a critical unit in any healthcare institution, ensuring that all reusable medical items are rendered free of microorganisms before patient use. Ethylene Oxide (ETO) gas sterilization is widely employed for heat- and moisture-sensitive items, but improper handling or misuse of used ETO cartridges can compromise infection control practices and pose safety hazards.

Objective: This study presents a simple, unique, and cost-effective initiative implemented in the CSSD to prevent misuse and adulteration of used ETO gas cartridges, while simultaneously enhancing revenue generation through structured waste segregation.

Methods: The initiative involved segregating the aluminum body and mild steel cap of empty ETO gas cartridges. Multiple methods—hammering, angle grinder, chop saw, and cutting plier—were evaluated, and the nail puller was identified as the most effective, safe and replicable tool for separating the two metal components. The process was incorporated into routine CSSD workflow without affecting sterilization efficiency or manpower distribution.

Results: A monthly generation of approximately 150 used ETO cartridges enabled significant material recovery. Removing the mild steel cap not only eliminated the possibility of refilling and adulteration of empty cartridges by external vendors but also doubled the scrap value, from ₹70/kg to ₹150/kg due to metal segregation. The initiative also strengthened compliance with infection control and occupational safety guidelines.

Conclusion: This low-cost, zero-waste initiative successfully integrated sustainability into healthcare sterilization practices. By preventing cartridge misuse, improving resource recovery, and supporting infection control protocols, the intervention demonstrates how simple innovations within CSSD operations can generate measurable economic and safety benefits.

Keywords: Prescription Pattern, Major Depressive Disorder, Anxiety, Escitalopram, Vortioxetine, Sertraline, Antidepressants.

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INTRODUCTION

This Unique, Simple, Cost-effective Initiative in any Healthcare Institution is basically incorporated in a department called the Central Sterile Services department (CSSD). This CSSD department looks into the processing of all surgical instruments, which are used for any surgical procedure, dressing procedure, Suture removal procedure, etc, in any healthcare setting. In a broader view any anything and everything that is used on a patient necessarily gets processed in this department. This department, CSSD, is supposed to be a very important department in any health care setup up and nothing that is going to be used upon a patient can bypass this department. This department is also called "The Heart of the Hospital". Such an important department is this in a healthcare setup. This unique initiative that is taken in this department enables avoiding misuse of used Ethylene Oxide (ETO) empty gas cartridges and contributing successfully to adhering to Infection Control

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Protocols in Ethylene Oxide Gas Sterilization, apart from enhancing revenue generation out of waste.

Would like to appraise on the important functions and process methods that happens in this important department so that it will give an insight into the usage of an important consumable like the Ethylene Oxide gas cartridge that is used in this departmental process to effectively do the Infection control and Quality control in any healthcare institution successful. These CSSD processes that are mentioned below are non compromisable and we cannot and should not cut corners in any of the steps that are to be followed diligently to get a Quality end result.

METHODS

CSSD, or the Central Sterile Services Department, is a very important department in any healthcare setup. In this department, anything & everything that is used on the patient has to necessarily go through this department for reprocessing before it is used on another patient. This department makes all the items that are to be used on a patient free from any invisible microorganisms. Visible microorganisms can be cleaned and removed physically, but it is the invisible microorganisms that also need to be removed and thereby the instrument made microorganism-free.

Location of the CSSD Department, Variable Uses in the CSSD Department and Important Different Zones of a CSSD Department

Acceptable Location:

CSSD is normally located in a central area of the hospital, where accessibility should not become a problem for the user departments

Keeping in mind that all the other departments will be in need of this department's services round the clock [12].

The department should be easily accessible to all the user departments, as all the user departments may be in need of the services of this department round the clock [12]. Such an important department.

Functioning of this department round the clock [12] helps in reducing the otherwise required huge inventory of disposable products in the hospital, which can be safely reprocessed and reused by this important department.

Multiple Processes that happen in the department:

CSSD Services caters to multiple processes that may be required by the hospital.

- Reprocessing of items that are not being used and have bypassed the sterilization expiry date on them, but the quality of the item is good enough to be reused safely.
- Reprocessing of items that have been used on another patient and as per the laid down Hospital Infection Control Policy are good for reuse the second time as well and are well within the protocols documented in the Standard Operating Procedures of the Hospital Reusability Policy.
- Reprocessing of items that are received as clean but unsterile from the vendor. Some of the products used in the hospital are procured unsterilized and sterilized in-house, which may help the purchase section in getting these products at a better and competitive rate and they are reprocessed at the in-house CSSD facility.

Different mandatory Zones in a CSSD

- Unsterile/Unclean or the Receiving Area-Unsterile Zone.
- Packing/Clean Area-Sterile zone with Restricted entry.
- Sterilizing /Clean/Sterile area- Sterile Zone with Restricted entry.
- Sterile Storage/Issue area – Sterile zone with Restricted entry.

The main difference between these above zones is as follows:

Receiving Zone

The Receiving area is always under negative pressure [8] in comparison with the other zones as due to the cleaning process that is undertaken in this zone be it a manual cleaning or a machine cleaning there might be lot of air borne microorganisms in the form of aerosols because of which the duct of other zones in a CSSD has to be separate then the unsterile or the unclean or the Receiving area. In the Receiving area/washing area, the staff working get changed from street dress to hospital dress and also change over from street footwear into departmental footwear.

All the items that are transported from the user departments to this zone will necessarily be transported in a dedicated closed stainless-steel trolley so that cross-contamination does not happen en route. Some of the hospitals do have a dedicated unmanned lift from the OT area to the CSSD, which is called dumb waiters and it connects the OT and CSSD instead of these closed stainless-steel trolleys.

Packing Zone

The Packing or the clean area/Sterile zone will be with a normal air exchange with a positive pressure. In this zone, the staff get changed into clean and sterile clothes. Also, the manpower deputed in the Receiving or Washing area should not be utilized in the Packing/Clean area, nor the staff deputed in the Packing/Clean area should be deputed in the Receiving/Washing area.

Sterilizing Zone

The Sterilizing/Clean/Sterile area will be with a normal air exchange with a facility of high exhaust in the event of a Pressurized steam leak from the Steam Sterilizers. The staff deputed in the Sterilizing area need to be in Sterile/Clean attire always and need to change as amnd when the staff goes out of the zone.

Sterile Storage Zone

The Sterile Storage/Issue area will be with a normal positive pressure with a normal humidity factor incorporated as well. Here, the staff will be in Sterile attire and will be treated as a high-sterile area.

No trespassers will be allowed in all the zones of the CSSD. This will avoid any cross-contamination.

Also, all the items that come into the receiving area will necessarily be brought in a dedicated closed trolley meant only for carrying unclean/used dirty/unsterile items.

And a dedicated closed trolley will be used to deliver sterile issues to the required departments of the hospital in a safe manner.

For eliminating these microorganisms, there are various steps involved in the CSSD Process, which are explained below. There are different types of sterilization processes that are done in this critical department.

- Moist Heat Steam Sterilization
- Dry Heat Steam Sterilization
- Ethylene Oxide gas cool sterilization.
- The Main one is the Moist Heat Steam sterilization process, where water is boiled at a high-pressure boiler and steam is generated, and this steam, in the form of moist heat, is used and the items are subjected to high-pressure to the tune of 30psi pressure & high temperature as high as 121 to 134℃.
- This type of Moist heat steam sterilization process uses saturated moist steam as the sterilant to sterilize the items, in other words, to destroy the invisible microorganisms. The moisture in the steam, in fact, activates the microorganisms, which are in the form of spores and then provides them a platform for reproduction and thereby multiplication and in turn destroys the microorganisms, making them unable to further reproduce.
- The next one is the dry heat steam sterilization process, which is used for items that cannot be sterilized by the moist heat steam sterilization Process, like, for example: mostly powders.
- But since all items cannot be subjected to this high pressure & temperature because of the physical property of the items as we are aware there are lot of single use items that are and can be safely reused globally and these items need to also undergo a method of sterilization to free them from invisible microorganisms so that they can be reused safely on the other patients.

This method of sterilization is called GAS sterilization, where ethylene oxide gas (ETO) is used to sterilize these items.

In this method of Sterilization, ETO gas is the main sterilant that is being used.

The ethylene oxide gas that is used as a sterilant in the ethylene oxide sterilization process is supposed to have various important properties as follows:

- The ethylene oxide gas that is used is highly inflammable [1].
- The ethylene oxide gas is known to be carcinogenic [2].
- The ethylene oxide gas is also known to be a reproductive hazard [2].
- The ethylene oxide gas is known to be highly toxic [2] in nature.
- Moreover, the Ethylene Oxide gas also has the following unique chemical properties as follows:
    - The ethylene oxide gas is odorless, hence no one can smell the gas in case of a gas leak.
    - The ethylene oxide gas is colorless, hence no one can see the gas in case of a gas leak.

Hence, it becomes more difficult for the personnel in case they abuse the ETO gas cartridge, so that they will unknowingly inhale the ETO gas without even knowing that they are inhaling the ETO gas and also be exposed to the ETO gas without even knowing that they are getting exposed to it.

Most of the heat-sensitive items, like the cardiac catheters, Ventillator circuits, cardiac surgery heat-sensitive items [11], neurosurgery heat-sensitive items, which are very expensive, are sterilized by this method as ETO sterilization is done at 37 & 55℃ °C. The items that need to be ethylene oxide gas sterilized need to be packed in medical-grade pouches wherein one side is plastic & transparent, whereas the other side of the pouch is made up of medical-grade breathable paper. This paper side facilitates the ETO gas to penetrate through the pouches to reach the items that need to be sterilized. To understand in a better way, the sterilization consists of important steps [5] like the pre-conditioning phase, the sterilization phase and the post-conditioning phase.

Unlike steam sterilization, where the post-conditioning phase is nothing but a drying phase because moist steam is used for steam sterilization and naturally, the items that are sterilized by moist heat need to be dried as a part of post-conditioning after the sterilization phase.

But in the case of an ETO gas sterilization, since the sterilant used is Ethylene oxide gas, the gas that penetrates through the pouches to reach the items that are packed for sterilization needs to be removed because of the dangerous properties of the ETO gas, which is called as aeration phase.

Also, the reusable items that are supposed to be ETO gas sterilized needs to be completely dry of moisture as the moisture [3,4] content in the items will react with the ETO gas during sterilization to form a still toxic substance called as ethylene glycol which is a poisonous substance and has the capacity to deteriorate the life of the patient upon usage.

Since the ETO gas is highly toxic [2] and because of its chemical properties, as mentioned earlier, the ETO gas needs to be completely removed from the packs as well as the chamber before the items sterilized by the ETO gas can be issued for consumption. Also, the chamber door of the ETO sterilizer should not be opened unless the ETO gas from the chamber is completely removed and sent out.

Knowing very well the properties of the ETO gas, this gas cannot be let out into the atmosphere. Due to this, the CSSD, wherever this ETO gas sterilizer is installed needs to necessarily have a copper pipe [10] running up the top of the building so that by the time the ETO gas traverses it gets converted into Carbon dioxide on getting combined with the Oxygen of the atmosphere before its being released into the atmosphere, thereby making it safe for environment.

This sort of arrangement is only possible in places where there are no hospitals with tall buildings. In case of hospitals with very tall buidings using a copper pipe [10] of that length to reach till the top of the building becomes very very difficult hence they use another equipment called as an abator which converts the Ethylene Oxide gas in to carbon dioxide before its

STATISTICAL ANALYSIS:
1. The Empty ETO Gas Cartridges without removing the cap fetches Rs.70/per kg.
2. The Empty ETO Gas Cartridge after removing the cap fetches Rs.150/per kg due to the different metal compositions that they are.

ETO Cartridge Resource Recovery	
Daily consumption of EO cartridges	5
Monthly consumption	150
Annual consumption	1800
Weight of one cartridge (aluminium - Al) in kg	0.033
Weight of one cap (mild steel - MS) in kg	0.004
Weight of Al. recovered in kg	59.4
Weight of MS recovered in kg	7.2
Revenue from resource recovery of Al. in Rs.	8910
Revenue from resource recovery from MS in Rs.	216
Total revenue in Rs.	9126
Revenue from resource recovery without separation	4662
Revenue from resource recovery with separation	9126
% increase in revenue with separation	**96**

Figure 1: Revenue Comparison after Innovation

being released in to the atmosphere thus making it environment friendly and customer safety is taking into account.

This sterilization method requires an ETO gas, which is available in the form of cartridges. Each cycle of ETO gas sterilization requires one ETO gas cartridge. So, if there are 4 ETO sterilizers in a hospital, every day, four cartridges would be consumed. Hence, if a hospital runs four cycles, then there would be a consumption of approximately 4x30 = 120 cartridges per day, which means in turn 120 empty ETO gas cartridges would be generated every month. This ETO gas cartridge is made up of a composition of metals. The bottom portion is made up of aluminum & the top portion, where the puncture of the cartridge happens, is made up of Mild steel. (MS)

Instead of disposing of these cartridges as they are, this simple method requires segregating the empty ETO gas cartridge cap from the body of the ETO gas cartridge. The tool required is a simple Nail Puller, and the time taken is less than a minute for one empty ETO gas cartridge.

This segregation of the MS cap from the Empty ETO gas Cartridges helps us in mainly two important ways:

- Prevents adulterated/low supply of ETO gas as removal of the MS cap avoids the ETO gas being refilled in the empty ETO gas cartridges.
- Generates a different scrap value due to the different metal composition of the ETO gas cartridges, the base being aluminium fetches a higher value in comparison to the cap, which is mild steel.

This statistic is provided in the table below:

This statistical analysis is explained as follows:

The Central sterile services department has 5 ETO gas sterilizers [6] in the department to cater to the re-sterilization of all the reusables in the hospital.

Hence, there will be 5 ETO gas cartridges that get used up daily a result in 5 empty ETO gas cartridges being generated as waste for disposal daily.

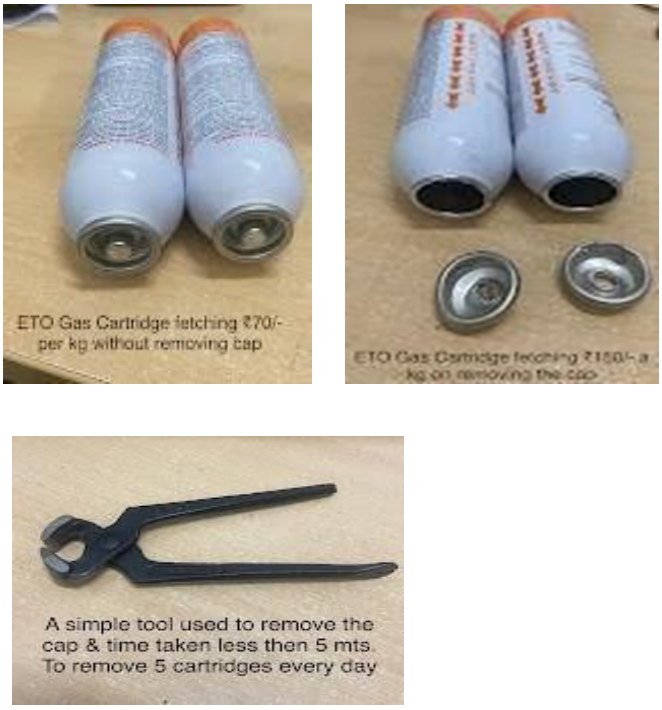

Fig 2: Product applied for Innovation & the Tool used

Hence, taking into account a 30-day monthly cycle, the number of ETO gas cartridges used per month amounts to 30 x 5 = 150 and as a result which 150 empty ETO gas cartridges are generated as waste for disposal on a daily basis. This removal of the mild steel cap from the empty Ethylene Oxide gas cartridges can be performed on a monthly basis at one time, initiating to remove from the 150 empty ETO gas cartridges that gets generated or the mild steel cap can be removed from the empty eto gas cartridges on a daily basis as only 5 emty eto gas cartridges gets generated on a daily basis.

Since the ETO gas cartridge is always made up of two metal compositions because of the following reason:

As the ETO gas that's being used in the cartridge is highly toxic [2] in nature and also corrosive in nature, it's appropriate to have the body of the cartridge made of aluminum, which does not corrode. If the cap of the cartridge were also made of aluminum, then the challenge would be that during the puncture of the cartridge as a process of the cycle, aluminum, being more fragile, may get crumpled and damaged; hence, the cap is necessarily made of mild steel, which is stronger and more robust than aluminum.

In case both the body and the cap are decided to be made of mild steel, then again, because of the chemical properties of the ethylene oxide gas, the long storage of the ETO gas cartridges will result in corrosion and, in turn, create leakage from the ETO gas cartridge itself. This leakage of the ETO gas, in case it happens, is a dangerous situation in a hospital environment and can turn out to be a potential hazard, which is not acceptable.

This is the main reason for having the ethylene oxide gas cartridges made out of two metal compositions. The body is

made up of aluminum and the cap is made up of mild steel, so that both the problem situations are taken care of safely.

Methodology for arriving at a solution to separate the aluminium canister from the mild steel cap.*

There were four methodologies used to separate the mild steel cap from the canister, as detailed below:

Hammering out the cap

This method worked, but it needed a skilled person to deftly tap out the cap. This method is time-consuming and not easily replicable.

Using an angle grinder

We also tried using an angle grinder with a cutting wheel to cut off the cap. However, since the aluminium neck is crimped to the cap, some aluminium will be left inside the cap. Also, for safety, this method requires a worktable, a vice and electrical tools and consumables (cutting wheels).

Using a chop saw

In comparison with an angle grinder, using a chop saw is faster, as the canister can be locked in place and the cut can be made in one go. However, the problem of aluminium being left along with the steel cap is not addressed.

Using a cutting plier

The cutting plier proved to be a good option to remove the steel cap fully from the canister; however, since the plier tip was blunt, there was not enough leverage to pull out the cap easily.

It was while using the pliers that the thought of using a nail puller for this purpose came to mind. Since the jaws of the nail puller are sharp, they offered good leverage, so the cap and canister could be easily separated.

Images of the method are attached herewith for better understanding:

RESULT

This simple process of removing the cap from the empty used ethylene oxide gas cartridges enhanced the revenue generated out of waste as shown above and at the same time helped us in avoiding misuse of empty used ethylene oxide gas cartridges gas cartridges with caps on in refilling and reusing the used empty ETO gas cartridges thereby receiving adulterated ETO gas cartridges from vendors which in turn compromises on the Infection control policies of CSSD.

Target Population

Hospital CSSD Staff, External Waste Management Vendors, Hospital Central Stores staff, Hospital Quality staff, Hospital Infection Control Staff, Hospital Finance staff.

Phenomenon Of Interest

Implementation of a zero-waste culture [9] through structured waste segregation, recycling and innovative low-cost sustainability initiatives.

CONCLUSION

Removing mild steel cap from empty ETO gas cartridges after usage to improve Resource recovery increases resource recovery by 100% and reduces possibility of reuse/refilling of the cartridge thereby not allowing adulteration in the cartridge after numerous trials that were undertaken and a simple tool like Nail Plier was found to be an ideal tool for execution and the time taken was just 5 minutes in a day. This zero-waste initiative successfully integrated sustainability into Healthcare Operations, reducing waste, generating economic benefits and inspiring broader environmental responsibility and also adhering to Infection Control Policies in the Central sterile services department.

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