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COMPARATIVE REVIEW OF INTERNATIONAL MODELS FOR MEDICINE DISPOSAL: CHALLENGES, SOLUTIONS, AND PUBLIC HEALTH IMPLICATIONS. LITERATURE REVIEW

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Abstract

Background: Unused and expired medicines pose both environmental and epidemiological risks, particularly when improperly disposed of by the public. Leading countries have implemented various models for the collection and safe disposal of pharmaceutical waste to mitigate harm to human health and the environment. This article presents a comparative analysis of international strategies for household medicine disposal, focusing on regulatory frameworks, public behavior, and program effectiveness. The need for systematic approaches in countries lacking established practices is emphasized.

Objective. To compare international models of household medicine disposal, identify effective practices, regulatory approaches, and key challenges, and assess their relevance to public health and environmental safety.

Search strategy. A targeted search of scientific and official literature was conducted for the period 2019–2025. Sources included PubMed, Scopus, and Google Scholar, as well as materials from international organizations (WHO, European Commission, OECD), national health authorities, and environmental agencies. The selection focused on peer-reviewed articles, regulatory documents, and analytical reports containing information on household medicine disposal practices, government policies, citizen involvement, and environmental impacts.

Results and conclusions. Many countries have implemented government or pharmacy-based drug return programs. Their effectiveness depends on regulation and public engagement. In developing regions, such systems are lacking, increasing environmental risks. Structured medicine disposal is essential for health and environmental safety. Adapting successful international models is necessary where such systems are underdeveloped.

Keywords: *medicine disposal, pharmaceutical waste, public health, environmental safety, drug take-back, international experience, pharmacies, community involvement*

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Резюме

СРАВНИТЕЛЬНЫЙ ОБЗОР ЗАРУБЕЖНЫХ МОДЕЛЕЙ УТИЛИЗАЦИИ ЛЕКАРСТВ: ПРОБЛЕМЫ, РЕШЕНИЯ И ЗНАЧЕНИЕ ДЛЯ ОХРАНЫ ЗДОРОВЬЯ. ОБЗОР ЛИТЕРАТУРЫ

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Введение: Неиспользованные и просроченные лекарственные средства представляют экологическую и эпидемиологическую угрозу, особенно в условиях их неправильной утилизации населением. Ведущие страны мира внедряют различные модели сбора и обезвреживания фармацевтических отходов, направленные на минимизацию

вреда здоровью и окружающей среде. Настоящая статья представляет сравнительный анализ международных стратегий утилизации лекарств на уровне населения, рассматривает нормативные подходы, поведение граждан и эффективность программ. Обоснована необходимость внедрения системного подхода в странах, где такая практика не развита.

Цель. Сравнить зарубежные модели утилизации лекарственных средств на уровне населения, выявить эффективные практики, нормативные подходы и ключевые проблемы, а также оценить их значение для охраны здоровья и окружающей среды.

Стратегия поиска. Для проведения обзора был осуществлён целенаправленный поиск научной и официальной литературы за период 2019–2025 годов. Использовались базы данных PubMed, Scopus и Google Scholar, а также материалы международных организаций (ВОЗ, Европейская комиссия, ОЭСР), национальных агентств здравоохранения и экологических платформ. Отбор включал рецензируемые статьи, нормативно-правовые документы и аналитические отчёты, содержащие данные о практике утилизации лекарств населением, государственном регулировании, вовлечённости граждан и экологических последствиях.

Результаты и выводы. Во многих странах действуют государственные или аптечные программы возврата лекарств от населения. Эффективность обеспечивается нормативной базой и участием граждан. В развивающихся странах такие системы развиты слабо, что увеличивает экологические риски. Системная утилизация лекарств — важный компонент охраны здоровья и экологии. Необходима адаптация успешных международных практик в странах с недостаточно развитой инфраструктурой.

Ключевые слова: *утилизация лекарств, фармацевтические отходы, общественное здравоохранение, экологическая безопасность, возврат медикаментов, международный опыт, аптеки, участие населения*.

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Түйіндеме

ДӘРІЛІК ЗАТТАРДЫ ЖОЮДЫҢ ШЕТЕЛДІК МОДЕЛЬДЕРІНІҢ САЛЫСТЫРМАЛЫ ШОЛУЫ: МӘСЕЛЕЛЕР, ШЕШІМДЕР ЖӘНЕ ҚОҒАМДЫҚ ДЕНСАУЛЫҚ ҮШІН МАҢЫЗЫ. ӘДЕБИЕТТІК ШОЛУ.

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Кіріспе: Пайдаланылмаған және мерзімі өткен дәрілік заттар халық тарапынан дұрыс жойылмаған жағдайда, экологиялық және эпидемиологиялық қауіп тудырады. Әлемнің дамыған елдері дәрі-дәрмек қалдықтарын жинау мен қауіпсіз түрде жою бойынша әртүрлі үлгілерді енгізуде, бұл қоғамдық денсаулық пен қоршаған ортаны қорғауға бағытталған. Бұл мақалада тұрғындар деңгейінде дәрілік заттарды кәдеге жарату бойынша халықаралық стратегиялардың салыстырмалы талдауы ұсынылады. Нормативтік тәсілдер, халықтың мінез-құлқы және бағдарламалардың тиімділігі қарастырылады. Мұндай тәжірибе дамымаған елдерде жүйелі тәсілді енгізу қажеттігі негізделеді.

Мақсаты: Тұрғындар деңгейінде дәрілік заттарды жою бойынша шетелдік үлгілерді салыстыру, тиімді тәжірибелерді, нормативтік тәсілдерді және негізгі мәселелерді анықтау, сондай-ақ олардың қоғамдық денсаулық пен қоршаған ортаға әсерін бағалау.

Іздеу стратегиясы: 2019–2025 жылдар аралығындағы ғылыми және ресми әдебиеттерге мақсатты іздеу жүргізілді. Дереккөздер ретінде PubMed, Scopus және Google Scholar мәліметтер базалары, сондай-ақ ДДСҰ, Еуропалық комиссия, ЭЫДҰ сияқты халықаралық ұйымдардың, ұлттық денсаулық сақтау органдары мен экологиялық агенттіктердің материалдары пайдаланылды. Таңдап алынған деректерге халық деңгейінде дәрі-дәрмектерді дұрыс жою тәжірибесі, мемлекеттік реттеу, азаматтардың қатысуы және экологиялық салдарлар туралы мәліметтері бар рецензияланған мақалалар, нормативтік құжаттар мен талдамалық есептер кірді.

Нәтижелер мен қорытындылар: Көптеген елдерде халықтан дәрі-дәрмектерді қайтару бойынша мемлекеттік немесе дәріханалық бағдарламалар бар. Тиімділік нормативтік база мен халықтың қатысуына байланысты. Дамушы елдерде мұндай жүйелер жеткіліксіз, бұл экологиялық қауіптерді арттырады. Дәрі-дәрмектерді жүйелі

түрде кәдеге жарату — денсаулық пен экологияны қорғаудың маңызды бөлігі. Мұндай тәжірибесі әлсіз елдерде халықаралық тиімді үлгілерді бейімдеу қажет.

Кілт сөздер: *дәрілерді жою, фармацевтикалық қалдықтар, қоғамдық денсаулық, экологиялық қауіпсіздік, дәріні қайтару, халықаралық тәжірибе, дәріханалар, халықтың қатысуы.*

Дәйексөз үшін:

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Introduction. The issue of unused and expired medicine disposal has garnered growing attention in recent years due to its direct implications for public health and environmental sustainability. Improper disposal methods—such as throwing pharmaceuticals in household waste or flushing them into sewage systems—contribute to water pollution, antimicrobial resistance, and the risk of accidental ingestion. Recent literature increasingly explores government strategies, pharmacy-based initiatives, and behavioral factors influencing medicine disposal at the household level.

Countries vary widely in their approaches, ranging from well-structured national programs with robust regulatory frameworks (e.g., in the United States, Canada, EU countries, and Japan) to fragmented or underdeveloped systems in parts of the Global South. Scientific studies highlight both the achievements of drug take-back programs and ongoing challenges, such as low public awareness, inadequate infrastructure, and limited intersectoral coordination.

Objective. To compare international models of household medicine disposal, identify effective practices, regulatory approaches, and key challenges, and assess their relevance to public health and environmental safety.

Search strategy. A targeted search of scientific and official literature was conducted for the period 2019–2025. Sources included PubMed, Scopus, and Google Scholar, as well as materials from international organizations (WHO, European Commission, OECD), national health authorities, and environmental agencies. The selection focused on peer-reviewed articles, regulatory documents, and analytical reports containing information on household medicine disposal practices, government policies, citizen involvement, and environmental impacts.

Search results and their discussion.

EU Strategy and Regulatory Framework

At the supranational level, the European Union sets the policy framework. As early as Directive 2004/27/EC, EU Member States were required to implement appropriate systems for the collection of expired or unused medicines. In March 2019, the European Commission adopted the EU Strategic Approach to Pharmaceuticals in the Environment (PiE), a comprehensive action plan covering all stages of the pharmaceutical life cycle—from production to disposal. This approach was endorsed by the EU Council and the European Parliament, which called for new measures, including both legislative and educational initiatives [30].

In particular, discussions in the EU have included the introduction of a “Do not flush” pictogram on medicine packaging and the organization of pan-European awareness campaigns. The use of extended producer responsibility (EPR) mechanisms has also been recommended to fund medicine take-back systems and public environmental education [21].

Between 2020 and 2023, the implementation of the PiE strategy progressed significantly. Guidelines were developed for national authorities on how to establish medicine return schemes, the exchange of best practices among countries was encouraged, and under the European Green Deal, environmental sustainability requirements for the pharmaceutical industry were strengthened. Pharmaceutical consumption continues to grow constantly. Unused/expired pharmaceuticals are disposed of to the municipal sewage system or waste disposal [34]. Consequently, many countries have implemented a system of collecting pharmaceutical waste, with pharmacies playing an important role. It is important to educate consumers on rational consumption and the appropriate disposal of unused/expired pharmaceuticals and to identify the level of public awareness. Two studies were conducted in Poland to estimate the problem of collection and disposal of expired/unused pharmaceuticals. The survey was aimed to identify patients’ attitudes regarding expired/unused pharmaceuticals at home. Of the respondents who participated in in survey I, almost 74% indicated that analgesics were among the over-the-counter drugs they purchased. Group of pharmaceuticals 65% of the respondents purchased were medicines for treating flu symptoms. Almost 68% of the respondents said they usually disposed of expired pharmaceuticals in their household waste or by flushing them down the toilet. In survey II more than 35% reported that they disposed of pharmaceuticals in the same ways. Of all respondents, ~30% returned their expired pharmaceuticals to pharmacies. Most respondents (over 65%) who participated survey I indicated that they were aware that pharmaceutical waste can be returned to pharmacies. It should be noted that local governments are currently not obliged by law to work with or compensate pharmacies in the collection and proper disposal of unused pharmaceuticals [2], [45].

In parallel, the pharmaceutical sector and environmental organizations launched initiatives to raise public awareness. For example, the pan-European #MedsDisposal campaign provides information on national medicine disposal systems and proper ways to discard unwanted pharmaceuticals [10].

International institutions such as the World Health Organization (WHO) and the OECD have also issued recommendations on the safe handling of pharmaceutical waste. The 2022 OECD report emphasizes that while the complete avoidance of pharmaceutical waste generation is

unlikely, proper separation and destruction remain necessary to prevent the release of hazardous substances into the environment.

France serves as a model example of a state-managed pharmaceutical waste disposal system. Since 2007, the national mandatory scheme Cyclamed has covered 100% of pharmacies in the country. All pharmacies accept unused medicines from the public free of charge, placing them into special containers provided by distributors. These are then centrally transported to Cyclamed facilities for disposal. The collected waste is incinerated with energy recovery (i.e., generating steam and electricity) [48].

The program is funded through the Extended Producer Responsibility (EPR) mechanism: pharmaceutical companies cover the costs through levies. With mandatory participation from all parties—over 22,000 pharmacies and approximately 190 pharmaceutical companies—France collected around 17,600 tons of pharmaceutical waste in 2018 (about 260 grams per capita). An estimated 62% of all unused medicines from households are returned via pharmacies—one of the highest rates in Europe [11].

To maintain public engagement, Cyclamed conducts regular awareness campaigns. Posters are displayed in pharmacies, prescription slips are stamped with return reminders, and advertisements are placed in public transport. This system demonstrates both environmental and social benefits: it reduces pharmaceutical substances in solid waste and wastewater, increases producer accountability (based on the "polluter pays" principle), and actively involves the population in environmental protection [28].

Belgium also operates a long-standing national program. Since 2000, a centralized collection scheme has functioned through pharmacies, financed by the pharmaceutical industry and distributors. Wholesalers provide pharmacies with containers and handle the transport and incineration of returned medicines, while producers cover these costs proportionally to their market share [16].

In 2011, Belgium disposed of 572 tons of medicines—equivalent to about 111 kg per pharmacy. Surveys showed that by 2013, 78% of citizens were aware of the program, though barriers such as a lack of information on procedures and insufficient collection points remained. Nevertheless, 96% of respondents stated they would use the system if clear instructions were available, underlining the importance of education for the success of such programs [3].

Germany lacks a unified national scheme, but most regions ensure safe medicine disposal through high-temperature municipal waste incineration. As the country bans landfilling of non-incinerated waste, nearly all solid household waste is incinerated. Consequently, it is legally acceptable to dispose of unused medicines in household trash (Restmüll), which meets environmental standards due to incineration [24].

Nonetheless, citizens are advised not to flush medicines down the drain and, where possible, to return them to pharmacies or municipal hazardous waste collection points. In about 95% of German municipalities, pharmacies voluntarily accept expired medications. However, these programs are not mandatory and are funded by local authorities, leading to variability between regions [13].

Efforts are underway to standardize practices, such as the Ecologic Institute's interactive map, which informs residents on proper disposal methods in each German region. A key challenge is raising awareness, as surveys show that many people still incorrectly discard medicines despite the availability of safe options [4].

The United Kingdom, though no longer part of the EU, maintains a similar established system. Under contracts with the National Health Service (NHS), all pharmacies are required to accept unwanted or expired medicines from patients. NHS local units contract specialized companies to regularly collect the waste and ensure environmentally safe incineration [33].

Pharmacies sort the waste (e.g., tablets, liquids, aerosols) in accordance with the Hazardous Waste Regulations. The program is fully funded by the government via the NHS, effectively through taxpayers, reflecting a model of public service responsibility rather than producer responsibility [23].

Although well-established, the issue persists: studies indicate a significant portion of UK residents still dispose of medicines in the general waste stream or flush them down the drain, despite the option to return them to pharmacies. Promoting correct disposal is a key component of NHS campaigns aimed at reducing medicinal waste and saving public funds (annual losses from unused medicines are estimated in the tens of millions of pounds) [37].

The Nordic and Northern European countries have long placed strong emphasis on the environmental aspects of pharmaceutical waste management. Sweden was a pioneer in this field, establishing a medicine return system in pharmacies as early as 1971. Initially introduced by the state-owned pharmacy chain Apoteket AB, the system aimed to prevent improper household medication disposal. In 2009, Sweden legally mandated Extended Producer Responsibility (EPR) for pharmaceutical companies (Regulation SFS 2009:1031). In practice, all pharmacies accept returned medicines free of charge, and pharmaceutical companies fund the collection and destruction through a collective organization [27].

A distinctive feature of the Swedish model is its incentive-based approach: many pharmacy chains offer loyalty points or discounts to customers who return expired medicines. As a result, Sweden achieves very high return rates, collecting approximately 1,300 tons of unused medicines from the public annually—one of the highest per capita volumes in Europe. In terms of collection efficiency relative to pharmaceutical market size, Sweden competes with France: about 270 mg of pharmaceutical waste is collected for every USD 1,000 spent on medicines, far surpassing most other countries [7].

Sweden also invests in education: for example, eco-labels and “green medicine” guides are being developed to help prescribers and patients consider environmental impacts when selecting treatments. However, despite the maturity of the system, improper disposal still exists: Swedish studies estimate that 10–20% of the population continues to discard medicines in the trash or down the drain, although overall awareness is high [18].

Norway and Denmark implement similar approaches through national-level return schemes. In Norway, the system is publicly funded, pharmacies accept medicines

free of charge, and centralized incineration is the primary disposal method. Finland also collects medicines mainly through pharmacies, with funding provided by municipalities and supported by national environmental programs. Finnish pharmacies actively participate in ecological initiatives: nearly every pharmacy offers medicine return services as part of their commitment to "a cleaner environment" [35].

In recent years, Finland has also proposed an eco-classification system for pharmaceuticals to inform both healthcare professionals and patients about the environmental impact of specific drugs and to encourage more responsible consumption [5].

In the Baltic States (Estonia, Latvia, Lithuania), mixed models are used. Legislation generally requires the availability of return points—typically within pharmacies—but funding and coverage vary. For example, in Lithuania, all pharmacies are mandated to accept returned medicines; however, actual public participation remains low. Research indicates that in Lithuania and some other Eastern European countries, a significant portion of the population continues to dispose of medications improperly (in household waste or wastewater), despite the formal existence of collection systems. This highlights the urgent need to strengthen public awareness campaigns and improve access to convenient return points [49].

Over the past decades, Southern European countries have developed effective national pharmaceutical waste management systems based on cooperation between government and industry. Spain, since the early 2000s, has implemented the SIGRE program (Sistema Integrado de Gestión y Recogida de Envases), which covers all pharmacies in the country. For over 24 years, SIGRE has offered citizens a convenient way to dispose of expired medicines: each pharmacy is equipped with a Punto SIGRE container where medications and their packaging can be returned free of charge [38].

The system is financed by pharmaceutical companies and distributors under the Extended Producer Responsibility (EPR) principle. Pharmacists play a central role by informing customers and encouraging them to return unused medicines, emphasizing the health risks of improper storage or disposal. Due to the proximity and trust in pharmacies, the habit has become deeply rooted: surveys from the 2020s show that 3 out of 4 Spanish households regularly use the SIGRE system. This represents a remarkable level of public engagement. Returned medications are sent for centralized destruction (thermal treatment), while recyclable packaging is recovered [46].

The Spanish experience demonstrates how long-term education efforts and public–private collaboration can successfully integrate environmentally responsible behavior into daily life. Portugal adopted a similar model under the Valormed program. Since 2001, national legislation has required pharmaceutical producers and distributors to establish a country-wide medicine waste collection system. Companies finance the non-profit organization Valormed, which supplies pharmacies with containers and organizes the collection and destruction of returned medicines [1].

As a result, Portugal has achieved one of the highest participation rates in Europe, comparable to Sweden. The EPR model has relieved municipalities of financial burdens by shifting costs to the pharmaceutical industry, in line with the "polluter pays" principle. According to statistics, Portugal's per capita and market-adjusted collection volumes rank among the top in the EU. Nevertheless, a portion of the population remains unreached, particularly in rural areas, highlighting the continued need for awareness campaigns [12].

Italy has organized medicine waste collection largely through local governments and pharmacies. Since the 1980s, the sector has relied on cooperation between trade associations: the Assinde consortium brings together producers, wholesalers, and pharmacies to manage the removal of expired medicines from both pharmacy stock and household waste. Pharmacists receive partial compensation for returned expired medicines, encouraging timely withdrawal from circulation [17].

In all Italian regions, collection points have been set up: in most cities, municipal containers for household pharmaceutical waste are installed in or near pharmacies. Municipalities are responsible for collection and disposal, working with licensed waste operators. In 2016, Italy's Ministry of Environment signed an agreement with Assinde to enhance monitoring of pharmaceutical waste flows and ensure environmental compliance. The system now covers nearly all populated areas, although public participation levels vary [50].

Italian experts identify a key challenge: reducing the volume of unnecessary medicines through improved prescribing and packaging, as significant pharmaceutical waste continues to accumulate despite a widespread collection infrastructure [14].

Greece has more recently established a national system. Until the 2010s, pharmaceutical waste collection was sporadic, but in 2019, a new national program was launched under the Institute of Pharmaceutical Research and Technology (IFET) with support from the Ministry of Health. Special green containers were installed in all pharmacies, allowing citizens to return expired or unwanted medicines [32].

When a container fills, the pharmacist notifies the local pharmaceutical cooperative, which dispatches certified staff to collect the sealed bag. The bags are then sent to an IFET warehouse and redirected to authorized high-temperature incineration facilities. The entire process is digitally tracked, and destruction is documented with formal reports. In 2019 alone, approximately 120 tons of pharmaceutical waste were collected through this system, covering an estimated 45% of medicines disposed of nationwide.

Greece has also launched educational campaigns. The Pharmacists' Association, in collaboration with the Ministry of Education, conducts school-based programs highlighting the environmental risks of improper medicine disposal. Public outreach materials encourage people—especially youth—not to discard medicines in trash but to return them to pharmacies. Additionally, Greek pharmacists have begun promoting the safe disposal of vaccination-related waste (e.g., needles, syringes) to prevent injuries and environmental contamination.

Greece's key achievement over the past five years has been the creation of disposal infrastructure from scratch and initial public engagement, although a large portion of unused medicines is still improperly discarded due to public inertia and lack of awareness.

In Central and Eastern European countries—including new EU members and neighboring states—medicine disposal systems have developed under the influence of EU directives, yet their effectiveness varies widely.

Poland, for instance, has legislated that medicines from households may be returned to pharmacies or designated collection points. However, for a long time, there were no uniform procedures. Municipalities are required to provide citizens access to hazardous waste disposal points, including for medicines, and often place containers in selected pharmacies or clinics. Yet not all pharmacies participate: formally, they are not obliged to accept medicines unless they have an agreement with local authorities, and there is no financial compensation for doing so.

A 2016–2019 study showed that only about 30% of Poles returned medicines to pharmacies, even though around 65% were aware of this option. A majority—up to 68%—admitted to disposing of expired medications in regular trash or flushing them down the toilet, indicating both insufficient public awareness and limited convenience. Since 2005, Poland's Waste Act has allowed pharmacies to accept medicine waste from the population, while responsibility for safe destruction lies with local authorities. However, the lack of funding and clear operational guidelines has led to inconsistent practices.

In recent years, the Polish government and NGOs have taken steps to improve the situation: local awareness campaigns have been launched, and some provinces have introduced pilot programs offering free pharmacy take-back. Still, Poland exemplifies a key regional challenge—the gap between regulatory requirements and actual implementation. Further effort is needed to transform formal "schemes" into fully operational services for the public [40] .

By contrast, Hungary has successfully implemented an EPR-based system. Since 2005, the national Recyclomed program has operated under a government-industry partnership. According to Hungarian law (20/2005 [VI.10]), all pharmacies must accept expired medications, and the collection and disposal are funded by pharmaceutical companies through a specialized producer responsibility organization (PRO). Collection points also exist in other healthcare facilities, enhancing accessibility.

As a result, government data indicate that a significant share of household pharmaceutical waste is collected annually. Hungary's per capita collection volumes are among the highest in Eastern Europe, though still lower than in Western countries. The EPR model has made Hungary a regional example, demonstrating that shifting financial responsibility to manufacturers encourages corporate participation in environmental initiatives and provides pharmacies with resources to fulfill their role without burdening public budgets.

Slovakia and Slovenia have chosen a different model, emphasizing public funding. In Slovakia, national and municipal authorities are jointly responsible for collection: pharmacies accept medicines, while the state covers transport and disposal costs. The scheme is nationwide, though funding is limited. Slovenia combines pharmacy-based and municipal collection: urban areas have public medicine bins, hazardous waste collection stations, and pharmacy-based return programs. While this improves access, the fragmented infrastructure may cause confusion among residents.

In non-EU Balkan countries (e.g., Serbia, North Macedonia, Montenegro), systems are still emerging. These countries are currently drafting regulations—often with support from the WHO and EU—aimed at establishing public take-back systems. However, implementation is still in its early stages: citizens are encouraged to return medicines to pharmacies or hospitals, but infrastructure is limited.

Turkey, partially located in Europe, adopted a 2020 regulation mandating pharmacy-based take-back of expired household medicines, but practical implementation remains hampered by logistical and organizational challenges [41], [29].

Overall, many Eastern European countries face similar issues: lack of funding, weak coordination between authorities and pharmacies, and low public awareness. However, the presence of a shared EU regulatory framework and increasing participation in international knowledge-sharing initiatives are gradually improving conditions.

For example, Latvia, in recent years, has launched several EU-supported public campaigns, which increased awareness. According to 2021 surveys, about 60% of Latvians knew that medicines should not be discarded in regular trash—though fewer than half actually returned them to pharmacies.

Regulatory Framework and Initiatives in the United States and Canada

In the United States, a key role is played by the nationwide initiative National Prescription Drug Take Back Day, organized twice a year by the Drug Enforcement Administration (DEA). These events allow the public to anonymously return both prescription and over-the-counter medications for safe disposal. The volume of collected pharmaceuticals is significant; for instance, in October 2020, during the program's 10th anniversary, a record was set with nearly 1 million pounds (≈493 metric tons) of medications collected nationwide [42].

Since the launch of the initiative in 2010, approximately 13.7 million pounds (over 6,800 metric tons) of unwanted medicines have been collected in total. DEA data confirms that such campaigns are in high public demand and successfully remove large quantities of potentially dangerous substances from circulation [51].

In addition to Take Back Days, the U.S. has established a network of permanent drug collection sites: as of 2019, about 11,000 DEA-authorized take-back locations were operating across the country (including in pharmacies, hospitals, and police stations). Thanks to this infrastructure, approximately 70% of the U.S. population lives within 5 miles of a drug disposal location [39].

Beyond federal initiatives, major pharmacy chains have voluntarily implemented their own disposal programs. For example, since 2019, Walgreens has offered year-round medicine disposal in all of its 9,000+ stores via either dedicated kiosks or by providing in-home disposal kits (absorbent pouches) to customers. Similar services have been introduced by CVS and other retail pharmacy chains [26].

Each year, during National Drug Take Back Week, local initiatives also participate in partnership with the DEA and public health agencies—often involving volunteers, NGOs, and law enforcement [8].

Canada operates a nationwide medicine return program through pharmacies. Every pharmacy in the country accepts expired or unused medications from the public year-round. This model is supported at the provincial and territorial levels, often in partnership with industry associations. For example, in British Columbia, Ontario, Manitoba, and Prince Edward Island, the Medications Return Program is managed by the Health Products Stewardship Association (HPSA).

Residents can return prescription drugs, over-the-counter medications, and natural health products free of charge to designated pharmacies. The collected products are then centrally incinerated, typically through high-temperature combustion. Additionally, some municipalities and police departments periodically organize special medicine collection days to supplement the pharmacy-based system.

Nevertheless, as noted by Health Canada, existing initiatives only capture a portion of unused medications—a substantial share still ends up in the environment (soil and water) or remains stored in households. This highlights the need to expand the reach and effectiveness of medicine return programs.

Despite the availability of disposal programs, behavioral studies point to a gap between official recommendations and the actual practices of citizens. Many people continue to throw medications in the trash, flush them down the toilet, or stockpile expired pills at home. According to recent surveys, a significant share of Americans are unsure how to properly dispose of medications: more than half of respondents reported difficulties or a lack of awareness about the existence of safe disposal methods. An analysis of practices related to unused opioids showed that between one-quarter and three-quarters of patients do not dispose of the remaining drugs, instead keeping them at home for potential future use or losing track of them altogether. Only a minority intentionally return medications to pharmacies or take-back events. As a result, surplus medicines become accessible for misuse: U.S. federal statistics show that up to 85% of intentional nonmedical use of prescription painkillers occurs with the knowledge of the original patient (for example, by giving away or selling leftover pills). In Canada, similar trends are observed—review data indicate that most residents have traditionally disposed of medicines with household waste or stored them at home, and only a small proportion have regularly returned them to pharmacies. However, a positive trend is emerging: as public awareness grows, the number of people using pharmacy return programs is gradually increasing. Studies identify several key factors influencing public participation. First, awareness and education: many citizens are simply unaware of these programs or underestimate the risks of improper disposal. Targeted campaigns (via public service announcements, counseling by physicians and pharmacists) can increase participation. Second, the availability of infrastructure: people are more likely to return medications if a collection site is nearby and the process is convenient. Accessibility is especially important for residents of rural and remote areas, where it can be difficult to find a pharmacy or police station with a disposal bin; long distances and transport issues often discourage visits or participation. As the American Farm Bureau notes, many farmers find it inconvenient to drive dozens of kilometers just to dispose of medicines and therefore tend to keep excess drugs "for later." In surveys of rural U.S. residents, many admitted to keeping unnecessary prescription medications out of fear they might not be able to obtain them again when needed, or simply due to lack of knowledge about disposal options. To address this issue, alternative, more convenient solutions are being implemented—such as free mail-back envelopes for sending drugs for incineration or distribution of special deactivation pouches to farming families for at-home use. Third, motivation and risk perception: when people understand that storing medicines at home can lead to child poisoning, accidental ingestion by the elderly, or misuse, they are more likely to dispose of them. Gradually, the public is becoming more aware of the risks, particularly regarding opioids and other high-abuse-potential drugs. This shift is being driven by information campaigns: for example, U.S. media often reports cases of children poisoned by vitamin supplements or pets harmed by discarded pills, which encourages responsible disposal. Therefore, increasing public engagement in proper medication disposal requires a comprehensive approach—improving awareness, ensuring easy access to drop-off locations, and offering convenient solutions tailored to various population groups (urban, rural, young, elderly) [15].

Regulatory Framework and Initiatives in Asian countries

In many countries around the world, collecting unused medications through dedicated programs is recognized as an effective method of safe disposal [47]. In recent years, Asian countries have also begun implementing similar initiatives at both national and local levels [19]. Government-run take-back programs typically involve setting up infrastructure to accept expired and surplus medicines from the public—such as collection points at pharmacies, hospitals, or designated centers—where the drugs are sent for destruction, most commonly through controlled incineration. Voluntary initiatives, often supported by pharmaceutical companies or environmental organizations, complement public measures in places where mandatory regulations are lacking [2]. By the 2020s, several Asian countries had already established official take-back programs. For instance, in Malaysia, the Ministry of Health launched the Return Your Medicines Programme, which enables patients to return unused medications to government pharmacies and clinics for safe disposal [43]. Despite the existence of such a program, its reach remains limited: a survey in the state of Selangor showed that only 25.2% of households returned medications through the official mechanism, although 73.8% of respondents agreed that pharmaceutical waste should be separated from regular trash. Many residents continue to dispose of medications with household waste (about half of respondents), while 10–12% flush them down the drain, unaware of the environmental harm. A majority (82.5%) acknowledged a lack of information on proper disposal methods. These findings highlight the need to expand and promote take-back programs in Malaysia [6]. Another

example is China, where since 2004, a large-scale annual campaign has been conducted to collect expired drugs from the public. The initiative, launched by the state-owned Guangzhou Pharmaceutical Holdings, has evolved into a nationwide voluntary take-back effort. Every year in March–April, over 6,000 pharmacies in 200 Chinese cities collect expired medications from citizens for proper disposal [31]. Over the past 20 years, more than 1,600 tons of medicines have been collected and safely destroyed. Citizens are encouraged to participate: those returning old medications receive small gifts such as basic over-the-counter medicine kits or pharmacy discount coupons. Thanks to this campaign, awareness of the issue is gradually increasing, with more residents recognizing the environmental and health risks of discarding expired drugs in regular trash. While most participants are older adults, youth participation is also visible, indicating the success of educational outreach [53]. In the Republic of Korea, both legislative and corporate initiatives exist for collecting pharmaceuticals. Since 2017, all pharmacies have been legally required to maintain special containers for expired and unused medications from the public, with local governments responsible for collection and destruction. The private sector is also involved; for example, in 2021, leading pharmaceutical company Dong-A Pharmaceutical signed an agreement with the Korean Pharmaceutical Association and the city of Dangjin to launch a joint household-level medication take-back project. Under this project, pharmacies accept expired medications from the public, and logistics company Yongma Logis centrally transports the collected drugs to an incineration facility. The initiative aims to protect public health and the environment, as disposing of medications with household waste poses serious risks (such as water and soil pollution and pharmaceutical residues entering the food chain). Estimates indicate that in 2018, approximately 4,690 tons of medications were discarded in Korea, a figure projected to rise to 6,700 tons by 2025 due to population aging. As such, these programs are seen as timely interventions. A photo captures the signing of the agreement between representatives of the pharmaceutical company and the Korean Pharmaceutical Association, exemplifying a partnership model involving industry, professional bodies, and local government to address pharmaceutical waste. Even in Asian countries lacking official take-back programs, some steps are being taken. For example, Japan still does not have a dedicated national system for collecting expired medications from households. Unused drugs are typically disposed of by Japanese residents with regular waste (as burnable garbage) or returned to physicians during follow-up visits. Nonetheless, government authorities advise citizens not to flush medicines and, where possible, to bring hazardous waste to municipal drop-off points. Some prefectures in Japan have launched pilot projects for household-level separation of medical waste, but a uniform system has yet to be established. Similar situations exist in other East Asian countries, where local initiatives or non-binding recommendations fill the role of official take-back programs [22].

Behavioral aspects of medication disposal largely determine the success of any take-back program. Studies show that even when safe disposal options are available, people do not always use them. The reasons vary—from lack of awareness about the existence of such programs to reluctance to make a separate trip to a pharmacy or collection point. A review of 12 studies conducted in South and Southeast Asia between 2013 and 2023 revealed a significant gap between public attitudes and actual practices [44]. Overall, people recognize the dangers of improper drug disposal and express support for safe disposal initiatives—most respondents were in favor of pharmaceutical take-back programs. However, actual behavior lags behind: a significant portion of respondents continue to throw medications in the trash or flush them down the drain [20]. Nine out of the twelve studies in the review reported insufficient public knowledge about proper disposal methods and limited access to reliable information. Surveys across various Asian countries show that many citizens are simply unaware that take-back programs exist or that medicines should not be discarded with regular waste [52]. For example, in Thailand, about 80% of respondents had never heard of designated medicine collection points. In Bangladesh, only one-third of respondents were aware of the environmental harm caused by pharmaceutical waste. On the other hand, the willingness to participate in solving the problem is quite high—provided people are informed and the process is convenient. When individuals are told that they can return medicines to a pharmacy and are educated on environmental risks, many act responsibly. In China, thanks to a large-scale information campaign, by 2023 citizens began planning visits to pharmacies specifically to return expired medicines—pharmacy staff report that residents now ask about the dates of upcoming campaigns and deliberately collect drugs for that purpose. Thus, education and awareness efforts play a decisive role. Most of the Asian population responds positively to appeals for safe disposal, but a lack of practical opportunities (such as nearby drop-off points or convenient hours) and insufficient information prevent people from changing established habits [9]. Therefore, changing behavior requires a comprehensive approach: expanding the accessibility of programs (more return locations, integration with municipal waste services), along with active public education on the dangers of improper disposal [25], [36].

Conclusion

The review highlights that while many countries have established pharmaceutical take-back programs, significant gaps remain in public awareness, infrastructure accessibility, and behavioral adherence. Successful models—such as those in parts of Europe, North America, and emerging efforts in Asia—demonstrate that integrating regulatory frameworks with public education and convenient disposal options leads to higher participation rates. However, in many regions, particularly in Asia and Eastern Europe, the effectiveness of these systems is still limited by inconsistent implementation and lack of public engagement. Addressing these challenges requires a coordinated strategy that combines legislation, industry responsibility, public outreach, and cross-sector collaboration to ensure safe and environmentally sound medication disposal practices worldwide.

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Literature:

1. *Abeles S.R.* Downstream - Water Pollution, Health, and Medicine's Duty to Engage. The New England Journal of Medicine. 2024. № 1 (391). P. 3–5.

2. *Ajekiigbe V.O. et al.* The increasing burden of global environmental threats: role of antibiotic pollution from pharmaceutical wastes in the rise of antibiotic resistance. Discover Public Health. 2025. № 1 (22). P. 120.

3. *Alhamad H., Patel N., Donyai P.* Towards Medicines Reuse: A Narrative Review of the Different Therapeutic Classes and Dosage Forms of Medication Waste in Different Countries. Pharmacy. 2020. № 4 (8). P. 230.

4. *Alnahas F. et al.* Expired Medication: Societal, Regulatory and Ethical Aspects of a Wasted Opportunity. International Journal of Environmental Research and Public Health. 2020. № 3 (17). P. 787.

5. *Alshehri D., Banjar H.* Increasing Awareness of Proper Disposal of Unused and Expired Medication Using a Knowledge-Based Disposal Management System. Journal of Environmental and Public Health. 2022. (2022). P. 1797440.

6. *Ariffin M., Zakili T.S.T.* Household Pharmaceutical Waste Disposal in Selangor, Malaysia—Policy, Public Perception, and Current Practices. Environmental Management. 2019. № 4 (64). P. 509–519.

7. *Arke M. et al.* Environmental and Health Consequences of Pharmaceutical Disposal Methods: A Scoping Review. Environmental Management. 2025. № 6 (75). P. 1388–1400.

8. *Banjar H. et al.* An Intelligent System for Proper Management and Disposal of Unused and Expired Medications. International Journal of Environmental Research and Public Health. 2022. № 5 (19). P. 2875.

9. *Biradar S.S. et al.* Assessment of Knowledge, Attitude, and Practice of Selected Community Pharmacists towards the Disposal of Unused and Expired Medicines at Kalaburagi City. Journal of Pharmaceutical Research International. 2025. № 2 (37). P. 1–23.

10. *Brașoveanu F.* The environmental impact of medical waste: challenges and legal solutions. Technium Social Sciences Journal. 2023. (52). P. 145–151.

11. *Cook E. et al.* Medical and healthcare waste generation, storage, treatment and disposal: a systematic scoping review of risks to occupational and public health. Critical Reviews in Environmental Science and Technology. 2023. № 15 (53). P. 1452–1477.

12. *Corte-Real A.L. et al.* Medical sharps in Portugal: a cross-sectional survey of disposal practices among the diabetic population. BMJ open. 2022. № 9 (12). P. e060262.

13. *Czarny-Działak M. et al.* Management of medical and veterinary waste - legal regulations, threats to people and the environment and methods of disposal. Environmental Protection and Natural Resources. 2020. № 2 (31). P. 6–16.

14. *Egan K. L. et al.* Development and Evaluation of Messages to Facilitate Secure Storage and Disposal of Prescribed Opioid Medication. Substance Use & Addiction Journal. 2024. № 3 (45). P. 346–355.

15. *Engster S.A., Bogen D.L., Molina B.S.G.* Adolescent and Parent Management of Controlled Prescription Medications. Substance Use & Misuse. 2019. № 14 (54). P. 2264–2274.

16. *Fadaei A.* Comparison of medical waste management methods in different countries: a systematic review. Reviews on Environmental Health. 2023. № 2 (38). P. 339–348.

17. *Godzik C.M. et al.* Knowledge, attitudes, and practices surrounding safe medication disposal in a hospice setting. Journal of Pain and Symptom Management. 2025. P. S0885-3924(25)00652–9.

18. *Gubae K. et al.* Ecopharmacology: Knowledge, Attitude, and Medication Disposal Practice Among Pharmacy Students. Integrated Pharmacy Research & Practice. 2023. (12). P. 185–193.

19. *Gupta N., Gupta P.* An Introduction to How to Dispose of Unutilized and Expired Medicine: A Comprehensive Review. Asian Journal of Management. 2024. № 3 (15). P. 283–290.

20. *Hendaus M.A. et a*l. Medication take-back programs in Qatar: Parental perceptions. Journal of Family Medicine and Primary Care. 2021. № 7 (10). P. 2697–2702.

21. *Herrera H. et al.* The public's perceptions and behaviours towards household disposal of medicines and its effect on the environment: a cross-sectional survey study. International Journal of Pharmacy Practice. 2024. № Supplement_1 (32). P. i1–i2.

22. *Hiew S.Y., Low B.Y.* The knowledge, attitude, and practice of the public regarding household pharmaceutical waste disposal: a systematic review (2013-2023). The International Journal of Pharmacy Practice. 2024. № 2 (32). P. 120–132.

23. *Huang L.C. et al.* Evaluating a health system-wide opioid disposal intervention distributing home-disposal bags. Health Services Research. 2023. № 6 (58). P. 1256–1265.

24. *Imarhia F. et al.* Prescription drug disposal: Products available for home use. Journal of the American Pharmacists Association. 2020. № 4 (60). P. e7–e13.

25. *Insani W.N. et al*. Improper disposal practice of unused and expired pharmaceutical products in Indonesian households. Heliyon. 2020. № 7 (6). P. e04551.

26. *Jafarzadeh A. et al.* Medicine storage, wastage, and associated determinants among urban households: a systematic review and meta-analysis of household surveys. BMC public health. 2021. № 1 (21). P. 1127.

27. *Jankie S. et al.* Pharmacists knowledge, perception and practice regarding medication disposal. Exploratory Research in Clinical and Social Pharmacy. 2022. (8). P. 100202.

28. *Kim V., Saunders G., Tahir M.A.* Review of Current and Novel Methods of Medical Waste Management. Journal of Student Research. 2022. № 4, P.11.

29. *Köksoy S.* Unused, leftover and expired medicine and disposal practices among health sciences faculty students in Burdur, Turkey. JPMA. The Journal of the Pakistan Medical Association. 2024. № 7 (74). P. 1280–1286.

30. *Lam J. et al.* Assessing the knowledge, attitudes and practices of healthcare staff and students regarding disposal of unwantead medications: a systematic review. BMJ open. 2024. № 12 (14). P. e093636.

31. *Lin L. et al.* Cleaning up China's Medical Cabinet-An Antibiotic Take-Back Programme to Reduce Household Antibiotic Storage for Unsupervised Use in Rural China: A Mixed-Methods Feasibility Study. Antibiotics (Basel, Switzerland). 2020. № 5 (9). P. 212.

32. *Lloyd J.S.* Expanding safe waste management to public health systems. Lancet (London, England). 2019. № 10168 (393). P. 225.

33. *Ma A. et al.* Effectiveness of interventions designed to increase safe medicine disposal: a systematic review and meta-analysis of randomised trials. Systematic Reviews. 2025. № 1 (14). P. 119.

34. *Mahnik S.N. et al.* Hospital waste – legislative framework and management differentiations in Austria, Belgium, Germany and Greece. Detritus. 2023. № 25. P. 71.

35. *Mohammed A.-U.M., Al-Hamadani F.* Assessment of general population knowledge, attitude, and practice on safe unused and expired drugs disposal: a cross-sectional study. F1000Research. 2023. (12). P. 1333.

36. *Naser A.Y. et al.* Medications disposal and medications storage in Jordan: A cross-sectional study. International Journal of Clinical Practice. 2021. № 3 (75). P. e13822.

37. *Nepal S. et al.* Poor and Unsatisfactory Disposal of Expired and Unused Pharmaceuticals: A Global Issue. Current Drug Safety. 2020. № 3 (15). P. 167–172.

38. *Paut Kusturica M. et al.* Consumer willingness to pay for a pharmaceutical disposal program in Serbia: A double hurdle modeling approach. Waste Management (New York, N.Y.). 2020. (104). P. 246–253.

39. *Roberts S., Peyatt N.O., Bunkley D.* At your disposal: A pilot for safely discarding medication in postoperative patients. Journal of the American Pharmacists Association. 2022. № 1 (62). P. 237–240.

40. *Rogowska J. et al.* Pharmaceutical Household Waste Practices: Preliminary Findings from a Case Study in Poland. Environmental Management. 2019. № 1 (64). P. 97–106.

41. *Rogowska J., Zimmermann A.* Household Pharmaceutical Waste Disposal as a Global Problem—A Review. International Journal of Environmental Research and Public Health. 2022. № 23 (19). P. 15798.

42. *Romanelli L., Lucente F.* Analysis of medicines returned to pharmacies for disposal and estimation of the cost due to medicine wasting. Exploratory Research in Clinical and Social Pharmacy. 2022. (5). P. 100133.

43. *Sapkota B., Pariatamby A.* Pharmaceutical waste management legislations: Where do ASEAN countries stand in harmonization? A review of regulatory documents. Waste Management (New York, N.Y.). 2025. (195). P. 107–128.

44. *Sarraf D.P. et al.* Knowledge, Attitude and Practice of Disposal of Unused, Unwanted and Expired Medicines among Healthcare Professionals. Kathmandu University Medical Journal. 2022. № 3 (20). P. 323–329.

45. *Seilkassymova R. et al.* Environmental Safety and Legal Regulation of Medical Waste Management: International Experience. Journal of Environmental Management and Tourism. 2022. № 7 (13). P. 1817–1824.

46. Shiferie F. Improper disposal of face masks during COVID-19: unheeded public health threat. The Pan African Medical Journal. 2021. (38). P. 366.

47. *Shoaib M. et al.* Disposal practices of unused and expired pharmaceuticals among the general public in Quetta city, Pakistan. PloS One. 2022. № 5 (17). P. e0268200.

48. *Tang M. et al.* Evaluation of propofol wastage and disposal in routine anesthesia care. Anaesthesia and Intensive Care. 2023. № 2 (51). P. 152–154.

49. *Vajda P., Botz L.* Monitoring pharmaceutical waste for environmental awareness. Orvosi Hetilap. 2024. № 17 (165). P. 672–679.

50. *Vatovec C. et al.* Pharmaceutical pollution sources and solutions: Survey of human and veterinary medication purchasing, use, and disposal. Journal of Environmental Management. 2021. (285). P. 112106.

51. *Wang L.S. et al.* Unused medicine take-back programmes: a systematic review. Journal of Pharmaceutical Policy and Practice. № 1 (17). P. 2395535.

52. *Wu S. et al.* Comparison of eco-directed and health-focused brief awareness-raising interventions for enhancing active participation of community residents in drug take-back program. Health Education Research. 2025. № 2 (40). P. cyaf002.

53. *Yang Z. et al.* Disposal practices of unwanted household medications in China: a cross-sectional study. BMJ open. 2025. № 5 (15). P. e088086.

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