# PHARMACEUTICAL WASTE MANAGEMENT

Why • The Case for Change
What • The Tools for Change
How • The Strategy for Change

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Canada

CASCADES

# NAVIGATION

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# INTRODUCTION

**This playbook focuses on strategies to reduce, reuse and recycle pharmaceuticals and their associated physical waste to lessen their environmental impact.**

It is intended for Canadian healthcare professionals working with pharmaceutical products for human use, including pharmacists, pharmacy technicians, pharmacy assistants, nurses, physicians, educators, trainees and environmental services. It can also be a guide for legislators, waste management leads, and industry.

Background information, resources, and considerations are included to provide guidance on more climate resilient and environmentally sustainable pharmaceutical waste management processes. The content of this playbook has been compiled from a range of subject matter experts, guidance documents, and resources.

This document is not intended to provide or take the place of clinical guidance. Providers are encouraged to seek, appraise, and apply best available evidence related to prescribing. The examples in this playbook provide suggestions and ideas based on the current evidence. Environmental benefits and availability of practices will differ based on workflows, processes, type of healthcare facility, and geographical location.

**PHARMACEUTICALS** also known as medications, pharmaceuticals contain an active pharmaceutical ingredient (API), and non-medicinal excipients such as fillers, preservatives, and/or propellants for drug delivery (1). An API is the component designed to cause a chemically and biologically desired therapeutic effect (2,3).

**ASSOCIATED PHYSICAL WASTE** with pharmaceutical products includes packaging and repackaging, and consumables that are used in the manufacturing and administration process, such as personal protective equipment for sterile and hazardous drug compounding.

## Suggested citation

Lam I, Wong G. Pharmaceutical waste management. Version 1.0 (2025) . [Internet]. CASCADES (Creating a Sustainable Canadian Health System in a Climate Crisis). [Cited DATE]. Available from https://cascadescanada.ca/action-areas/pharmacy-and-prescribing/

# PLAYBOOK STRUCTURE

## WHY
### The Case for Change

An introduction to the issue being addressed in the playbook

## WHAT
### The Tools for Change

A structured presentation of the opportunities for action and resources to plan and implement change

## HOW
### The Strategy for Change

An outline of strategies for sustaining change

# WHY

## The Case for Change

1. Chemical Contaminants: Unique Risks of Active Pharmaceutical Ingredients (APIs)
2. Impact of Unused Pharmaceuticals

# Chemical Contaminants: Unique Risks of Active Pharmaceutical Ingredients (APIs)

**This section provides an overview of the different sources, routes of entry (Figure 1), and environmental impacts of pharmaceuticals (Figure 2), followed by the impacts of unused pharmaceuticals and associated physical waste.**

## PRIMARY ROUTE OF ENTRY OF APIs INTO THE ENVIRONMENT

The primary route of entry of APIs into the environment is through human excretion via urine and feces into sewage systems (4–7). High-density urban areas and hospitals connected directly to sewage systems are the main routes of entry into aquatic environments (8). In most cases, the sewage enters wastewater treatment plants (WWTPs) where some APIs are removed. However, as WWTPs are not designed to remove all APIs, even treated water contains APIs. This is reflected in studies detecting APIs in drinking water and rivers worldwide (9–12). Additionally, the by-product of WWTP, (i.e., sludge), may also contain APIs. Some sludge becomes biosolids that meet regulatory standards and can be transformed into fertilizer (13,14). Reducing the amount of APIs used and excreted can thus decrease the amount released into the environment.

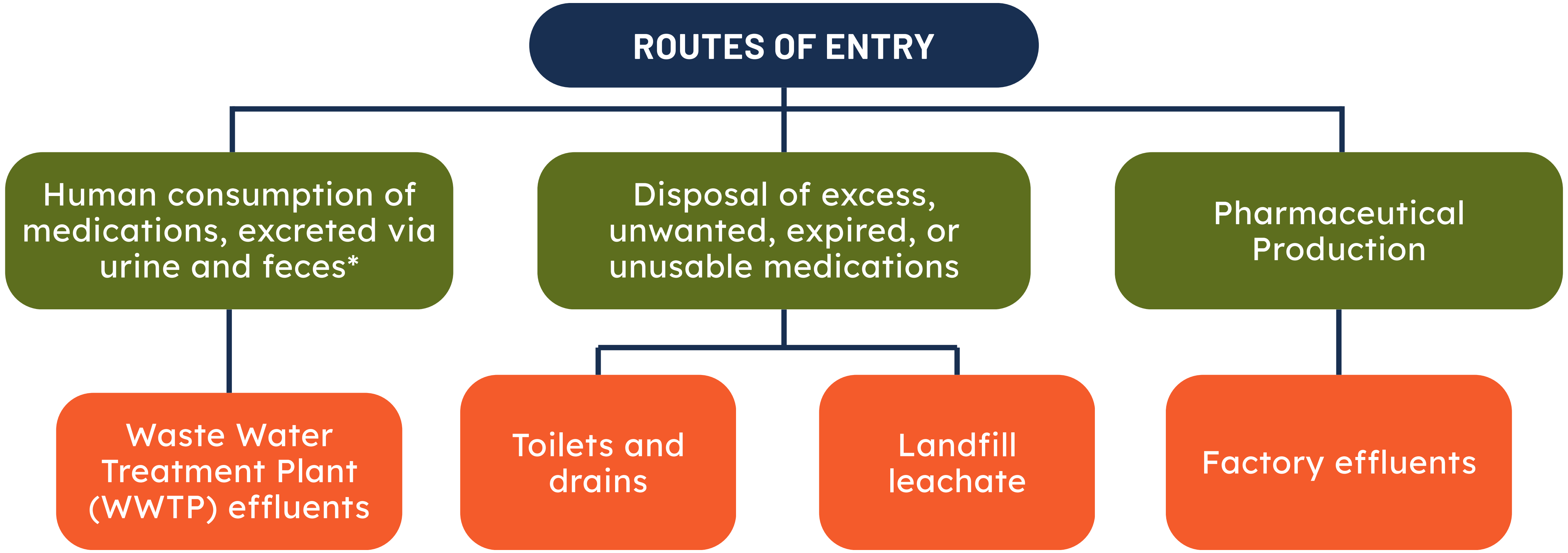



Figure 1. Routes of entry of active pharmaceutical ingredients for human consumption into the environment (16).

*Estimates in Switzerland indicate that pharmaceutical residues in water is mostly linked to patient use at 88%, followed by inappropriate disposal at 10% and production at 2% (OECD, 2018).

## IMPROPER DISPOSAL OF MEDICATIONS

APIs can also enter the environment when medications are improperly discarded, for instance into toilets, garbage, or sharps containers. Medications flushed down the toilet or sinks will enter the sewage system and at potentially higher concentrations than excreted medication, increasing their risk to the environment. Medications thrown into the garbage or into sharps containers may end up in landfills or at low-temperature incineration sites, both options which may not inactivate APIs, leading to their entry into waterways through leachate (15). Landfills are contaminated with APIs, including antimicrobials and antineoplastic medications, causing chemical pollution and promoting antibiotic-resistant bacteria, which are both growing public health concerns (15).

## ENTRY OF APIs INTO THE ENVIRONMENT FROM OTHER SOURCES

There are other ways APIs can enter the environment, such as through manufacturing and agricultural use (16,17). High concentrations of medications have been found in wastewater near manufacturing sites. A study of surface, ground, and drinking water in a major pharmaceutical production area for the global market found very high concentrations of many medications, including the antimicrobial **ciprofloxacin**.

### CIPROFLOXACIN

Ciprofloxacin was found in very high concentrations in tested effluent from the WWTP and two lakes, highlighting insufficient water processing to remove APIs (10). This directly impacts human health given the prevalence of fluoroquinolone resistance in Escherichia coli (18) and Neisseria subflava (19) is positively correlated with the concentration of ciprofloxacin in the environment.



APIs pose unique risks to the environment as they not only contribute to physical waste but are also chemical agents. Issues arise when these chemicals unintentionally impact other organisms. Aquatic animal body tissues can absorb APIs in their environment (18), with concentrations of APIs found in aquatic ecosystems known to cause acute and chronic toxicity (15).

For example, exposure of diclofenac in aquatic systems was suspected to cause damage to the inner organs of rainbow trout (20), while estrogen led to the collapse of a fish population in isolated Canadian lakes (21). APIs can also enter scavenger animals through the food chain, as was the case of the population collapse of vultures in Southeast Asia, where in only 5 years, diclofenac was responsible for killing 99.9% of the white-rumped vultures (Gyps bengalensis) (22).

For more information on the effects of estrogen and diclofenac, watch: [Pharmaceuticals and the Environment: Impact on non-target organisms.]

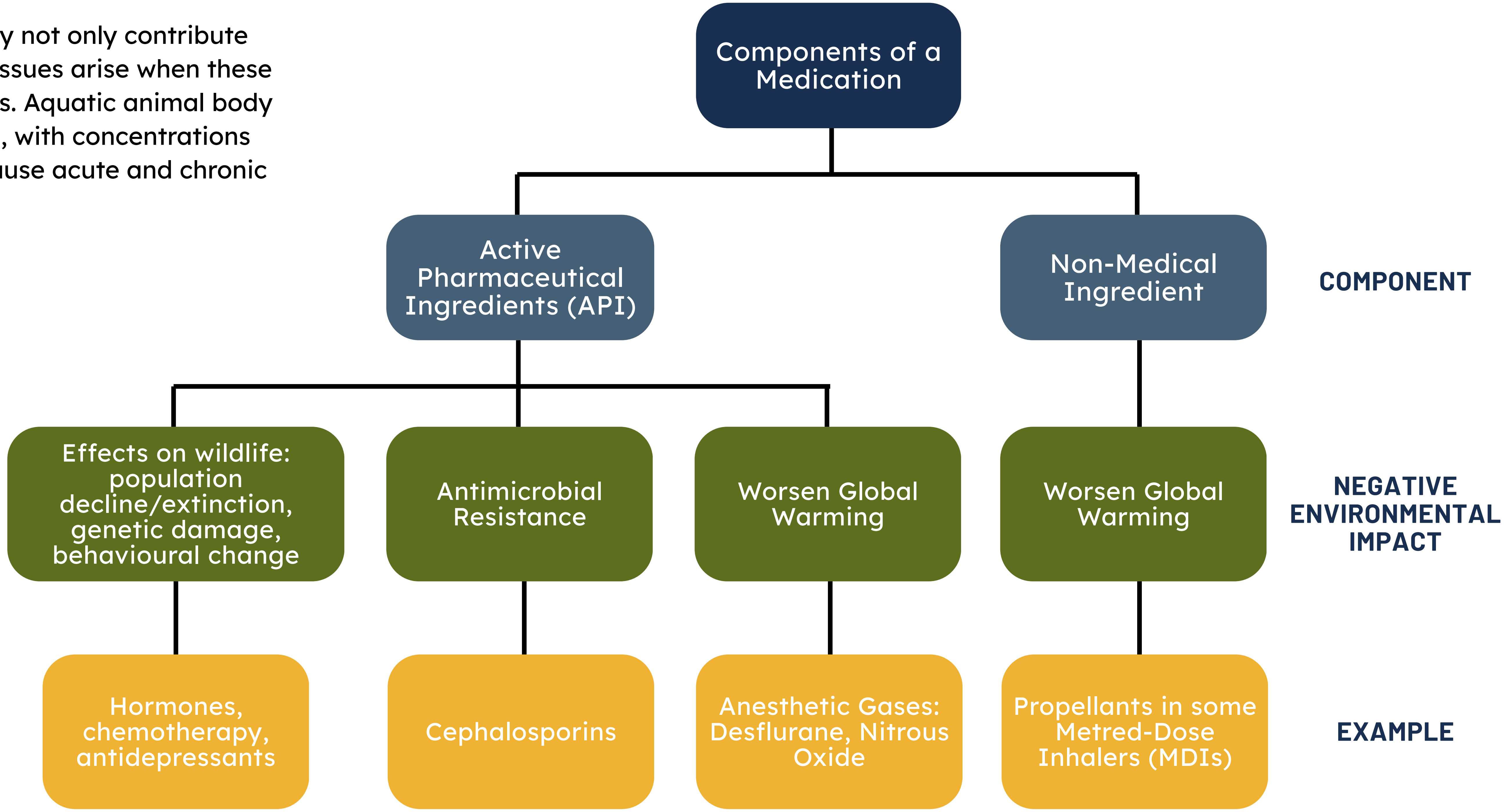



Figure 2. Environmental impact of medications (21,23–27).

# Impacts of unused pharmaceuticals

**Canadians waste over $100 million of unused pharmaceuticals annually (28).**

Given the known harms they exert on biological organisms, pharmaceuticals should be destroyed through inactivation or shielded from entering the environment. The most common method of API inactivation in Canada is destruction using high-temperature incineration above 1200°C (29,30). In contrast, regular municipal waste incinerators are usually at lower temperatures between 780°C to 1200°C (31), which may be insufficient to inactivate all APIs.

Table 1: Carbon Footprint of Different Methods of Waste Management (34,35)

| Treatment Method | Carbon Footprint |
|---|---|
| High-Temperature Incineration | 1075 kg $CO_2$e/t* |
| Autoclave Decontamination + Low Temperature Incineration | 569 kg $CO_2$e/t |
| Low Temperature Incineration | 337 kg $CO_2$e/t |
| Recycling | 167 kg $CO_2$e/t |

*CO2e/t stands for Carbon Dioxide Equivalent per tonne

While there is clear harm from APIs entering our environment, the process of incineration itself has an environmental impact. In Canada, waste incineration has been historically responsible for a significant portion of atmospheric dioxin and furan emissions, which are toxic, persistent, and can accumulate in biological tissues (32). Despite greatly tightening its air quality standards over the past several decades, waste incineration facilities remain the second largest source of dioxin emissions, approximately 22.5% of total dioxin emissions within the country (33). Additionally, when comparing the carbon footprint of the different methods of waste management streams, in the absence of waste-to-energy offsets, high-temperature incineration has the highest global warming potential - greater than recycling, autoclaving, and landfilling (Table 1) (34,35). High temperature inactivation should be reserved for medications and cytotoxic contaminated waste and avoided for supplies and packaging. Ultimately, prioritizing waste prevention of APIs at production and distribution stage can potentially reduce the volume waste requiring inactivation treatments.

**Considerations for wasted medications should not end at recognizing the harms from disposal, but also from the wasted emissions from creating those medications in the first place.**

Canadians spent an estimated $50 billion on medications in 2024 (36,37). The energy required to produce those medications is approximated to be equivalent to 2,430,000 metric tons of $CO_2$ equivalents ($MtCO_2e$), or consuming over 1 billion litres of gasoline (see calculations for carbon footprint of medication use in Canada). This figure includes only emissions from pharmaceutical production and distribution, not from use and managing their waste. Prescription and non-prescription medications account for 25% of all healthcare-related greenhouse gas emissions in Canada (38). Emissions occur at each step of the production process, from raw material extraction, manufacturing, packaging, distribution, and material disposal.

## CALCULATIONS FOR THE CARBON FOOTPRINT OF MEDICATION USE IN CANADA

- Total pharmaceutical sector average emission intensity: 48.6 Mt-$CO_2$e/ millions of dollars (41).
- Expected total health care spending in Canada (2024) = $372 billion (36)
- Drugs as a percent of health care spending = 13.7% (42)
- Total Canadian spend on prescription medications = $50,964,000,000 (43)
- Emissions = 48.6 Mt-$CO_2$e /1million x $50 billion = 2,430,000 Mt-$CO_2$e (38)
- Greenhouse Gas Equivalencies Calculator = 1,035,194,829 litres of gasoline consumed (44)

**The most effective and environmentally sustainable method to manage pharmaceutical waste is to avoid generating the waste in the first place.**

When we dispose of medications, all the energy spent on creating them in the first place is also wasted. Additional energy needs to be spent to replace medications that have been discarded. Figure 3 is a simplified illustration of the medication journey from source ingredients to waste treatment and depicts the multi-step processes that occur before and after medication use. It reveals the vast amount of resources, energy as well as emissions of various types that are emitted throughout. For most medications, the largest carbon footprint is during production and distribution (39,40).

### Associated physical waste

Associated physical waste for pharmaceutical products includes items such as packaging, repackaging, components and consumables needed in the manufacturing and administration process including personal protective equipment used for sterile compounding and handling hazardous drugs. Given the difference in cost, carbon footprint (Table 1), and negative environmental consequences (Figure 3), associated physical waste should largely be managed separate from pharmaceutical waste.

For more information on associated physical waste sorting and specific medication recycling programs, see waste segregation.

# MEDICATION FROM SOURCE TO WASTE TREATMENT

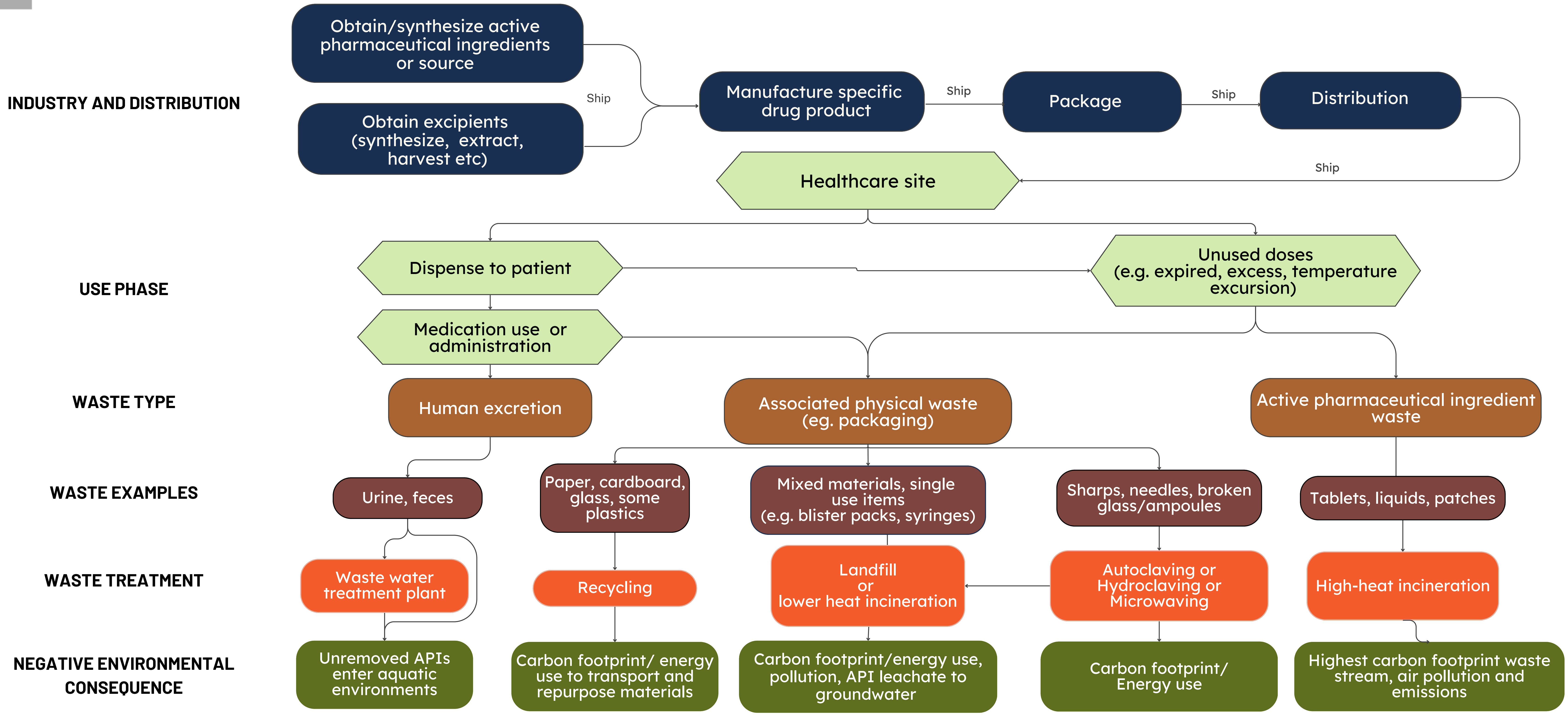



Figure 3. Journey of medication from source to waste treatment with negative environmental impacts of each waste management stream.

# WHAT

## The Tools for Change

1. Reduce
2. Reuse
3. Recycle

# Action Areas

This section showcases ideas that could decrease the environmental impacts of pharmaceuticals and their associated physical waste. The actions have been separated by **waste types** (pharmaceutical waste or associated physical waste) and **waste management streams** (reduce, reuse, recycle).

| WASTE TYPE | REDUCE | REUSE | RECYCLE |
|---|---|---|---|
| **PHARMACEUTICAL WASTE** | Action 1: Embed sustainability into medication assessments<br>Action 2: Manage inventory to reduce waste | Action 5: Redispense suitable medications | Not Applicable |
| **ASSOCIATED PHYSICAL WASTE** | Action 3: Reduce packaging<br>Action 4: Reduce administration supplies | Action 6: Choose reusable materials | Action 7: Segregate waste materials |

There is tremendous opportunity to decrease the environmental impacts of pharmaceuticals and their associated physical waste. The most effective waste strategy is not creating the waste in the first place, followed by a transition to a circular economy in which products are reused as much as possible (45).

*Not Applicable as unwanted medications are not currently broken down and transformed into a new product.

Action 1

# EMBED SUSTAINABILITY INTO MEDICATION ASSESSMENTS

There are many opportunities to embed environmental sustainability into prescribing. Assessment of medications typically include considerations for indication, efficacy, safety, and adherence (47). Sustainability actions can be applied to each of these considerations, whether medication assessments are being done at the point of prescribing, initial dispensing, refill, or during annual medication reviews. This section details specific opportunities for reducing pharmaceutical waste and its associated physical waste.

| | INDICATION | EFFICACY | SAFETY | ADHERENCE |
|---|---|---|---|---|
| CONSIDERATIONS | Is there a clinical indication for this medication? | Is the medication meeting the goals of therapy? | Are there any contraindication, interactions, side effects, or signs of toxicity? | Is the patient willing and able to use the medication? Is the patient taking the medication as prescribed? Is the medication meeting the patient's goals of therapy? |
| SUSTAINABILITY OPPORTUNITIES | A. Avoid unnecessary medications<br>B. Optimize current medications<br>C. Consider pharmacological alternatives | | | D. Avoid automatic refills<br>E. Minimize initial quantities<br>F. Encourage take-back of unused medications to pharmacies |
| DESIRED OUTCOME | Decrease medications being used and excreted | Decrease risk of hospitalization | Avoid harmful medication use, hospitalization, and protect organs, such as kidneys. | Decrease unused medications ending up in the environment |
| SUSTAINABILITY OUTCOME | Decrease APIs in sewage systems | Decrease emissions from use of healthcare | Decrease emissions from APIs, hospitalization, and high carbon outpatient treatments such as dialysis. | Decrease medications in landfills or flushed down drains |

## A. AVOID UNNECESSARY MEDICATIONS

- Consider non-pharmacological alternatives
  - Non-pharmacological options should be considered as monotherapy or as an adjunct if clinically appropriate and preferred by patients. They can help avoid initiation of a medication, use a lower dose, or support patients during medication deprescribing. Many non-pharmacological options are low risk, cost-effective, better for the environment, and have other health co-benefits.

## A. AVOID UNNECESSARY MEDICATIONS (CON'T)

- Exercise
  - Exercise has been associated with lowering the risk of mortality, cardiovascular disease, hypertension, type 2 diabetes, anxiety, depression, certain cancers, dementia, and weight gain, while improving bone health, cognition, quality of life, and physical function (48,49). There are minimum levels of intensity, type, duration, and quantity of physical activity needed to benefit health. For example, in an adult, a minimum of 150 minutes of moderate to vigorous aerobic exercise with muscle and bone strengthening activities two times a week are recommended.

### **SPOTLIGHT:** EXERCISE AS A TREATMENT

The Canadian Network for Mood and Anxiety Treatments (CANMAT) 2023 update on the clinical guidelines for management of major depressive disorder in adults recognize supervised exercise as first line monotherapy for mild depression and second line adjunctive treatment for moderate severity illness in patients with mild severity and low safety risk.

Exercise increases serotonin and dopamine, and can increase feelings of confidence, self-esteem, and sense of control over mood (50). Exercise may also be used as an adjunct to support patients on a pharmacological deprescribing regimen while tapering medications for mood. Healthcare providers can share a patient education sheet for those who are getting started or refer the patient to a social prescribing program (where available).

**Example Prescription:** Depression

Exercise : brisk walk, light cycling or water exercise
Intensity : moderate intensity that increases heart and breathing rate
Length : 30 minutes
Frequency : minimum 3-5 times a week

Learn more

**RESOURCES:**

- Exercise and Depression Toolkit, Campus Mental Health
- Communication Toolkit, Canadian Society for Exercise Physiology (CSEP)
- Primary Care Toolkit, CSEP
- Canadian Physical Activity Guidelines, CSEP
- Exercise is Medicine worksheets, American College of Sports Medicine (ACSM)
- Exercise Prescriptions in Older Adults, Lee PG, Jackson EA & Richardson CR (2017)

## A. AVOID UNNECESSARY MEDICATIONS (CON'T)

- Nature Prescribing
  - Exposure to greenspace is associated with improvements in health, including reductions in the incidence of stroke, hypertension, dyslipidemia, asthma, and coronary heart disease (51). Nature prescribing is not only good for patients, but also good for the environment by encouraging communities to preserve green spaces.
  - **The recommended minimum is 2 hours a week, for 20 minutes at a time. For more information and to register as a prescriber, visit PaRx.**

- Social Prescribing
  - Social determinants of health are social and economic factors that influence health, such as income, education, employment, and social supports (52). Social prescribing is an approach where healthcare providers that identify a social need can connect patients to non-medical, health-related social resources.
  - Social prescribing has been shown to reduce the number of repeat primary and emergency care visits (53), and increase a sense of social connectedness (54), a particularly important connection in an era of increasing climate disasters, such as wildfires and extreme weather events. Healthcare providers can refer patients to a social prescribing connector. The connector finds community supports and resources the patient can participate in and follows up with the patient to ensure the activities are appropriate and meet their desired health outcomes.

- Viral or Delayed Antimicrobial Prescriptions
  - An estimated 30-50% of antimicrobial prescriptions for respiratory tract infections in community practices are deemed unnecessary (59). Overuse of antimicrobials not only has a carbon footprint resulting from drug production but also results in antimicrobial resistance through drug excretion and improper disposal. (28,60). Providing patients with 'viral prescriptions' (i.e. rest, fluids, use of OTC when appropriate) can still provide patients symptom management for their illness without the use of antimicrobials (see: ChoosingWisely). Delayed prescriptions can also be used where a prescription is post-dated if the patient's condition worsens to avoid going back for a visit in case a bacterial infection is suspected, or a swab has been collected.

### RESOURCES:

- Social and Nature Prescribing Playbook, CASCADES
- Canadian Institute of Social Prescribing (CISP)
- Social Prescribing resource for health professionals, Centre for Effective Practice
- Social prescribing in pharmacies: What is it, does it work and what does it mean for Canadian pharmacies?, Hussein T et al. (2024)
- Using Antibiotics Wisely, Choosing Wisely
- Prescription Tools, Choosing Wisely
- The Cold Standard Toolkit, Choosing Wisely
- Why is Antimicrobial Stewardship Important?, University Health Network Patient Education

## A. AVOID UNNECESSARY MEDICATIONS (CON'T)

- Deprescribing
  - Deprescribing, a pillar of medication optimization, is the process of reducing a medication dose, stopping the medication, or switching the medication to a safer alternative (55). Deprescribing can benefit patients with polypharmacy (56) and also has environmental co-benefits as using less medications reduces the amount of APIs entering the environment. Non-pharmacological adjuncts can also be added when implementing deprescribing and tapering algorithms.
  - While many helpful tools (see Resources) target specific medications for deprescribing due to considerations such as their prevalence or risk of harm to patients, deprescribing can also target medications with a larger carbon footprint, such as metered-dose inhalers. About 33% of patients with physician-diagnosed asthma have no evidence of the disease. 26% of patients on using daily asthma-controlling medications were deemed not to have asthma on reassessment and 96% remained symptom free 12 months after stopping their medications (57).
  - This highlights the overuse of inhalers and importance of spirometry or other objective testing to confirm respiratory illness diagnoses (58).

### RESOURCES:

- Deprescribing Algorithm, American Academy of Family Physician
- Medication Optimization for Sustainability in Inpatient Care, CASCADES
  - Resource Tool Box
- Deprescribing, Deprescribing.org
- American Geriatrics Society 2023 updated AGS Beers Criteria for potentially inappropriate medication use in older adults, (2023)
- STOPP/START criteria for potentially inappropriate prescribing in older people: version 3, (2023); with list of recommendations in Appendix 1)
- Climate Conscious Inhaler Prescribing in Outpatient Care, CASCADES

## B. OPTIMIZE CURRENT MEDICATIONS

Medications should be optimized to ensure chronic conditions are well-controlled. This can include increasing or decreasing the dose, adding non-pharmacological adjuncts, or changing therapy. When a patient's condition is well controlled, they are less likely to require access to emergency and hospital services for that condition, which is one of the largest carbon footprint categories in healthcare, second only to medications (38).

### **SPOTLIGHT**: INHALERS

The maximum need for a reliever is 2 or less doses per week for a patient with well-controlled asthma according to the Canadian Thoracic Society (61). For patients on salbutamol metered dose inhalers, this amounts to dispensing at most 2 inhalers per year. Pharmacy staff can check their dispensing history and discuss with patients who have refilled more than two salbutamol inhalers a year whether the issue is with losing their inhaler, not being able to tell how many doses are left in the inhaler, potential exacerbating triggers, inability to operate the inhaler properly, or if their disease is not well controlled. For patients will poorly, controlled asthma, they may require additional assessments.

Healthcare professionals should also keep in mind that patient technique deteriorates over time, and patients should be encouraged to bring their inhalers to demonstrate their use.

Not only is poorly controlled asthma bad for the patient, it is also bad for the environment, with a 3.1 times greater carbon footprint than patients with well-controlled asthma (62).

Learn more

Additional Example of Current Medication Optimization:

- Feasibility of an Individualized Dispensing Program for Patients Prescribed Oral Anticancer Drugs to Prevent Waste (Netherlands)

# C. CONSIDER PHARMACOLOGICAL ALTERNATIVES

There is currently limited data to help apply a sustainability lens when considering pharmacological alternatives. The overall carbon footprint of a product will depend on many factors, including where the source materials are mined, how the APIs and excipients are manufactured, and how far the materials must travel before it reaches their final destination (63). Since much of this information is proprietary, it is difficult to make in class and between class drug comparisons. The most robust environmental assessments are cradle to grave life cycle assessments (LCAs), an internationally recognized and standardized assessments of a product's environmental impact (64). There are currently very few carbon footprint analyses and LCAs available for pharmaceutical products, with inhalers and anesthetic gases being the exception where comparisons can be made (Table 3).

Beside LCAs, other environmental impact data from research on APIs can be used for decision making (Table 3). Considerations in Region Stockholm's Pharmacy and the Environment classification system include a medication's environmental hazard defined as persistence, bioaccumulation, and toxicity, and rating the likelihood of toxic effects on aquatic organisms, expressed as risk (65).

| | ISSUE | EXAMPLE PRACTICE CHANGE | RESOURCES |
|---|---|---|---|
| LIFE CYCLE ASSESSMENT | Metered dose inhalers (MDIs) have the largest carbon footprint of all inhaler types due to its propellant. | Prescribe/recommend dry-powder inhalers and soft-mist inhalers preferentially for new prescriptions if clinically indicated and the patient is agreeable. | PRESQUIPP inhaler carbon footprint<br>CASCADES Inhaler Coverage Chart<br>Inhalerguide.ca |
| LIFE CYCLE ASSESSMENT | Desflurane has the largest life cycle greenhouse gas impact among anesthetic drugs. | Remove desflurane from formulary. | Life Cycle Greenhouse Gas Emissions of Anesthetic Drugs<br>CASCADES Eliminating Desflurane |
| ENVIRONMENTAL IMPACT | Diclofenac has known toxic effects on vultures and some aquatic animals. | Remove diclofenac from formulary.<br><br>Consider other anti-inflammatory or pain alternatives such as acetaminophen or meloxicam. | Region Stockholme Pharmacy and the Environment |

Table 3: Examples of medications where data is available for environmental considerations.

## D. Avoid Automatic Refills

Automatically refilling medications without talking to the patient is a missed opportunity to assess a patient's actual medication use. About 50% of patients are non-adherent to medication therapy, with forgetfulness cited as one of the most common reasons for missing doses (66). Patients on chronic medications may end up with a large surplus supply of medications if their prescriptions are automatically refilled.

Other than forgetfulness, there are other reasons why patients may not be using their medications as prescribed, including cultural beliefs and issues with access (67). Having conversations with patients helps disclose any issues that might be resolved and avoid medications from being unnecessarily dispensed only to be discarded.

## E. Minimize Initial Quantities

Discontinuation of medication therapy occurs more frequently at the initiation phase with an estimated 20% of drugs stopped due to adverse drug reactions (68), thus providing an opportunity to maximize medication resources.

Many provinces have limits on the quantity that can be dispensed on first fills, from 7 to 30 days. Pharmacists can also use their discretion to reduce the amount of controlled substances dispensed using part-fills in consultation with the patient. Part fills are dispensing a lesser quantity than the amount specified by the prescriber, and may be done by request of a patient, when a pharmacy is dealing with an inventory shortage or other situations where the nature of the part fill is a matter of discussion between the pharmacist and patient (69).

## F. Encourage take-back of unused medications to pharmacies

Many Canadian provinces encourage return of unused medications to pharmacies through voluntary or regulated take-back programs. Educating patients on medication take-back programs can help reduce the amount of inappropriately disposed unused medications (74). Pharmacy staff can routinely educate patients to return unused medications during medication reviews and counselling sessions.

**RESOURCES:**

- Database Summary, HealthcareLCA

## **SPOTLIGHT**: ONCOLOGY

A study by an American specialty pharmacy split the initial quantity on the first fill of anticancer medications from 28 - 30 days to 14 - 16 days' supply, given that discontinuation rates range from 35-70% in this group of medications (Table 4). Reasons for discontinuation included toxicity, progression to another therapy, dose increase, or death. Estimated savings from implementing such a program were $2,646.74 monthly per patient at a single pharmacy, with a co-benefit of reducing the amount of medication waste generated (70).

Table 4: Anticancer medications studied for reduced initial quantities (70–73).

- Bexarotene
- Ceritinib
- Crizotinib
- Dasatinib
- Erlotinib
- Everolimus
- Nilotinib
- Pazopanib
- Sorafenib
- Sunitinib
- Vorinostat

Examples of provincial programs allowing pharmacists to reduce initial quantities:

- Trial Prescription Program, British Columbia

  Learn more

- Trial Prescription Program, Saskatchewan

  Learn more

Action 2

# MANAGE PHARMACEUTICAL INVENTORY

## AVOID KEEPING MEDICATIONS UNTIL THEIR EXPIRATION DATES

Inventory management, which includes purchasing, preparation, and dispensing processes, can help minimize medication waste. In general, reducing stock volume can help reduce medication waste and its accompanying costs. Strategies to do so include calculation of optimal stock volumes, and first-in-first-out principle. Stock levels should be regularly reviewed and ensure that only the minimum necessary quantity of each medicine is kept. Expiration dates should be checked during restocking to ensure earlier expiring medications are kept closer to the front and avoid dispensing expired products (75).

**INFO:**
While some pharmaceutical companies provide credit for unused medications in its original packaging, these medications are not reused or recycled, but are sent for destruction by incineration (76).

**RESOURCES:**

- Steps to return your expired or unused medications, Health Products Stewards Association
- Inventory of recycling programs in Canada - See Pharmaceuticals, Government of Canada
- Returning Medications, Health Products Stewards Association

## MAINTAIN COLD CHAIN

Temperature excursions can lead to significant product loss or safety concerns if administered to patients. Many public health agencies have inventory management guidelines for vaccines and refrigerated products.

### TIPS WHEN ORDERING COLD-CHAIN PRODUCTS

- Do not order more than the refrigerator's capacity.
- Avoid over ordering during a back order.
- Estimate supply based on monthly or seasonal averages.

### TIPS TO AVOID POWER DISRUPTIONS AND MINIMIZE TEMPERATURE EXCURSIONS

- Create a backup plan for electricity disruption to protect refrigerated items. Always have an alternative means of storage available.
- Mark refrigerator electrical plug clearly so the refrigerator is not unplugged or turned off accidentally.
- Use plugs with a generator back-up preferentially for medication and vaccine refrigerators.
- For healthcare facilities, require all medication fridges to have centralized and monitored remote temperature alarms. All medication fridges should be easily identified and flagged for proper maintenance and in the event of a power outage.

### SPOTLIGHT: NOVA SCOTIA

The Nova Scotia College of Pharmacists' 2025 practice policy on refrigeration of drugs, vaccines and biologics requires pharmacies to have temperatures maintained for public health vaccines throughout a power outage and not require human intervention for the first 24 hours.

Options to fulfill this requirement include using a:

- refrigerator that maintains the temperature without a power source
- battery backup
- generator (77).

### RESOURCES:

- National Vaccine Storage and Handling Guidelines for Immunization Providers 2015, Government of Canada
- Vaccine Storage and Handling Guidelines for Immunization Providers, Nova Scotia Department of Health and Wellness
- Vaccine Storage & Power Outage Guidelines & Tips, City of Toronto
- Power Outages and Vaccine Storage Checklist, City of Toronto

# Action 3 REDUCE PACKAGING

Life cycle assessment comparisons of oral medication packaging between bottles, blisters, and sachets revealed blister packaging having the worst environmental profile (78,79). Other general considerations can be made when looking to purchase different packaging of the same medication.

Choose packaging that has (78–81):

- Less weight
- Less unnecessary packaging or elements
- Less empty space for bottles and sachets
- Less space between medications for blister packs
- Most compact packaging
- Packaging that is more easily recyclable, such as those made of a single material

In general, larger medication quantity pack sizes reduce the carbon footprint of each individual pill, meaning large hospitals and high-volume community pharmacies that can use whole large quantity bottles before the product expires can save on the plastic used versus small quantity bottles. However, the carbon footprint of pharmaceutical manufacturing outweighs that of packaging manufacturing. Thus, package size should be selected based on medication use patterns instead of maximizing quantity per bottle.

## SPOTLIGHT: SUCCESSFUL COLLABORATION TO DECREASE PACKAGING WASTE IN SPAIN

The SIGRE program in Spain is an example of a successful collaboration between the pharmaceutical industry, pharmacies, and pharmaceutical distribution companies. The initiative aims to ensure proper environmental management of unused patient medications and packaging. Patients are encouraged to return expired and unused medications in their original packaging, medication boxes, and even empty packaging. The collection bins are left in pharmacies for patients to deposit their waste, eliminating the issue of healthcare providers handling patients' health information. Patients do not have to take the extra step of separating oral medications from packaging, making it easier to properly dispose of pharmaceutical products. The SIGRE treatment plant separates recyclable packaging, non-hazardous waste, and hazardous waste.

Due to waste segregation occurring at the SIGRE facility, they can advise and collaborate with manufacturers to improve the environmental sustainability of packaging through eco-design measures. In 2018, SIGRE reported 2,327 eco-design measures being applied, resulting in improvements to over 470 million containers and a 23% reduction in the weight of pharmaceutical packaging from 2000 to 2017 (82).

VIDEO:
What is SIGRE and what is Point SIGRE

SIGRE has also created an interactive platform, ecoPHARMACY, with actions pharmacies can take to reduce their environmental impact.

## Action 4 REDUCE ADMINISTRATION SUPPLIES

The number of resources and supplies needed to administer a medication is another waste consideration. Oral medication administration creates less waste than intravenous (IV) administration (83–85), while IV push using syringes produces less waste than IV infusions using IV bags and tubing sets (86).

### SPOTLIGHT: FRASER HEALTH TRANSITIONS TO IRON SUCROSE INTRAVENOUS (IV) DIRECT INJECTION IN HEMODIALYSIS (HD) CLINICS

Over 2000 doses of iron sucrose are administered intravenously every month at Fraser Health HD clinics. The method of administration is traditionally by IV infusion, meaning over 2000 IV tubing sets and 2000 normal saline (NS) bags were also being used every month. An initiative was rolled out to switch from IV infusion administration to IV direct administration.

Based on monthly results, annual savings of medical waste were estimated to be 1548 kg, enough to fill 77 garbage cans. With reduced use of IV tubings and mini-bags, this resulted in annual cost savings of $153,360 per year. The outcome of this initiative resulted in low adverse events from IV push, similar to adverse events rates by IV infusion, and staff administering the medication reported that overall workload was not affected.

Learn more

Another Example on Reducing Administration Supplies

- Switch from IV Acetaminophen to oral use: The paracetamol challenge in intensive care: going green with paracetamol (Netherlands)

# REUSE

**Although reuse in pharmaceutical waste management is not yet mainstream, some international examples of small scale programs and pilot projects showcase initiatives that promote safe, regulated redistribution of medications and use of reusable pharmaceutical packaging and supplies.**

## Action 5 REDISPENSE SUITABLE MEDICATIONS

### HEALTHCARE FACILITIES

Approximately 30 to 50% of unused medications are not redistributed to patients, and instead placed in the waste stream, with barriers noted to be infection control, workload, inadequate staffing, time constraints, and lack of procedure or processes (87).

Three British Columbia hospitals collected oral solid medications from nursing units, and determined an estimated 460,000 units of medications could be diverted from incinerators across 21 sites. The cost of the medications was estimated to be about $415,000 annually, sufficient to off-set the labour cost of returning medications with savings to the overall healthcare system (88).

Canadian hospitals and bed-based facilities need to maximize the recirculation of usable medications that are not expired, damaged, or from outbreak areas. Procedures and processes to address infection control and workload should be addressed. Designated staff should be given protected time to restock and credit returns to ensure the success of such programs.

**RESOURCES:**

VIDEO:
Fraser Health Medication Recirculation Project

## DRUG DONATION PROGRAMS

Drug donation programs take returned unopened, unexpired medications and redistribute them to qualified patients. By reusing medicines that would have otherwise been discarded, medication waste is reduced and there is increased access to those who need them. A Dutch study found a fifth of returned medications are unopened, undamaged and have a remaining shelf-life exceeding 6 months, making them eligible for redispensing (89).

In the United States of America, an estimated $5 billion of medications are thrown out every year from hospitals and long-term care facilities. Instead of discarding all these medications, most states have drug donation and reuse programs, also referred to as drug repository programs. Some states also accept medications that have been dispensed to patients. Drug donation programs have a number of common provisions for recirculating donated medications which include (90):

- All prescription drugs must be unopened and in sealed, tamper-evident packaging.
- Expiration dates must be visible, and drugs must not expire before use.
- All products must be checked by a pharmacist prior to being dispensed.
- Adulterated or misbranded medications are not accepted or transferred.

For more information on state repository systems:
- State Prescription Drug Repository Programs
- Oncologic drug repository programs in the United States
- Sustainable use of medications: Medication waste and feasibility of redispensing

### **SPOTLIGHT:** WASTE REDUCTION THROUGH RE-DISPENSING UNUSED ORAL ANTICANCER DRUGS

Cancer drugs are classified as contaminants of emerging concern because of their hazardous impact on the environment. They are often found in aquatic ecosystems and even drinking water supply (91). One study demonstrated a 68% reduction in oral anti-cancer drug waste through redispensing. (92).

The ROAD study was a study conducted in the Netherlands that demonstrated the effectiveness of redispensing unused medication. This was a prospective, single-group, multicentre intervention study done to evaluate the effect of redispensing unused oral anticancer drugs on waste reduction and net cost savings. The study found that for every eight patients using oral anticancer medications, waste from one patient was avoided (92). Therefore, drug donation programs can be a beneficial way to decrease cancer drug waste.

In 2020, the American Society of Clinical Oncology released a position on drug repository programs in support of such programs for oral cancer medications. They note the impacts of cancer drugs on the environment and cost as important factors in determining their support of these programs (93,94).

## INTERNATIONAL EXAMPLES OF PHARMACY TO PHARMACY EXCHANGE NETWORKS

Pharmacy to pharmacy exchange networks allow pharmacies to buy and sell surplus medications to help prevent medications from expiring and being wasted. Examples of online platforms include Pharmaswap in the Netherlands and Medicycle in the United Kingdom.

Pharmaswap was created by two pharmacists in Netherlands with the goals of reducing storage costs, minimizing medication waste, and decreasing carbon emissions (95). Pharmaswap's digital platform allows pharmacies to connect to each other and swap medications that are nearing their expiration date at an agreed-upon price. Wholesale organizations can also use PharmaSwap to offload medications with limited expiry dates to pharmacies. From 2013 to 2024, PharmaSwap has saved €1.9 million and 49.2 kg of $CO_2e$ (95).

Medicycle is a government-regulated online medications marketplace for pharmacies to buy and sell stock in the United Kingdom as a solution to decrease the over £300 million of medication waste produced annually. Pharmacies and pharmaceutical wholesalers with excess stock can list unused medicines on the Medicycle platform. Controlled drugs and cold chain products are not accepted for sale from pharmacies.

# Action 6 CHOOSE REUSABLE MATERIALS

Using reusable products instead of single-use items can lead to significant reductions in waste resource consumption and greenhouse gas emissions (96,97). Whenever a product is produced, it requires the use of natural resource extraction as well as energy to manufacture, both greenhouse gas emitting processes and often the greatest GHG emitting process of a product's entire life cycle. By reusing items, emissions generated from extraction, manufacturing and end of life processing, such as incineration, can be reduced or avoided.

## Reusable sharps containers

A study in a US hospital found an 83.5% decrease in global warming potential by switching from disposable to reusable sharps containers (98). Even when the reprocessing plant to clean the sharps container was further than the disposal plant, they found a 65.3% reduction in greenhouse gas emissions using the reusable sharps containers, eliminating 50.2 tonnes of plastic from landfill or incineration (96). Similarly, a study in the United Kingdom demonstrated a 83.9% reduction in global warming potential when 40 National Health Service trusts switched from single-use sharps containers to reusable sharps containers (99). Contracted waste haulers often offer both single use and reusable sharps waste containers, a change that can made throughout healthcare systems. Fraser Health in British Columbia made the switch at their healthcare facilities after a successful pilot at their COVID-19 immunization clinics. The reusable bins had an additional safety feature to reduce needlestick injuries, with a co-benefit of reduced greenhouse gas emissions (100).

Check with your waste management leads whether this option is available to you.

Reusable Sharps Containers Research Analysis by Allen Bridge, investigated Canadian reusable sharps container programs to determine best practices, environmental impacts, and advantages and disadvantages through online literature and peer contributions. Key considerations are listed in section 2.1.1 Industry requirements (pages 4-5).

Other reusable products that can be implemented include:

- Pharmaceutical waste containers
- Delivery containers and padding for pneumatic tube delivery systems
- Icepacks/temperature trackers
- Transportation containers
- Non-cytotoxic sterile compounding gowns

**RESOURCES:**

- Reusables First Approach to Healthcare Procurement, CASCADES

# Recycle

## Action 7 SEGREGATE WASTE MATERIALS

**HIGH-TEMPERATURE INCINERATION**

- Unusable medications
- Contaminated cytotoxic prducts such as supplies for compounding/ administration

**AUTOCLAVE/ HYDROCLAVE/ MICROVAVE**

- Sharps
  - Needles
  - Broken glass
  - Used ampoules

**LANDFILL/ LOW-TEMPERATURE INCINERATION**

- Most mixed materials
- Single-use items including PPE
- Anything that does not fall into other categories

**RECYCLE**

- Availability varies
- Examples include:
  - Paper products
  - Carboard
  - Glass
  - Some types of plastics

**REUSE/ CIRCULAR ECONOMY**

- Availability varies
- Examples include:
  - Non-cytotoxic sterile compounding gowns
  - Sharps and pharmaceutical waste containers

**REDUCE PURCHASING/ USAGE**

- Reduce medication use
- Examples of clinical activities:
  - Deprescribing
  - Non-pharmacological options or adjuncts

HIGHEST CARBON FOOTPRINT — CARBON FOOTPRINT PREFERRED

Figure 4. Different waste streams from least to most preferred waste management methods.

Not all pharmaceutical waste production can be avoided. Sorting waste in the most appropriate waste stream can make a difference due to the difference in their environmental impact (Figure 3), carbon footprint (Figure 4), and cost. Waste segregation should occur at the site where waste is being generated to reduce transportation costs, diminish waste volumes, and minimize contamination (Figure 5) (53).

While pharmaceutical and cytotoxic waste typically undergoes high-temperature incineration to inactivate them, associated physical waste can undergo less carbon-intensive processes. Every region and waste hauler has different rules around what they accept in each waste stream.

It is best to consult with the contracted waste haulers or municipality that handles waste to determine what products will be accepted in each stream. Figure 5 shows an example of the different waste streams with the type of waste that may be placed in each stream.

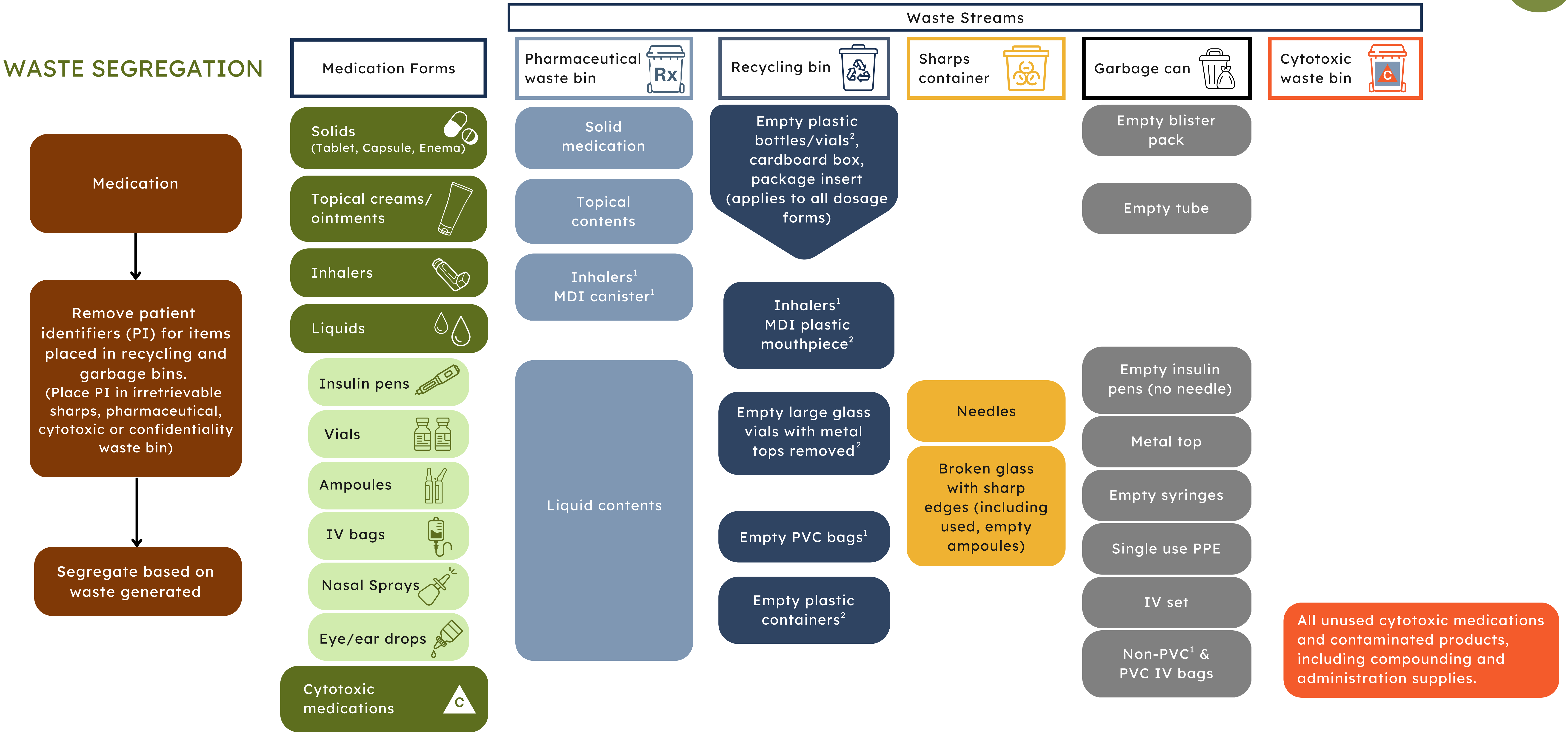



Figure 5. Example of waste segregation for various medication formats and associated packaging. (1) Inhalers and PVC bags are typically not accepted in municipal recycling programs and currently require participating in specialized programs to accept this waste. If a recycling program is not available, empty non-cytotoxic PVC bags and have sharps removed and placed in garbage cans. (2) Size of glass and types of plastics accepted for recycling will vary. Check with the waste hauler.

## RECYCLING

Recycling of packaging should follow recycling instructions from the waste hauler. What can be recycled will be different based on the contractor and the region. While recycling waste has a much smaller environmental impact than waste reduction and reusing supplies, it is preferred to other waste streams, thus recyclable products should avoid being placed in pharmaceutical waste bins, sharps containers, and garbage cans.

Still, recycling is particularly challenging. Waste placed in recycling bins may not get recycled due to challenges around inappropriate sorting and segregation (83). While most municipalities and recyclers accept plastics, what types of plastic accepted varies. Likewise, there might be a minimum in the size of paper or glass product that can actually be recycled. Usually, mixed materials, such as blister packs, are hard to separate for segregation, further creating a barrier for healthcare providers. In ambiguous cases, products should not be placed in recycling bins to avoid contamination that can lead to the whole recycling bag ending up in landfill.

### RESOURCES:

- Navigating biomedical waste management policies for sustainability playbook, CASCADES
- Guidelines for the Management of Biomedical Waste in Canada, Government of Canada
- Examples of institutional pharmaceutical policies including local waste segregation instructions:
  - Lower Mainland Pharmacy Services Policy
  - Fraser Health Acute Care Pharmaceutical Wastage Policy



## SPECIALIZED RECYCLING PROGRAMS

Outside of standard recycling programs, there are some specific healthcare recycling programs that repurpose materials at a cost. In Canada, programs exist to recycle inhalers and polyvinyl chloride (PVC) bags. In Australia, aluminum blister packs can be recycled.

## INHALERS

Many inhalers are disposed of in general waste, where they may release potent greenhouse gases with 7 out of 10 inhalers thrown away before being empty (101).

Inhaler recycling programs are available by Canadian companies for a fee. The plastic and metal canisters are separated, broken down, and remade into new materials, while the propellant undergoes thermal degradation. In the United Kingdom, inhaler recycling is taken to the next step with the gas extracted from the canisters to be repurposed for use in refrigeration and air conditioners (102). In Canada, this final step is not yet available.

For more effective inhaler mitigation strategies, refer to the CASCADES climate conscious inhaler prescribing in inpatient and outpatient care playbooks.

## POLYVINYL CHLORIDE

PVC is the most prevalent polymer used for medical supplies and equipment, including in IV bags, oxygen delivery devices/masks, tubing among other healthcare products. It poses serious risks to our health and environment, from its production, use, and disposal (103). PVC bags placed into pharmaceutical waste bins are incinerated, releasing toxic chemicals into the air (104).

Some Canadian healthcare facilities have implemented PVC recycling programs through creation of new partnerships with waste haulers and PVC recyclers. Designated collection PVC hampers are used to collect specific types of IV bags, oxygen masks, and oxygen tubing for recycling. For more information, see the case study Plastic Waste at St Joseph's Health Centre Toronto, Ontario.

## BLISTER PACK RECYCLING

Pharmacycle is a voluntary blister pack recycling program for Australian household and commercial medication waste. Once blister packs are collected, medications and packaging are separated. Medications are sent for incineration while empty packs undergo a mechanical processing to separate the aluminum foil from other plastic components for recycling (105).

## RESOURCES:

- Sustainable Perioperative Care Project Charter Summary, CASCADES
- The polyvinyl chloride debate: Why PVC remains a problematic material, Health Care Without Harm Europe
- Managing Non-Cytotoxic IV/Fluid Line & Bag Waste, CASCADES

# HOW

## The Strategy for Change

1. Re-think/Redesign
2. Waste Audits
3. Education

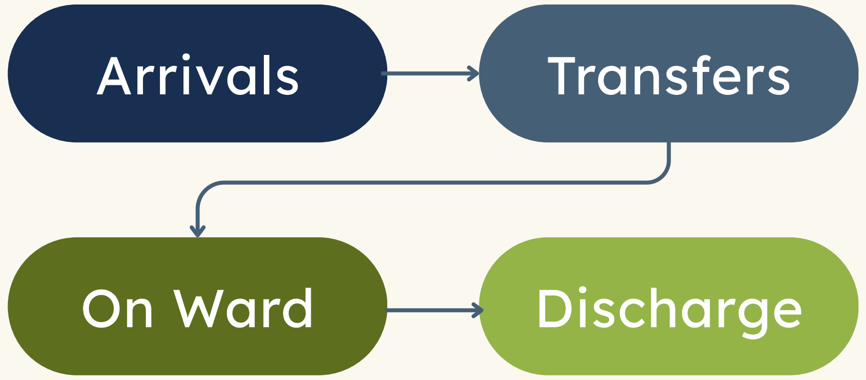
# Re-think/Redesign

The waste hierarchy is a model that ranks the methods of waste management from the most to least environmentally preferred approaches. The hierarchy first encourages us to rethink and redesign our workflow processes to avoid creating waste, followed by considering how we can reduce the amount of waste we produce, then reusing materials or products through repair or reprocessing, and finally placing recycling, recovery, and management of residuals as less desirable waste management strategies (106). All Canadian provinces and territories have adopted a similar model (107). The Zero Waste International Alliance identified key considerations for re-thinking and redesigning workflow processes (108):

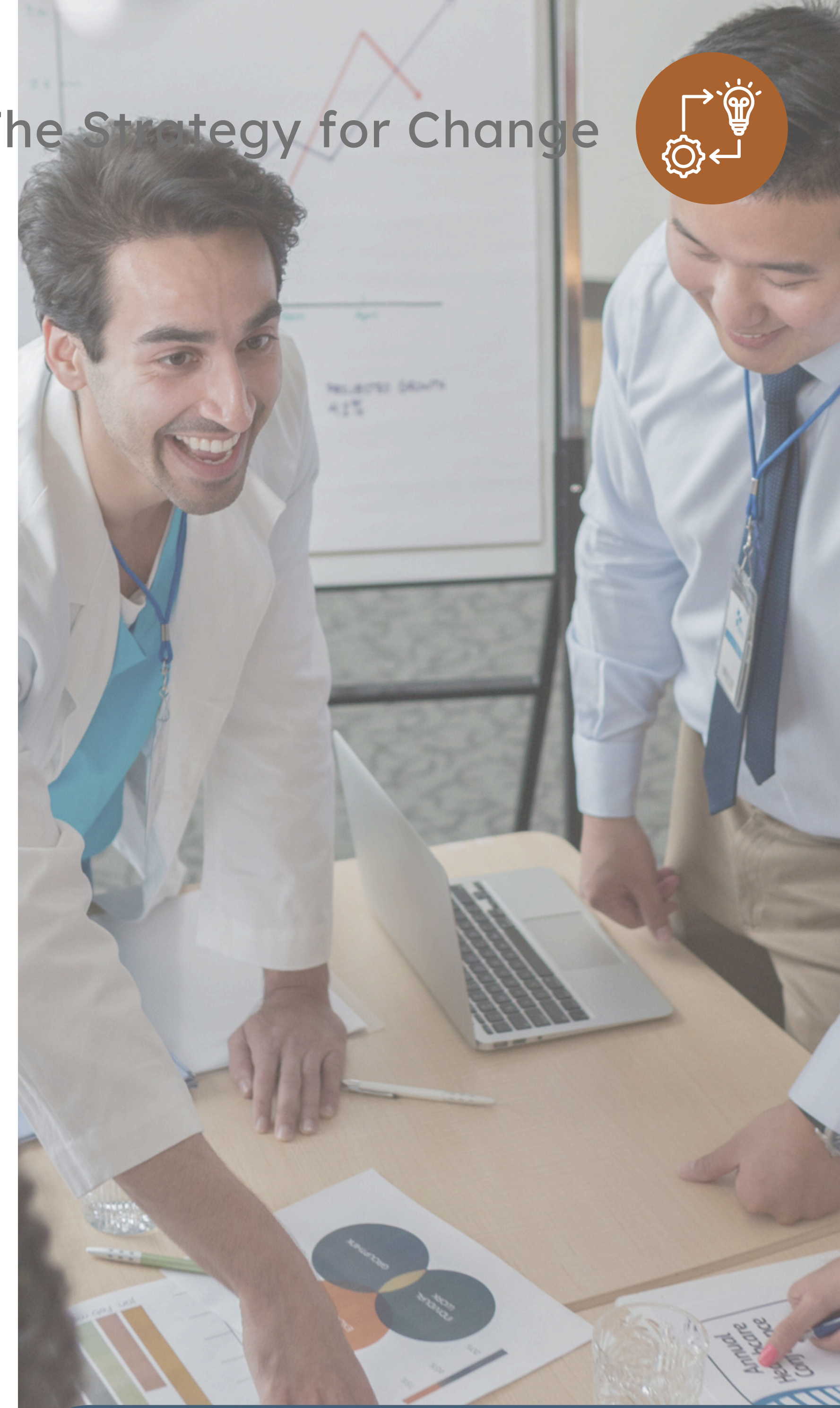
- Eliminate or avoid systems that drive needless consumption
- Consider if purchases are necessary
- Assess single-use disposable products for reusable alternatives
- Facilitate and implement policies and systems to encourage and support local economies
- Choose products that are made from materials that are easily and continuously recycled

Identifying all the steps in a process can help reveal areas of intervention for improvement. Process mapping and project charters are helpful tools that can help. Process mapping involves creating a visual representation of a sequence of actions for a specific activity. A project charter can be used to plan and execute a change idea based on an identified problem or opportunity in the process map.

Pharmacies can use these tools to map out their own processes. For example, in the CASCADES Climate Conscious Inhaler Practice in Inpatients Care Playbook, the inhaler journey was tracked across the 4 stages of a patient journey to identify areas to reduce the climate impact of inhalers.




While this process tracked the movement of the patient, the journey of the inhaler could also be tracked from procurement to end of life management. Likewise, other pharmacy processes, such as for refrigerated and high waste items, could also be analyzed.



## RESOURCES:

- Process mapping: A cornerstone of quality improvement, American Cancer Society
    - Step-by-step guide to create a process map
- CASCADES Project Charter

# Waste Audits

There is currently no standardized protocol for performing pharmaceutical waste audits which makes it difficult to set comparisons and references for waste management. Nevertheless, waste audits are performed to enhance waste sorting policies, reduce waste generation, and improve regulatory policy development (109). These audits can also help set a baseline value to measure change ideas, target areas for improvement or education, and highlight inefficiencies.

## SUGGESTED AUDIT PROCEDURE STEPS:

1. Identifying a period of time for analysis of the waste and the containers that will be surveyed from the pharmacy. Gather background metrics such as number of patients treated. Establish waste collection points that can be allocated for each container.
2. With appropriate PPE (gloves, goggles) and equipment (tongs), measure or estimate the percentage composition in the container and assign a numerical value based on the number of incorrect items.
3. Summarize observations and make recommendations for better waste management (110).

Along with the audit procedure, general facility observation and education can be conducted to enhance the waste management practice. General observation of the placement of waste containers, content, and compliance by staff can also be part of the audit. Results from the audit can help inform education needs and barriers to improve waste practices and increase compliance.

An estimated carbon footprint can be estimated based on the weight of the type of waste generated by multiplying the weight of the waste type by its environmental metric for the waste stream it will undergo (incineration or autoclaving/landfilling). This will give an estimated carbon footprint in kg CO2e. Facilities can then estimate the impact of the various types of waste streams and review the impacts of interventional changes.

### ACTIVITY/OUTCOME METRIC

1A. Weight of pharmaceutical waste (kg) generated per month
and
2A. Difference in weight from previous month

- Source from a waste audit, waste hauler data, or financial data (hauler fees).
- Number of bags/bins of recycling will do if you can get average weight per bag/bin from the hauler or your own audit.

×

### RELATED ENVIRONMENTAL METRIC

1B. 1.833 kg $CO_2e$/kg for hazardous waste (incineration)
and
2B. 1.190 kg $CO_2e$/kg for regular waste (incineration)
or
2C. 0.461 $CO_2e$/kg for regular waste (autoclaving/landfilling)

- All metrics are adapted from kg $CO_2e$/tonne, and may not precisely reflect every center (varies with factors like distance from site to waste treatment facilities).

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### ENVIRONMENTAL IMPACT

Estimation of total impact in kg $CO_2e$

- Calculation #1 will estimate environmental impacts of pharmaceutical waste. Waste removed from the pharmaceutical stream will still produce emissions (as regular waste), so environmental savings can be calculated by subtracting calculation #2 from #1.
  - This should reduce over time as waste practices improve.
- Use the Natural Resources Canada Greenhouse Gas Equivalencies Calculator to translate your results to stakeholders.

## RESOURCES:

- Performing Hospital Waste Audits
- Estimating the carbon footprint of pharmaceutical waste, CASCADES

# Education

All healthcare professionals working with pharmaceutical products can become stewards in pharmaceutical waste management, thus contributing to reducing its environmental impact. There are many opportunities to engage in sustainable pharmaceutical waste - from participating in courses/training or supporting sustainable practice changes, all involve a multi-disciplinary approach towards achieving transformative, sustainable changes.

## **SPOTLIGHT**: REDUCING BIOMEDICAL WASTE

An audit at the former Wellesley Hospital in Toronto found that 18.5% of waste was being disposed of as biomedical waste, a more costly and energy-intensive process compared to other waste management streams. Given that most waste generated by healthcare facilities does not require hazardous waste management, the facility found an opportunity to reduce costs with environmental co-benefits.

They created a program to redefine biomedical waste, reviewed waste practices throughout the hospital, educated staff, and monitored outcomes. Their interventions decreased biomedical waste amounts by 7.9% with a cost savings of $67,000 over 18 months (111).

### Important components that helped the program succeed were:

- support and leadership from infection-control personnel
- a clear definition of biomedical waste
- institution-wide awareness
- an education program about biomedical waste
- regular audits
- direct feedback to staff members (111).

Learn more

**RESOURCES:**

- Education Module: The Fate of APIs, American Chemical Society

# Summary

1. Active pharmaceutical ingredients (APIs) have been detected in our drinking water, ground water (including soil), and aquatic environments globally.
2. Pharmaceutical waste management efforts should aim to target the sources of APIs entry into the environment such as reducing inappropriate medication use.
3. Prioritizing a waste prevention first approach for pharmaceutical waste, such as implementing non-pharmacological strategies to improve health can produce greater carbon savings compared to other waste management streams.
4. Examples of high impact actions that can mitigate pharmaceutical waste production include:
   a. Regularly assessing medications used to ensure those with low to no therapeutic value are discontinued.
   b. Medication stewardship program (i.e. deprescribing, optimize dosing etc)
   c. Manage medication inventory to avoid preventable waste
   d. Reduce packaging and administration supplies
   e. Re-dispensing suitable medications
   f. Choosing products with less packaging & using less supplies
   g. Choosing reusable materials and avoid single-use items when possible
   h. Segregate waste materials
5. Building organizational awareness around the environmental impact of pharmaceutical waste and its associated physical waste can promote actions towards establishing tools and programs to mitigate negative impacts on planetary health
6. Providing educational opportunities in sustainability to healthcare professionals working with pharmaceutical products can create champions engaged and committed to improving how pharmaceuticals flow through the healthcare system.

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