The Critical Air Project

DEVELOPING CLIMATE CONSCIOUS INHALER PRACTICES IN INPATIENT CARE

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Introduction

Climate change is the single greatest threat of the 21st century[1]. It is impacting the health of Canadians as part of an overall global trend towards adverse health outcomes.[2] The healthcare system is uniquely positioned in this regard. On one hand, healthcare workers see the downstream effects of climate change by treating and managing health-related complications from critical climate events such as forest fires, floods, and heatwaves. On the other hand, providing such care can be very carbon intensive, which further contributes to the changing climate. The Canadian healthcare system accounts for 4.6% of Canada's total greenhouse gas (GHG) emissions.[3] Prescription and non-prescription drugs are the single largest carbon expenditure category, accounting for 25% of healthcare-related carbon emissions in Canada.[3]

Within this category, metered-dose inhalers (MDIs) deserve specific mention. Studies from the UK show that 3.5% of the National Health Service's (NHS) carbon footprint relates exclusively to MDI use.[4] Pressurized MDIs contain a hydrofluoroalkane (HFA) propellant, which provides the force to expel the medication from the cannister with each actuation. HFAs are potent greenhouse gases, the most common of which (HFA134a) is 1,300 times more potent than CO2.[5] While each individual actuation is negligeable in terms of GHG release, the cumulative effect is staggering. On a global level, 18 million MDIs are prescribed yearly worldwide releasing nearly 13 billion tons of CO2 equivalents.[6]

This exorbitant carbon impact has not gone unnoticed. The NHS has targeted initiatives to reduce inhaler-related GHG emissions in the primary care setting.[7] These include education campaigns for patients and prescribers, promoting a change to propellant-free inhalers where appropriate and integrating pharmacists into a supportive role to increase uptake in the community.[7] Similar primary care initiatives are underway in Canada.[8]

While MDIs are common in primary care, they are also ubiquitous in adult inpatient care. Despite their frequent use in hospital, little is known about the processes and methods by which we can decrease inhaler related GHG emissions in the inpatient setting.

Island Health is a healthcare authority providing care and support services to more than 860,000 people on the West Coast of British Columbia across 145 sites, including 11 hospitals providing acute inpatient care.[9,10] Each month, acute care centres at Island Health dispense ~2930 inhalers which corresponds to ~50 tCO2e, or the equivalent of driving around the circumference of the earth 4.5x in a standard gasoline powered vehicle.[11]

Island Health is committed to operational excellence and providing high quality care through climate change response. The organization's strategic framework includes

active support of environmental sustainability best practices which include climate–conscious prescribing to minimize carbon footprint.[12] Similar initiatives aimed at climate conscious prescribing are underway across Canada including Sunnybrook Hospital and The Ottawa Hospital.

The Critical Air Project is a climate–conscious prescribing initiative aimed at decreasing our organization's inhaler–related carbon footprint through changes in health policy, operational changes, and a widespread education campaign.

Setting up the groundwork

These are three foundational steps we have identified that create the underpinning of each Change Idea developed in The Critical Air Project. They include the importance of developing partnerships, creating a process map of inhaler use and cultivating patience.

Developing partnerships and seeking organizational support

There is urgency to address climate change and reduce harm to the planet, organizations are increasingly taking notice. From organizational strategic plans to governmental commitments, climate change mitigation and resilience strategies are center stage.

Start by **assessing your organization's readiness for sustainability** – you can refer to the CASCADES Playbook on the topic.[13] Seek out your health authority's (or hospital's) strategic plan– we identified Island Health's Environmental Sustainability commitment[14] through an online search. As you build your case for the "why" of your project and engage various stakeholders, repeatedly reference this guiding document and how it relates to sustainable inhaler practices to **demonstrate that the initiative is in line with the existing organizational mandate**.

If you cannot find a connection to climate change within your organization's strategic framework or priorities, look provincially. Each province and territory has some form of climate leadership plan that can be referred to, and your provincial ministry of health, specifically the Minister of Health's mandate letter[15, 16] can also be an excellent source to reference. Alternatively, consider the Government of Canada's commitment through the Conference of the Parties 26 (COP26) Health Programme.[17] Canada is a signatory on this historical milestone agreement, committing to climate–resilient health systems and sustainable low–carbon health systems.

Once you can demonstrate that your project plan is in line with government strategies or your organization's values and strategic plan, **identify the governance and leadership structures in your organization** that relate to medication operations and clinical practice. This might include one or multiple quality councils or committees that you will want to engage early in your project. By having this leadership endorsement, it will be easier to move forward with change ideas. You will be able to let stakeholders

know that the project has the support of these councils/committees, which in turn may raise your project higher in their list of priorities to address.

This is an example of the stakeholder map we have identified at Island Health (see Figure 1). The original map shows that each bubble is populated with the name and contact information of our relevant stakeholders, which we have removed for confidentiality purposes.

Start socializing the idea around this project early to build awareness and identify allies. This could involve informally talking about the environmental impact of inhalers at staff huddles or with interdisciplinary team members. If an internal climate change or environmental sustainability group exists, they can help amplify the message. As people start to become more aware of the issue, they may be more receptive to proposed change ideas to reduce inhalers' environmental impact within your organization. Change can be daunting and can take time. Start early. Find your village.

Figure 1: Stakeholder map for The Critical Air Project

Patience is a virtue

The biggest takeaway from implementing an inpatient climate–conscious medication management initiative such as The Critical Air Project is that patience is a virtue.

Steering a complex system in a direction of change takes time. It will be helpful to manage your own expectations of progress as it takes significant time to engage the various and critical stakeholders for meaningful and lasting change. Drafting, reviewing, incorporating feedback, approving, and then implementing new policies takes time. Significant amounts of time. Progress will be measured in months and years, not in weeks. Simply identifying the wide array of relevant stakeholders for each project, contacting them and meeting with them will involve email–writing, coordinating schedules and discussion. Although this is time–consuming, it will be the foundation for a successful change in practice.

You may be doing this work outside the scope of your actual position, or if you are lucky enough to have dedicated, funded time to do this work, you will still have to carve out time from your other duties and clinical practice to work on this project. Manage your own expectations for what you can accomplish given the competing priorities in your personal and professional life.

Systemic change is slow going, but the advantage is widespread and sustained change on a meso and macro scale that has massive and far–reaching implications – which is well worth the patience and perseverance invested upfront!

Identifying change management metrics

As with any sustainable QI initiative, measuring the impact of your interventions will be important to determine whether you have achieved your targets with regards to environmental, social, and financial impacts, while continuing to provide high quality, patient–centered care.[18] Demonstrating measurable improvement and associated costs will go a long way to strengthen the organizational partnerships you have developed.

The Critical Air Project established an early partnership with the Pharmacy Informatics team at our Health Authority, which included a Clinical Informatics Pharmacist and a Systems Analyst.

With regards to the **educational arc**, we were interested in seeing whether prescribers' behaviours were influenced by our interventions. We collected prescribing data though Cerner software by a custom extract of the inhaler dispensed to Island Health patients. An algorithm was written by the Clinical Informatics Pharmacist enabling us to identify the number of orders written by providers monthly stratified by hospital site.

With regards to **dispensing data**, we obtained data from two different sources. We used pharmacy dispensing data as tracked in Cerner Pharmacy module (PharmNet)

within the Cerner Health Information Management (HIM) system. to identify the number of inhalers directly dispensed by pharmacy.

However, our process map revealed that a substantial number of inhalers are taken directly from ward stock – which would not be tracked by this software. There is heterogeneity throughout the health authority with how this data is tracked, since some wardstock is stored in low tech medication cupboards and bins, whereas other wardstock is kept in automated dispensing cabinets (Acudose, Omnicell, etc). To encompass the various forms of wardstock, we have elected to use restocking data as tracked in the Cerner inventory transfer system. We are tracking the frequency and number of inhalers sent from the pharmacy to each individual ward to replenish the wardstock and using this data as a surrogate marker for wardstock inhaler use.

The algorithm written enables us to gather monthly dispensing data from pharmacy and monthly wardstock replenishing data, stratified by location. This helped us arrive at a run chart tracking our intervention in real time.

We have also collected **higher-order financial information** such as ordering data, purchasing data and associated costs to identify overall decrease in use and to quantify financial implications for the Health Authority.

Lastly, we are continuously collecting stakeholder feedback about the policy, operational and education changes being implemented to ensure that they are feasible, realistic, and practical for practice.

Identifying the "lifecycle" of an inhaler in the hospital

Develop an understanding of the pattern of inhaler use, e.g. the "inhaler lifecyle" or "journey," within your hospital setting. This step should involve stakeholders from multiple levels of the organization including nurses, physicians (both specialists and hospitalists), physician trainees, pharmacists (both clinical and dispensary), pharmacy technicians, respiratory therapists, housekeeping, facilities maintenance and porter services.

Doing so will provide a holistic picture of inhaler use within your hospital and will highlight areas where there is room for improvement, an important step for identifying where you might target your change ideas.

We have developed the following process maps for our tertiary care center through individual interviews and focus groups:

Arrival to the hospital

Prior to their arrival on the medical ward, patients are prescribed inhalers in one of two contexts:

1. Patients who present to the emergency department with respiratory difficulties have inhalers ordered as deemed appropriate by their treating physician. (This Playbook focuses on inpatient care – however, our practice survey reveals that when a patient presents in respiratory distress, the first inhaler is often administered directly in the ambulance. This inhaler seldom makes it to the emergency department; it is discarded on the patient's arrival.)

2. All patients admitted to hospital will have a Best Possible Medication History (BPMH) completed by a care provider. Patients who use an inhaler at home and who present to the emergency department for an unrelated issue, or those who present for a planned admission (e.g. elective surgery), will usually have their home inhalers represcribed in hospital as part of medication reconciliation using the BPMH.

Despite some existing supportive policy, at the time of our process mapping, neither group of patients is encouraged to bring their own inhalers to hospital. Those who do bring their own inhalers will typically have hospital inhalers dispensed regardless, particularly if the inhaler is included on the hospital formulary (which is different than the outpatient provincial formulary).

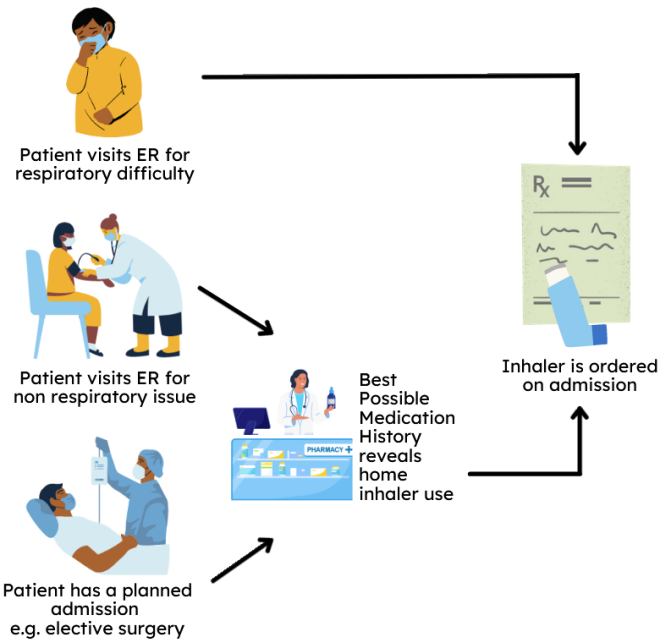

Figure 2: Process map at the time of patient admission to our tertiary centre

Inpatient ward

There is substantial loss of inhalers on transfer. For instance, only a fraction of the inhalers dispensed in the emergency department are transferred to the ward along with the patient. The same is true when the patient is transferred from one ward to another.

Once admitted, if the need for an inhaler is identified, for instance the patient experiences acute shortness of breath, there are three possible situations (see Image 2):

A. The inhaler is readily available at the bedside and the patient can use it immediately.
B. The inhaler has already been dispensed during this admission but cannot be located.
    - There is considerable variability where inhalers are kept: at the patient's bedside, at the nursing station, in the medication cart, etc. If the patient's inhaler isn't immediately visible – for instance, it is "hidden" under a newspaper or in a toiletry bag on the bedside table – then a new inhaler is obtained from wardstock or from pharmacy.
    - If the initial inhaler was not labeled correctly with the patient's name or uncertainty exists about which patient the inhaler belongs to, then a new inhaler is obtained from wardstock or from pharmacy.
    - It is not unusual for patients to have multiple identical inhalers at the bedside because of such duplications.
C. The patient does not yet have an inhaler ordered or dispensed.

If there is a need for an inhaler, but one isn't prescribed yet, the Most Responsible Physician or their designate will write a **new order in the chart**.

- If the inhaler ordered is available on hospital wardstock, the nurse will directly remove it from wardstock – either a medication cabinet or an automated dispensing cabinet, depending on the technology available at the site. These inhalers are not automatically labelled; it is up to the nurse to affix a patient–specific label onto the inhaler. The order is subsequently processed at the pharmacy. In the case of overnight orders, a second new inhaler is often dispensed because the pharmacy dispensary has no way of knowing whether an inhaler was taken from the night cupboard.
- If the inhaler is not available on wardstock, it is dispensed directly from the pharmacy dispensary with a patient–friendly label.

If an **inhaler dispensed from pharmacy has an order change** , the previous inhaler is discarded and a new inhaler is obtained from pharmacy.

- This is true even if there are only dose changes; for instance, if fluticasone 125mg BID is increased to fluticasone 250mg BID, a new inhaler will be dispensed rather than using the existing inhaler to achieve the higher dose.
- If the instructions are changed from "regularly scheduled" to "as needed," a new inhaler is dispensed.
- This is related to labelling practices; there are scope of practice limitations to nurses "re–labelling" inhalers previously dispensed and labelled by pharmacy. If the instructions are changed, a new label must be issued.
- Inhalers dispensed from pharmacy are labelled in accordance with the same standards as patient–friendly labels used in community pharmacy. When inhalers are obtained from wardstock, nurses should label inhalers with patient identifying information as well as patient–friendly instructions; our process mapping noted an inconsistency in this practice occurring.

Inhalers at our tertiary care site are sent to the ward in a small plastic bag with a tamper–proof seal across the top. Any inhaler returned to pharmacy with the tamper–proof seal intact can be reused for a different patient. Our process mapping found that once on the ward, the inhaler is almost always immediately removed from this bag (thus breaking the tamper seal) and placed in the medication cart by the nurse. Any inhaler returned with a broken tamper seal is considered contaminated and will be discarded, regardless of whether it was used, whether it left the medication cart or not.

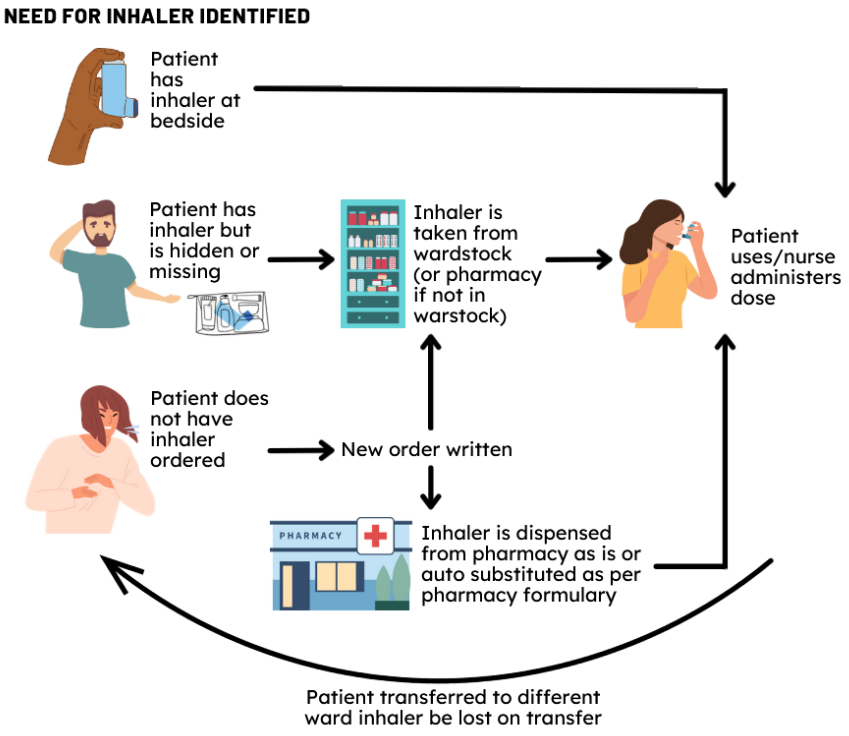

Figure 3: Process map of inhaler practices in admitted patients at our tertiary centre

Discharge from hospital

Once the patient is ready to leave hospital, there is no current procedure to help guide the practice of patients taking any hospital–dispensed medications home. General guidance currently is that medications used for patients in hospital are not to be taken home upon discharge. There is significant heterogeneity among nursing staff discharge practices. For instance (Image 2; D), if a patient is prescribed an inhaler at discharge that is identical to the one they have already been using in hospital, the patient would not necessarily be provided with currently hospital–dispensed device. The patient may need to leave the hospital inhaler behind and take an outpatient prescription to purchase a new, identical inhaler at an outpatient pharmacy. This results in substantial waste of usable medication that cannot be repurposed for another patient.

Any inhaler discontinued while in hospital or left behind in the patient's room at discharge will be discarded. If it is found by housekeeping, our process mapping found that it is either returned to the nursing station or disposed of in the trash. If the inhaler is found by nursing, it will be sent down to pharmacy through a "return to pharmacy box" at the nursing station or placed in the sharps waste receptacle. The gold standard for safe inhaler disposal is incineration to neutralize the propellant. However, there is currently no mechanism in place to consistently target inhalers for incineration.

Safe inhaler disposal practices are an important area to target. Although we are actively working on it, this level of systemic change is more than could be achieved in a one–year timeframe at our institution. In line with "the 3 Rs" of waste management, we opted to focus on reducing before reusing, and then recycling (or disposing).

In summary, our process map revealed multiple areas of inefficiency within the hospital system that resulted in significant amounts of inhaler waste. We are calling this "**the inhaler attrition rate**". The challenging part was choosing which areas to focus on during our first round of implementation. Although we explored 10 potential avenues for change, some of them could not be achieved within a one–year timeframe and we elected to set them aside for later (e.g. inhaler disposal).

We chose 6 initiatives ("the Change Ideas") to pursue during the first year of The Critical Air Project, which include a mix of policy changes (significant effort involved, but far–reaching changes) and operational changes (overall lower hanging fruit, with high reward).

Change ideas

Policy changes

Broadly, health policy encompasses decisions, strategies, and actions to achieve a specific goal on a societal scale. For the purposes of this Playbook, we use the term policy to mean macro or systemic–level changes that extend beyond an individual hospital and beyond a single tool. These are long–term strategies to implement that will require concerted effort from many stakeholders coming together to advocate for effective change.

The Critical Air Project has developed a number of resources to support the implementation of these change ideas, which are listed in each section. These resources are published as part of the **Climate conscious inhaler practices in inpatient care** playbook.

Based on our process map, we chose three policy areas to target for change: the availability of low carbon options on hospital formulary, the HFA content of contracted inpatient salbutamol inhalers and the Multidose Medication Provided to Patients on Discharge policy.

Hospital formulary

Authors V Stoynova, C Culley, C. Webb

There are over 35 different inhaler products commercially available in Canada,[19, 20] only a subset of which is available in the inpatient setting. It can be found on the Hospital Formulary. In certain provinces, such as Ontario, the inpatient formulary varies from hospital to hospital and is left at the discretion of individual institutions. In other provinces, such as BC, the inhaler formulary is provincial, meaning that every hospital in the province has access to the same inhalers.

This is both a challenge and an asset. On one hand, changing the hospital formulary on a provincial level can be cumbersome and requires input from several stakeholders across different health authorities. On the other hand, changing the hospital formulary will have far reaching downstream effects as it spread to every hospital provincially.

Our initial strategy was to identify which inhalers are on hospital formulary and review them through a planetary health lens to ensure that a low carbon option is available in each pharmacologic category.

Important considerations include the carbon footprint of the inhaler, the cost of the inhaler in the outpatient setting, and whether it is covered in the outpatient setting.

Resources

- Step–by–step illustrated guide
- Worked example – Terbutaline formulary request assessment

Low-Volume versus High-Volume HFA Salbutamol Inhaler Options

Metered-dose inhalers (MDIs) contain a hydrofluoroalkane (HFA), a potent greenhouse has (GHG) that expels the medication from the cannister with each actuation. Although each individual actuation is negligeable in terms of GHG release, the cumulative effect is staggering. We know that 3.5% of the UK's National Health Service's carbon footprint is related directly to MDI use at the point of care.[3]

At a given hospital or health authority, it is feasible that 10,000 MDIs are used annually, if not more. This would be a combination of short-acting beta-agonists, short-acting muscarinic antagonists, inhaled corticosteroids, and combination products. This number will depend on the size and catchment area of the hospital or health authority, which is why connecting with pharmacy purchasing team and/or pharmacy informatics specialists is key to determining the metrics.

The corresponding GHG emissions associated with these inhalers depend on the specific HFA (HFA-134a vs HFA-227ea), as well as the volume of HFA contained within the different devices. There can be significant variability in the carbon footprint of different MDIs, **even within the same pharmacologic category**. For instance, a low-volume HFA salbutamol MDI has the GHG equivalent of driving 38.8km in a standard gasoline powered vehicle (9,720 gCO2e), whereas a high-volume salbutamol MDI is 112.6km (28,200 gCOe).[19, 21]

Due to the confidential nature of the data, we are unable to release the exact numbers used at Island Health. We are using general numbers in an effort to provide some concreteness on how to conduct an analysis.

Both low and high-volume HFA inhalers contain the same active ingredient and the same delivery mechanism; there is no published data demonstrating a meaningful difference between these inhalers, which are felt to be clinically equivalent and interchangeable. The only difference is the marked increase in GHG emissions for high volume HFA MDIs.

We reviewed the carbon emissions of the current salbutamol HFA provider provincially and prepared an environmental impact analysis to present to the provincial directorship, with recommendations to weigh the climate impact when awarding inhaler contracts. (See Salbutamol Briefing Note).

Resources

- Step-by-step guide
- Worked example – Salbutamol briefing

Multidose Medications on Discharge Procedure

Patients with asthma and COPD are prescribed inhalers in hospital, whether they are admitted with an acute exacerbation of their underlying lung disease or whether they are represcribed their home maintenance inhalers while admitted for an unrelated indication. By the time of discharge, there are often multiple doses remaining in the inhaler device, which are then discarded. This results in waste of otherwise useable medication. In addition to the increased carbon emissions, this has significant financial implications to the hospital and represents an untapped opportunity for improving patient care by through improved compliance.

The Critical Air Project focuses on decreasing inhaler-related carbon footprint. However, we realized we could expand this policy to include other multidose medication products (such as ophthalmic solutions, nitroglycerin sprays, creams, etc) by minor adjustments in the language used to write the policy. Doing so will further decrease unnecessary medication waste. For the remainder of the change idea, we will use multidose medication product to refer to such medications that are dispensed in hospital containing more than one dose.

Please see the summary of the evidence for a detailed review of the rationale behind this change idea.

With this in mind, we set out to develop a policy and associated procedure at Island Health to support staff in providing previously dispensed multidose medication products at hospital discharge. The goal is to improve patient outcomes, decrease carbon footprint and decrease costs to the Health Authority while facilitating compliance with medication dispensing best practices and minimizing added workload for staff.

Resources

- Summary of the relevant literature
- Step-by-step guide
- Policy versus procedure chart

Operational changes

Operational changes refer to the day-to-day activities and processes at our institution. These seemingly small changes in how things are done practically can result in meaningful, large-scale reductions in inhaler waste and associated greenhouse gas emissions.

Tamper sealing the inhaler cap

Our process map revealed that the location of the inhaler tamper seal can lead to unintended consequences including increased waste of unused inhalers and associated increased greenhouse gas emissions.

At our tertiary care hospital, the inhaler is affixed with a patient-friendly label, then placed in a plastic zip-sealed bag with a tamper-proof seal across the top of the bag. Once on the ward, the inhaler is placed in a patient's designated drawer on a medication cart by nursing. This plastic bag does not easily fit in the medication drawer and our survey showed that a significant percentage of nurses immediately remove the inhaler from the plastic bag to place it in the patient-specific medication drawer, thereby breaking the tamper seal.

This leads to an unintended consequence: once the tamper seal is broken, there is no reliable way to determine if the inhaler has been used by the patient. Therefore, each inhaler without a tamper seal will be sent for disposal at the end of a patient's hospital stay, whether it has been in contact with the patient or not.

This leads to waste of unused inhalers that could otherwise be repurposed, increased pharmaceutical disposal costs for the Health Authority and significant climate impact due to the carbon intensive nature of MDIs.

We propose to move the tamper seal directly to the inhaler cap, so unused inhalers can be readily identified.

Resources

- Step-by-step guide
- Worked example – tamper seal policy

Prioritizing inhaler wardstock

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The authors gratefully acknowledge the instrumental work of Isla Drummond, Elissa Aeng and Deborah Heidary in the development of this change idea.

Wardstock is defined as medications stored in a patient care area without being labelled for a particular patient to use.[22] These medications are typically kept directly on the medical ward, either in automated dispensing cabinets (ADCs; eg. Accudose, Omnicell) or in low-tech cabinets and bins.

The role of wardstock is to have certain medications immediately accessible without waiting to have them dispensed from pharmacy. This is particularly important when a

medication is needed on an urgent basis and delay in having the medication dispensed from pharmacy may cause. This is a safe strategy when there is no overnight staff in the pharmacy and a medication, such as a short–acting bronchodilator, is needed urgently.

In contrast, maintenance inhalers such as inhaled corticosteroids, long–acting bronchodilators, long–acting muscarinic and combination inhalers are seldomly needed on an emergency basis. Except for budesonide/formoterol,[23] maintenance inhalers are not approved for rescue inhaler use. As such, there is no indication for emergent use overnight and it is generally safe to wait until daytime hours to have an inhaler sent from pharmacy.

Maintenance inhaler ward stock is associated with significant inhaler waste.[24,25] In a Canadian study reviewing inpatient salmeterol–fluticasone inhaler waste, nearly 1 in 5 patients received a duplicate or unnecessary inhaler during their hospital stay.[24] The second most common cause was removing the wrong inhaler from wardstock, followed closely by removing a second identical inhaler from wardstock within an hour of the first inhaler being removed from the medication cabinet.[24] Fluticasone–salmeterol waste led to an annual loss of over 176,000$ of useable medication.[24]

These maintenance inhalers are MDI devices, which have an outsized climate impact. Regardless of device type and GHG emissions, maintenance inhalers are expensive, and each device contains several weeks' worth of medication – in other words, losing a single inhaler leads to a substantial loss of useful medication, which is costly financially and environmentally.

Resources

- Step–by–step guide
- Worked example – Fraser Health Memo Removal of inhalers from wardstock
- Worked example – Fraser Health Project slides

A pilot project at Fraser Health Authority removed maintenance inhalers from ADCs at a single community hospital, while continuing to include rescue inhalers.[26] Doing so saved 106 inhalers and over 4,000$ in reduced waste over a 6–month trial period.[26] There were no significant increases in workload for staff and no adverse patient–related events identified.[26]

We recommend reviewing the contents of wardstock and considering the removal of maintenance inhalers.

Clinical order set redesign

Standardized clinical order sets are mainstream in many hospitals. These clinical decision support tools are meant to "facilitate appropriate prescribing by providing the prescriber with a pre–defined set of applicable drugs are recommended dosages, based off of evidence–based guidelines for a specific disease area".[27]

Clinical order sets are typically curated to include best practice alternatives,[27] such as narrowing the available antibiotic options for a given infection through an antimicrobial stewardship lens. We make the case that clinical order sets should include a climate stewardship component. Akin to antimicrobial stewardship, clinical order sets should highlight the least harmful environmental alternatives – while ultimately leaving the prescribing decision to the individual clinician.

Resources

- Step-by-step guide
- Worked example – before and after clinical COPD exacerbation order set at Island Health

We are keeping in mind that lower carbon alternatives may not be appropriate for every patient and the patient's most responsible inpatient prescriber is the best person to judge whether a lower carbon alternative is appropriate.

Education campaign

The cornerstone of any large–scale culture change is an understanding of the issues and why change is necessary. The operational and policy changes we developed are happening at a higher, systemic level of the organization and are largely provider independent.

However, providing accessible, tailored education to relevant stakeholders is an extremely important adjunct to any intervention. At our centre, we have identified the following stakeholder groups needing to be targeted for educational intervention: prescribers (primary care providers, inpatient care providers), nurses, pharmacists and pharmacy technicians, respiratory therapists, healthcare trainees, porter services, housekeeping.

Trainees

- At our tertiary center, we have a high turnover of medical students, internal medicine residents, off service residents and pharmacy trainees rotating through our clinical teaching unit. The number of trainees and the brief nature of their CTU rotations made for a unique challenge.
- We have created a brief ~5min orientation video to be presented at the end of the mandatory CTU orientation provided to every new trainee who starts on service.

Physicians

- We have created a webinar detailing some of the efforts put in place; we have also presented at grand rounds and division meetings to reach a variety of groups, each with their own perspectives
- A patient's hospitalization lies on a spectrum of continuity between inpatient and outpatient care. We know that prescriptions written at hospital discharge are often continued in the outpatient setting by primary care providers and effective communication about planetary health focused inhaler changes is important to ensure continuity. We have created a letter to be printed and sent to the primary care provider upon hospital discharge.

Patients

- We know that sustainable healthcare is important to most patients. Studies from the UK reveal that 80% of patients consider the climate impact of their treatment to be important. We also know that non–consensual switches can be associated with decreased satisfaction of care and also lead to worse outcomes. Patients are important partners in their care.
- We have created a brief educational video that can be played by patients on their hospital television which contains an overview.
- We are mindful that many patients in hospital may have lower inspiratory capacity and that lower–carbon inhalers may not be the best choice in the

inpatient setting – however, we are planting the seed that their outpatient regiment can be crafted as lower carbon once they are discharged.

Nurses

- Given the large numbers and turnover of nurses staff on different units, we have focused our efforts on educating the nurse educators about the environmental impact of inhalers and the various practice change ideas
- This has been through engagement related to change idea planning, email communication, and in-person learning sessions
- We have created an infographic for distribution to nursing staff

Pharmacists & pharmacy technicians

- Pharmacists and pharmacy technicians are also key stakeholders given their intersection with operational, policy, and clinical practices. They also regularly liaise with community pharmacies.
- We have presented at a local pharmacy conference about inhalers and presented at clinical learning sessions ("Clinical Chit Chats"). As our change ideas continue to roll out over time, we will ensure pharmacy staff are aware of these changes and resources

Respiratory therapists

- We have also engaged local respiratory therapists as we have proposed and implemented change ideas. RTs regularly recommend inhaler therapies for their patients and thus also benefit from having the knowledge about the environmental impact of these devices. They can act as advocates of proper inhaler technique, which is a critical aspect of stewardly inhaler use.
- We have created an infographic for distribution to RT staff

Resources

- Respiratory therapists infographic
- Nursing infographic
- Inpatient pharmacy infographic
- Letter to outpatient pharmacists
- Pharmacy technicians infographic
- Letter to primary care provider
- Trainee infographic
- Trainee video

Other avenues for exploration

There are many areas of improvement that can be tackled and we have only had time to address a few during the inaugural stages of The Critical Air Project. Here are some further avenues that we are currently exploring and that you can consider implementing at your centre:

- Safe inhaler disposal practices
- Encouraging patients to bring their own inhalers from home during brief, preplanned elective admissions such as joint replacement surgeries
- Considering a pharmacy–led dispensing strategy to avoid sending duplicate inhaler to the hospital ward
- Considering a respiratory educator to provide inpatient inhaler teaching
- Minimizing inhaler loss on hospital transfers

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Appendix: Critical Air Project step-by-step processes

These step–by–step accounts of the Critical Air Project's implementation of each change idea form the basis of the illustrated step–by–step guides published as part of the **Climate conscious inhaler practices in inpatient care** playbook.

Hospital Formulary

1. Locate your hospital formulary
    - At Island Health, the hospital formulary is located on the Intranet. This requires a staff login to access.

2. Identify which inhalers are on hospital formulary and their relative carbon footprint
    - For the purposes of this playbook, we are focusing on two inhaler pharmacologic categories withing Island Health; short–acting beta–agonists (SABAs) and inhaled corticosteroid/long–acting beta–agonists (ICS/LABAs)
    - Within short–acting bronchodilators
        - Salbutamol MDI – 9.7–28.2 gCO2e per inhaler (which is equivalent to driving 38.8–112.6 km in an average gas–powered car)
        - Salbutamol DPI (Ventolin Diskus) – 600g CO2e (2.4 km)
    - Within ICS/LABA
        - Budesonide/formoterol (Symbicort Turbuhaler) – 800g CO2e (3.2 km)
        - Fluticasone/salmeterol (Advair Diskus, Wixela Inhub) – 900–1,125g CO2e (3.5–4.5 km)
        - Fluticasone/vilanterol (Breo Ellipta) – 780 gCO2e (3.5 km)
        - Mometasone/formoterol (Zenhale MDI) – 34,800gCO2e (139 km)

3. Decide which inhalers you would like to see on hospital formulary and why
    - In the SABA category, we wanted to include terbutaline (Bricanyl Turbuhaler – DPI)
        - The Salbutamol DPI on formulary was expensive and seldomly used (inpatient cost is confidential). It was often substituted for salbutamol MDI.
        - The Salbutamol DPI on formulary is not covered by the outpatient provincial drug plan, meaning that patients who are started on Salbutamol DPI in hospital are often unable to afford it in the

community, and are changed to MDI in the outpatient setting. (Salbutamol DPI cost per dose 0.40$ vs MDI 0.09$)
        - The carbon footprint of Terbutaline is marginally better (Terbutaline 1.9km vs Salbutamol DPI 2.4km)
        - It is not realistic or appropriate to remove MDI from hospital formulary altogether because many inpatients have poor inspiratory capacity when they are have an acute exacerbation and wouldn't be able to use a SABA DPI for this reason. MDIs are also necessary for intubated patients and children under 6.

- In the ICS/LABA category, we wanted to change mometasone/formoterol to fluticasone/salmeterol (Advair MDI) due to their relative carbon footprints.
    - Mometasone/formoterol (Zenhale) is the only MDI on the Canadian market using HFA227 as a propellant, which is 3200x more potent than CO2. It has the highest carbon footprint of any inhaler available in Canada at 139km.
    - The alternative MDI (fluticasone/salmeterol Advair MDI) only has a carbon footprint of 78km.
    - Both use the same MDI device and therefore require the same technique.
    - Both have the same Special Authority coverage criteria in the outpatient setting.

4. Identify the formulary management team at the hospital and create allies
    - We are grateful to the **Medication Use and Management pharmacist was the lead on this project**. She also collaborated closely with pharmacy colleagues at different health authorities because of the provincial scope of the hospital formulary in BC.
    - The formulary management team may have a different title at your center, such as drug use and evaluation, formulary pharmacists, etc.
    - We were very fortunate that we had such strong allies from the get–go. You may need to meet with them several times to socialize them to the planetary health impact of different inhalers – the relationship building upfront will help amplify the message to formulary decision–makers.

5. Identify the process by which formulary change requests are made
    - A form is available online titled British Columbia Health Authorities Drug Review Request form which requires a submission for the requested drug, proposed indication and rationale including supporting clinical evidence. A department head and Pharmacy & Therapeutics (P&T) co–chair or delegate are also required to sign–off on the request form.
    - Once the Medication Use Management Pharmacist receives this form, they present it to a provincial drug review committee and if approved to move forward, a formal formulary drug review is completed including cost analysis.

- For Terbutaline, the initial form was approved and moved on to the next stage.

- For Zenhale, a preliminary cost analysis revealed that, given the small number of ICS/LABA MDIs used provincially, the cost of making the change to a different ICS/LABA MDI was prohibitive. This request did not progress past this stage. You win some, you lose some.

6. Make a compelling case for formulary change including organizational priorities, carbon analysis, and cost analysis of the change
    - The Medication Use Management Pharmacist spearheaded the writing of the Terbutaline Formulary Drug Review Report along with a colleague at a different Health Authority.
    - For the details of how this was accomplished at Island Health, please see the Worked Example. The data regarding number of inhalers and inhaler cost is confidential to the health authority; we have used fictional numbers to illustrate the concept.

7. Determine the process for requests to be reviewed by committees, including the timelines, and whether clinician stakeholder feedback impacts the decision–making process
    - In BC, the committee deciding on the contents of the provincial hospital formulary is called the Pharmacy and Therapeutics Committee (P&T Committee)
    - We learnt that, once a request is made, different health authorities receive stakeholder feedback in different ways. There is a critical review period for stakeholders including clinicians to provide feedback. Once you have submitted the form, clarify when and how feedback will be solicited.
    - At Island Health, this was done through an email request to the MUM pharmacist.

8. If stakeholder feedback is elicited, ensure like–minded clinicians are aware of the formulary request and how they can make their voice heard.
    - We presented at hospital Grand Rounds, hospitalist rounds and primary care rounds on inhaler sustainability during the critical feedback period and included information on how to show support for this initiative during the talk.
    - We forwarded the feedback email to like–minded clinicians, pharmacists, nurses within our health authority.

9. Once low carbon alternatives are available on hospital formulary – publicize and spread the word so these new options can be adopted into practice.

- Once the addition of Terbutaline to the hospital formulary was confirmed, we communicated this decision to clinicians through the same channels we used to elicit feedback.
- We also incorporated this new information to the clinical order sets and wardstock.

- Key stakeholders for this change idea
  - Medication Use Management Pharmacists
  - Pharmacy administration
  - Drug Review Subcommittee
  - Pharmacy & Therapeutics Committee
  - Clinicians with an interest in planetary health
  - Pharmacy Operations leadership

Low–Volume versus High–Volume HFA Salbutamol Inhaler Options

1. Contact the pharmacy purchasing team to identify the type of salbutamol inhaler current on formulary – is it low–volume or high–volume HFA?
   - In BC, products are contracted nationally through HealthPRO. BC and Island Health currently contract with a low–volume HFA salbutamol provider.

2. Ask the purchasing team about the contract cycle for salbutamol MDIs, to determine when the contract will be reviewed again.
   - This will help determine the priority of this change. For example, if the contract was just secured last month and the cycle is every three years, then you may choose to prioritize different work. This process does start years before the decision is made, so it is likely never too early to start, but it is still helpful to be aware of the timeline.
   - In BC, the contracts are committed on a provincial level. We learned the contract was up for renewal with HealthPRO in late 2022/early 2023.

3. Identify the current yearly salbutamol usage at your hospital.
   - This data may be sourced from the purchasing team or with the help of pharmacy informatics.
   - We identified this information by contacting HealthPRO, a procurement organization that acts on behalf the health authorities in BC.
   - Since this information is confidential, we are unable to release the number of inhalers purchased provincially or at Island Health.

4. Calculate the current carbon emissions. Assess the impact of changing to a low–volume or high–volume HFA salbutamol MDI.
   - Please see the Appendix in the worked example for the details of our calculations.

- Since the number of inhalers purchased provincially and their cost is confidential, we are unable to share the exact numbers. However, we have used a fictional number to illustrate the concept in the briefing document.

5. Ask your supervisor or someone in a pharmacy leadership position about accessing the appropriate template to use for a briefing note.
    - The form was provided to us by the Clinical Pharmacy Coordinator at our tertiary center.

6. Write a briefing note detailing your findings.
    - Use a succinct executive summary to relay your key findings – keep in mind that your target audience will be very busy and may not have the time to go through the detailed calculations, though they should be included.
    - For a briefing note example, please see the Worked Example. Since the number of inhalers purchased provincially and their cost is confidential, we are unable to share the exact numbers. However, we have used a fictional number to illustrate the concept in the briefing document.

7. Book a meeting with pharmacy purchasing leadership to present your briefing.
    - We met with the Director of Pharmacy and the Pharmacy Supervisor and Buyer to relay our findings. We had a separate meeting with HealthPRO staff.
    - They then circulated this document to the Directors of other health authorities and to the provincial Director for Purchasing.

8. Find out when the decision will be made and follow up.

Key stakeholders

- Pharmacy purchasing team
- Procurement agency acting on behalf of hospital (i.e., HealthPRO in BC)

Multidose Medications on Discharge Procedure

1. What is the current state at your institution for handling multidose medications, such as inhalers, upon hospital discharge? Keep in mind that practice may differ from existing policy.

    - We conducted a survey of nurses to better understand current practices around sending patients home with hospital-dispensed inhalers to obtain a baseline understanding of current practice – we applied for a pharmacy student to conduct this work.

    - We identified that there is significant heterogeneity in practice among nursing staff, with only 20% of nurses saying they "always" send patients

home with inhalers.[14]

2. Identify existing policies and procedures on labelling of multidose products and/or providing medications to patients on discharge.

    - We reviewed pharmacy, physician, and nursing policy on our Health Authority Intranet and we spoke to pharmacy leadership to identify relevant documents.

    - We identified only one policy addressing patient–specific multidose medications. Policy C.36 addresses "safe handling, labelling and storage processes to prevent cross–contamination" of products dispensed from automated dispensing cabinets. It does not address multidose medications (or labelling of such medications) on discharge.

    - We identified two policies that address providing medications to patients leaving hospital:

        i. Policy C.16 supports the provision of small quantities of regularly scheduled medications when patients require a temporary leave from hospital (e.g. "day pass") to avoid disruption in treatment.

        ii. Policy C.42 supports the provision of small quantities of medications to be taken home from the emergency department to minimize harm until the patient can obtain the required medication from a community pharmacy.

        iii. Neither of these policies address the provision of already dispensed multidose–medication products on hospital discharge.

3. If there are no policy or procedure documents, identify the pathway to creating new policy or procedure. The process for document development will likely be specific to your organization.
    - We reviewed our Health Authority's Policies & Procedures page (P&P) – there was a section on Creating Policies, Procedures, Guidelines and Protocols, with a framework outlining the process.

    - The P&P website, through the Policy Stewardship Office, provided a Policy Framework and Development Guide – which is divided into initiation, development, implementation, and evaluation stages. Each organization may have differing processes for the creation of Standards Documents; please connect with your local Policy Stewardship Office to determine the local approach.

- At Island Health, we learnt that each procedure needs to be anchored to an associated policy in order to be implemented. We set out to create a policy and a procedure to incorporate best available evidence on providing multidose–medication products on discharge.

4. In the initiation stage, you may need to conduct a needs assessment, which outlines the rationale, urgency, desired outcome, stakeholders, risks of not having a policy, and feasibility.
    - At Island Health, the needs assessment is a critical early step. This was a specific form we obtained from our P&P webpage that included these and other fields.

5. Identify key roles for the document development, including the lead (probably you!) and development team, the sponsor (the primary champion, typically in a senior level leadership role), and the approval and issuing authority (typically at least one Quality Council)
    - For us, we determined the following roles:
        1. Development leads: Val Stoynova, Celia Culley – The Critical Air Project leads
        2. Sponsor: Director of Pharmacy for Procedure (Executive Director for Policy)
        3. Approval and Issuing Authority: Medication Systems & Therapeutics Quality Council

6. Submit to the Policy Stewardship Office (or equivalent at your organization) and review and incorporate their feedback.

7. Create quality content using the approved templates. Ideally the first draft is as complete and thoughtful as possible, acknowledging that stakeholders will have feedback you hadn't considered, such as issues relating to professional practice and medication safety
    - We needed to familiarize ourselves with the scope of practice of nurses, particularly relating to dispensing from wardstock, including labelling of medications that could potentially be self–administered by patients while in hospital (medications remaining at the bedside) and after discharge.
    - We also needed to consider outpatient medication information systems, and how we could optimize the occurrences of these medications being manually added to our provincial system (Pharmanet) to improve communication to community pharmacists, primary care providers, and even back to the hospital, should be patient be readmitted
    - We included a section in the procedure specifically addressing environmental stewardship to provide this context to the readers.

8. Engage interested/invested parties to review the draft document

- Creating new hospital– or Health Authority–wide policies and protocols is a very time–consuming process that requires multiple rounds of stakeholder engagement and feedback. This is as far as we were able to get within the first year of The Critical Air Project.
- The remainder of the bullet points will illustrate the anticipated steps for which we are planning while engaged in the stakeholder feedback process.

9. Implement the Policy Document Review Process and Final Approvals specific to your organization
    - Examples include present the document to governance bodies relevant for approval

10. Prepare for change in practice and roll out. The document will need to be submitted for posting to the P&P site and there will be a number of implementation steps.
    - Identify barriers to implementation and work with your issuing authority to determine what resources will be needed to support implementation, specific to your organization
    - Considerations for implementation include communication of new policy, change management strategies, interprofessional educators, and practice consultations
    - Engage with nurses, pharmacists, and pharmacy technicians about the procedure, but also communicate to prescribers so they are aware patients could be sent home with hospital dispensed inhalers under certain circumstances outlined in the procedure

11. Evaluate the new document
    - A preliminary review should be done within 6–12 months to observe whether practice had changed compared to the baseline survey results

- Key stakeholders:
    - Clinical pharmacists
    - Operations pharmacists
    - Pharmacy Technicians
    - Nursing leadership and educators
    - Nurses
    - Physicians
    - Pharmacy leadership
    - Patients and families
    - Professional Practice
    - Medication Safety
    - Risk Management
    - Quality Councils

- Policy Stewardship Office

Tamper sealing the inhaler cap

1. Where is the inhaler tamper seal located on inhalers at your hospital? Engage with pharmacy staff (technician or pharmacist supervisor) about the history and rationale for tamper seal location.
    - We reached out to pharmacists and pharmacy technicians at all inpatient hospitals across Vancouver Island to enquire about their tamper seal practice.
    - The inhaler tamper seal is in one of two locations. At our two tertiary centers, the tamper seal is located across a plastic bag that contains the inhaler. At all other centers, the inhaler tamper seal is situated across the inhaler cap.
    - At our tertiary care centers, the staff cited infection control concerns as the underlying motive to tamper seal the plastic bag rather than the cap.

2. Are there any unintended consequences to this location?
    - At RJH, the tamper seal is placed across a plastic bag that contains the inhaler. Once on the ward, the inhaler is placed in a patient's designated drawer on a medication cart by nursing. This plastic bag does not fit in the medication drawer and our survey shows that a significant percentage of nurses immediately remove the inhaler from the plastic bag to place it in the patient–specific medication drawer, thereby breaking the tamper seal.

    - Once the tamper seal is broken, there is no reliable way to determine whether the inhaler has been used by the patient. Therefore, each inhaler without a tamper seal will be sent for disposal at the end of a patient's hospital stay, whether it has been in contact with the patient or not.

    - This leads to waste of unused inhalers that could otherwise be repurposed, increased pharmaceutical disposal costs for the Health Authority and significant climate impact due to the carbon intensive nature of MDIs.

    - Please see the diagram in the briefing note for a visual representation.

3. Discuss your proposal with infection control to receive their approval.
    - We spoke with the head of infection control at Island Health who reviewed the two different tamper seal locations. They had no concerns about changing the location of the tamper seal to the inhaler cap.
    - This was a crucial step to alleviate staff concern since they described infection prevention as the main rationale for current practice.

4. Engage relevant stakeholders with your recommendations
    - We considered the impact of technician workflow including applying the tamper seal and the ease of determining whether the tamper seal is intact.

    - We considered the logistics of returning an inhaler to pharmacy from the nursing perspective, and how to safely repurpose the unused inhaler from an infection control standpoint.

5. Write your briefing note using the approved template at your site, outlining the tamper seal location, the unintended consequences, and proposed alternative solution(s) that account for the historical context.
    - Please see the attached briefing note as a Worked Example of the process at Island Health.
    - We made sure to include a relevant summary of the supporting literature; we did not assume any prior inhaler–related planetary health knowledge.

6. Present your briefing note to pharmacy operations leadership and then determine next steps for implementation, or necessarily modifications as you move towards a successful and sustainable change.
    - We discussed our findings and reviewed the briefing note with the pharmacy operations manager at Island Health, the pharmacy operations coordinators at both tertiary hospitals and the lead pharmacy technician supervisors at both tertiary hospitals.

- Key stakeholders
    - Pharmacy operations and leadership
    - Pharmacy technicians
    - Infection control

Prioritizing the inhaler wardstock

1. Review which wards have maintenance inhalers in wardstock, including in a night cupboard if the pharmacy is closed overnight.
    - At our tertiary hospital, we pulled data on wardstock using the Acudose–Rx software, which is derived directly from the automated dispensing cabinets.
    - We identified that none of the hospital wards' automated dispensing cabinets carry maintenance inhalers.
    - However, the Night Cupboard carried fluticasone and beclomethasone metered–dose inhalers, which are maintenance inhalers. The Night Cupboard is a room located within the tertiary care center that can be accessed by nursing overnight for urgently needed and commonly used medications when a pharmacist is not immediately available on site. (A pharmacist is always available on call.)

2. Review the evidence supporting the removal of maintenance inhalers from wardstock.
    - We have created a summary of the relevant literature to facilitate this for you, available in the introduction of this change idea.

3. Write a briefing note that estimates maintenance inhalers removed from wardstock which includes cost savings and anticipated carbon footprint reduction.
    - Please see the slides provided by a colleague in Fraser Health with a similar project. The original slides contain confidential data which has been redacted where appropriate.

4. Present your briefing report to pharmacy operations and discuss a start date for implementation.
    - We presented to nurses to explain the relevant changes and rationale.
    - We also presented to the pharmacy technicians to explain the changes and the rationale.

- Key stakeholders
    - Pharmacy operations coordinator
    - Pharmacy operations manager
    - Pharmacy technicians
    - Nurses

Clinical Order Set redesign

1. Identify existing clinical order sets at your institution that contain metered dose inhalers (MDIs)
    a) A Pharmacy Informatics Pharmacist extracted relevant information from our order set library.
    b) Our health authority is currently in a hybrid electronic medical record activation state, with some sites using electronic and some using paper order sets.
        i. Our tertiary hospital is still using paper order sets. There are currently 12 paper order sets that contain metered dose inhalers. Of those, we excluded nine order sets designed for critical care, emergency and/or pediatric populations, leaving three order sets to edit.
        ii. At other sites, there were 21 order sets with MDIs. Of those, we excluded 12 order sets designed for critical care, emergency and/or pediatric populations, leaving 9 order sets to edit.

2. Select among these order sets those that would benefit from incorporating a planetary health lens
    a) We recommend excluding critical care order sets from this review because critically ill patients likely lack the necessary inspiratory capacity to consider DPI devices. Additionally, at our institution, invasive and non–invasive ventilation support machine are not designed to use DPI devices. (Such machines are reportedly under development but have not yet been involved in clinical trials to our knowledge.)[28]
    b) We selected the COPD Exacerbation Admission Order set, the Bronchodilator Mini–set Order set and the Respiratory Inhalers and Nebulizers Mini–set Order set to review in the initial phase of The Critical Air Project.

3. Identify key stakeholders who are responsible for editing and implementing these order sets
    a. At our institution, the clinical order sets are all coming under review as part of a move to Computerized Provider Order Entry (CPOE). We contacted the lead for the clinical order set update for respirology to be added as interested subject matter experts, clearly stating our expertise as clinicians with a planetary health lens.
    b. We attended the group meetings where the order sets are being discussed. At our center, this is a multidisciplinary group that includes pharmacists, specialists, nurses, and informaticists

4. Highlight the climate impact of prescribing choices within the order set.
    a. We were somewhat limited by the preset boundaries of CPOE and our hospital formulary.
    b. We included lower carbon inhaler options where clinically relevant that had not been included previously (e.g. terbutaline, which is a novel addition to the hospital formulary – see relevant Change Idea for details), and requested that lower carbon options be placed higher in order on the order sets.
    c. We advocated to include the carbon footprint of each inhaler adjacent to the order entry, so that the relative carbon footprints are visible to the ordering provider whenever an inhaler is ordered.

5. Make it easy to access additional information on climate–conscious prescribing
    1. We included a link to reputable planetary health initiatives to facilitate finding further information for interested providers.

6. Make it easy for people to prescribe climate friendly alternatives

a) Consider adding a "green leaf" next to lower carbon options. This was an idea we considered, which unfortunately wasn't feasible (yet!) in the current EMR.
b) Consider making DPI inhalers a "tick box" while requiring MDIs to be manually selected. Make it easier for people to adopt a climate friendly practice where appropriate.

7. Stakeholder feedback
   a) The updated order sets were reviewed in a group setting that included nurses, pharmacists, physicians and IT specialists and relevant feedback was incorporated.

Key stakeholders

- Specialists
- Other prescribers
- Clinical Pharmacists
- Nurses
- Pharmacy Informatics
- Nurse Informatics