EHMA
European Health Management Association

POSITION PAPER

A call for comprehensive EU action on medication waste and management

February 2026

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Introduction

Medication waste represents a substantial yet often overlooked challenge for European healthcare systems, sitting at the intersection of economic sustainability, environmental protection, and clinical effectiveness. Whilst comprehensive data remains scarce across Europe, evidence from individual Member States illustrates the scale of the problem. Greece reported €1 billion worth of unused medicines annually. Households in France discarded 17,600 tonnes of unused or expired medicines in 2018. Pharmacies in Belgium recovered over 700 tonnes in 2024. Spain collected 104.4 grams per resident of packaging containing unused or waste medication in 2022, and Lithuania collected 35.5 tonnes of returned medicines in 2024. Similarly, England's estimates of unused prescriptions in primary care cost the NHS approximately €350 million annually, roughly 4% of England's primary care medicines budget [1-5]. These figures represent only the measurable portion of medication waste, but the problem intersects with other areas demanding urgent policy attention.

First, medication waste signals systemic care failures. Every unused medication represents a breakdown in the system, whether through non-adherence, inappropriate prescribing, inadequate training and patient education, or simply due to failures in treatment adaptation. Non-adherence is perhaps a major element to consider, as it is associated with approximately 200,000 premature deaths in Europe annually, and according to WHO estimations, around half of the medicines prescribed for long-term conditions are not taken as advised [6]. This has important economic consequences because when patients fail to take medications as prescribed, health systems pay twice: once for those medications that yield no therapeutic benefits, and again for the downstream costs of negative patient health outcomes [7]. This translates into annual losses across Europe reaching €80-125 billion solely from preventable hospital admissions, emergencies, uncontrolled disease progression and premature mortality [8].

Second, medication waste contributes to environmental pollution. Pharmaceutical residues are present across Europe in water reservoirs, rivers, seawater, and soils, with more than 150 different active pharmaceutical ingredients detected, including antibiotics, analgesics, hormones and antidepressants [9]. These molecules can stimulate biological responses at low concentrations and persist in the environment, affecting non-targeted organisms [10]. Communities downstream of pharmaceutical manufacturing hotspots, hospital effluent

discharge points, and areas with weak infrastructure face disproportionate exposure to these substances. Whilst the quantities of pharmaceuticals in drinking water and those uptake from contaminated soils and biomagnification through the food chain remain below therapeutic dosages, the risks associated with long-term, low-dose exposure to complex mixtures of substances across different age groups remain poorly understood and warrant further research [11].

Third, medication waste coexists paradoxically with critical medicine shortages. Whilst the EU is actively addressing medicine shortages through the proposed Critical Medicines Act and the revision of the EU Pharmaceutical Package, current proposals do not explicitly address medication waste, missing the opportunity for comprehensive reform that could simultaneously enhance supply resilience, reduce environmental impact and improve patient health outcomes.

The challenge facing Europe is clear: to ensure sustainable healthcare delivery, health systems must transform their approach to the use of medicines and medication management to minimise waste, improve patient outcomes and protect the environment. This paper tries to synthesise evidence on the drivers of medication waste and builds a comprehensive framework of solutions to call for coordinated EU action.

Methodology

This paper draws on a review of the literature surrounding medication waste and medication management, examining several dimensions, including economic impact, environmental consequences, clinical implications, systemic drivers and evidence-based solutions. Evidence was gathered from multiple sources of information, including peer-reviewed publications, policy documents, reports, implementation studies and expert advice. Examples from healthcare systems that have successfully deployed pharmaceutical waste reduction interventions were also included. The search strategy primarily focused on publications from 2010 onwards to capture current challenges and solutions, and included key search terms such as medication waste, pharmaceutical waste, non-adherence, polypharmacy, deprescribing, automated dose dispensing, health literacy and digital health. Particular attention was given to evidence from Belgium and the Netherlands, as they have established medication management systems incorporating state-of-the-art technologies and comprehensive medication review programs.

Results

Systemic drivers of medication waste

The findings presented in this section provide an overview of the main drivers of medication waste identified across Europe. They highlight how systemic, behavioural, and organisational factors interact to influence the efficiency and sustainability of medicine use. By analysing these underlying causes, the results lay the groundwork for evidence-based policy responses and practical interventions at both national and EU levels.

- **Medication non-adherence**

Non-adherence is the largest driver of pharmaceutical waste in community settings. On average, up to 50% of medicines prescribed for chronic conditions are not taken as directed by healthcare professionals. Patients forget doses,

intentionally skip medications due to side effects or perceived lack of benefit, discontinue therapy prematurely, or take their medications at incorrect intervals or dosages, often guided by unreliable information. The consequences extend beyond accumulated unused medication: non-adherence is associated with approximately 200,000 premature deaths annually in the EU, suboptimal control of diseases, avoidable complications, and increased healthcare utilisation [6]. For example, 30% of hospital readmissions within 30 days were attributed to medication non-adherence and lack of continuous monitoring [12].

Current healthcare delivery models inadequately address adherence challenges. Staff shortages and significant demand from ageing populations limit the implementation of continuous medication monitoring mechanisms. Among several factors, lack of time, inadequate methodology, insufficient data, and absence of widely validated guidelines and interoperable electronic systems were identified as common barriers to comprehensive medication reviews [13].

- **Polypharmacy and clinical complexity**

Medication regimen complexity is a key driver for non-compliance. The more medications a patient must take, the greater the cognitive burden and the higher the likelihood of confusion. This particularly affects older adults, especially those who may experience cognitive decline, visual impairments, arthritis, and difficulty differentiating between multiple similar tablets. Furthermore, complex regimes increase non-adherence rates, leading to unused medications accumulating in homes [14]. To further understand these issues, the COST Action "European Network to Advance Best practices & technoLogy on medication adherencE" (ENABLE) aims to create a multidisciplinary network to work collaboratively implementing new interventions to address the intertwined problems surrounding medication adherence and polypharmacy by leveraging the power of new technologies.

- **Treatment changes and prescription adjustments**

When prescriptions are changed or discontinued, remaining medication supplies typically become waste. Medication regimens for older adults undergo frequent modifications due to evolving clinical needs, including ineffective therapy, intolerable side effects necessitating discontinuation, drug-drug interactions identified during medication reviews, and proactive deprescribing initiatives [15].

- **Patient mortality**

Patient mortality creates another significant waste stream for medicines, particularly in countries with ageing populations and high prevalence of chronic diseases [16]. This challenge intensifies in hospice and end-of-life care settings, where protocols for safely disposing of residual medications are essential but not always well-established or consistently implemented [17].

- **Inadequate medication review and reconciliation**

Lack of systematic medication reviews contributes to waste generation [18]. Many patients, particularly those with chronic conditions managed in primary care, may continue receiving repeated prescriptions for medications no longer clinically appropriate or necessary, including medicines that may have limited therapeutic value or pose inappropriate risks to patients [19]. Barriers identified for adequate medication management include time constraints, lack of standardised methodologies, insufficient integration of medication data across care settings, and absence of reimbursement models that incentivise comprehensive medication reviews [20-22].

☐ **Pack size and dispensing policies**

Standard pharmaceutical pack sizes reflect manufacturing, storage and distribution efficiencies rather than individual patient needs. This approach creates inherent mismatches when therapy durations do not align with pack sizes or when medications are discontinued. For instance, if a patient receives a 30-day or 90-day supply and therapy changes after 15 days, potentially 15-75 days' worth of medication becomes waste. Additionally, many refill policies encourage dispensing larger quantities to reduce pharmacy workload and patient inconvenience. These approaches may seem administratively efficient, but they increase the volume of medications at risk of becoming waste if therapy changes occur [23].

Today, the availability of medicines in bulk formats from pharmaceutical manufacturers across Europe remains very limited, despite the widespread adoption of automated dispensing systems in hospital and pharmacy settings. This lack of suitable bulk presentations forces healthcare providers to rely on blister-packed medicines and to undertake costly and labour-intensive deblistering processes in order to enable unit-dose preparation and automated dispensing. Such practices generate avoidable operational costs, increase medication handling and associated risks, and reduce the efficiency gains that automation is designed to deliver. In addition, the systematic use of individual blisters results in substantial plastic and packaging waste.

☐ **Weak disposal infrastructure**

The European Directive 2004/27/EC on the "Community code relating to medicinal products for human use" requires Member States to implement appropriate collection schemes for unused pharmaceuticals; however, implementation remains inconsistent across countries. Even where collection infrastructure exists, many households dispose of medicines unsafely, allowing them to enter the environment and contributing to pharmaceutical pollution [11, 24, 25].

☐ **Minimal medication redistribution schemes**

If the primary goal is reducing medication waste, good prescribing practices should be coupled with redistribution strategies as an important equity measure. However, redistribution of medication raises legal and safety concerns regarding storage conditions, chain of custody, liability, and potential diversion of controlled substances. Member States where redistribution schemes are in place apply specific safeguards, including full traceability verification systems to redistribute only unopened and unexpired medications, pharmacist verification, and liability insurance. However, the scope of such programs remains very limited, even for important scenarios including end-of-life returns, therapy changes, and recalled or reformulated products with intact packaging [26].

Addressing medication waste through evidence-based approaches

Addressing medication waste requires multifaceted strategies that tackle the root causes whilst creating system-level efficiencies. Evidence suggests multiple complementary approaches to overcome the systemic, behavioural, and organisational barriers previously described.

☐ **Incentivised reimbursement models**

In successful implementations across Nordic countries and the Netherlands, for instance, reimbursement mechanisms cover only dispensed doses rather than full packages, aligning incentives with waste reduction [27, 28].

☐ **Health literacy and patient education interventions**

Low levels of health literacy are negatively associated with medication adherence and patient outcomes. Patients with low health literacy showed a 35% increase in hospital readmissions within 30 days [29], and 2.6 times higher rates of unintentional non-adherence and 68% more misinterpretations of prescriptions [30]. Effective health literacy strategies take many forms, including the development of plain-language materials explaining the risks and benefits of medications, visual aids and pictograms, or accessible technology-based solutions with clear explanations on the proper use of medicines [31, 32].

☐ **Integrated and interoperable prescribing systems**

Electronic prescribing systems offer multiple benefits to tackle different aspects of medication waste, including support for clinical decision-making, automated checks for interactions, and real-time monitoring for medication reconciliation [33, 34]. Interoperability enables the sharing of medication data and patient alerts across multiple systems and databases, generating evidence to support the implementation of new interventions on medication waste. For example, the Netherlands' G-Standaard enables physicians to look up available medicines and prescribe correct dosages whilst pharmacists check compatibility with current medications and insurance reimbursement status [35]. While this is just an example, it is fundamental for the development of the European Health Data Space, incentivising cross-border knowledge exchange and collaboration in medicines and health at the EU level.

☐ **Deprescription and systematic medication reviews**

Deprescribing coupled with systematic medication reviews is associated with improved health outcomes, reduced adverse drug reactions, and decreased healthcare utilisation. Evidence demonstrates that this planned and supervised approach to reducing or discontinuing medications is not only safe but also creates valuable opportunities to optimise therapeutic regimens, minimise polypharmacy-related risks, and enhance patients' quality of life [36, 37].

☐ **Digital health and remote monitoring technologies**

Digital health technologies offer new opportunities to tackle medication waste. For example, digital applications can provide reminders, education materials and adherence tracking to support medication adherence [38]. Smart packages incorporating sensors can track when medications are taken and enable real-time monitoring of adherence and pharmaceutical efficiencies [39].

☐ **Automated Dose Dispensing (ADD) technologies**

ADD systems package medications into unit-dose or multi-dose packs according to dosing schedules into sealed, labelled pouches that are machine-prepared for short medication cycles and usually supplied via community pharmacies or centralised dispensing hubs [40]. These technologies make it easier for patients and caregivers to take correct medications at correct times, significantly improving adherence among older patients [41]. Shorter medication cycles are also linked to less oversupply when medications are stopped or changed, contributing to reducing medication waste through tailored dispensing [42].

Nordic countries and the Netherlands demonstrate the clearest evidence for ADD effectiveness, achieving notable medication waste reduction and health system savings through reimbursement mechanisms that cover only dispensed doses rather than full packages [43-49]. While implementation details vary from the Netherlands' universal coverage under the Medicine Reimbursement System to Sweden's widely adopted ApoDos system, Finland's targeted program for elderly

polypharmacy patients, Denmark's adherence-focused approach with 2023 updates for medicine reuse, and Norway's age-unrestricted home care coverage, all share a common framework: dose-based reimbursement with minimal or no direct patient charges.

In many European countries, the regulatory framework does not allow hospital or community pharmacists to repackage medicines supplied in manufacturer blisters into unit-dose or multidose packaging, even when such repackaging is required to support safe and efficient automated dispensing. National medicines legislation and restrictive interpretations of Good Manufacturing Practice often limit repackaging activities to the original manufacturer or to licensed industrial facilities, leaving pharmacists with little legal flexibility to adapt medicine presentations to clinical and operational needs. For example, in Germany, medicinal product law imposes stringent constraints on pharmacy-led repackaging, while in France and Spain, hospital pharmacies face legal uncertainty and liability risks when converting blister-packed medicines into unit-dose formats for automated systems. Similar limitations are observed in Italy, where repackaging is tightly regulated and generally discouraged without specific authorisation. This situation stands in contrast with the Good Practices on Automated Dose Dispensing issued by the European Directorate for the Quality of Medicines & HealthCare (EDQM), which explicitly recognises ADD and unit-dose preparation as tools to improve medication safety, efficiency, and traceability. The disconnect between these professional standards and national regulatory constraints underscores the need for greater regulatory alignment at the European level, either by enabling controlled pharmacy repackaging in line with EDQM guidance or, preferably, by promoting the availability of manufacturer-supplied bulk and automation-ready medicines that remove the need for repackaging at the point of care [40].

Case Studies

Case Study: Belgium

Pharmaceutical waste in Belgium is difficult to estimate, with the latest data reporting over 700 tonnes collected [50]. Research links this figure to systemic challenges, including prescribing practices requiring optimisation, non-adherence and polypharmacy, especially in the context of an ageing population with 20% of it being +65 years of age [51]. Belgium's comprehensive primary care coverage and well-developed pharmaceutical ecosystem provide strong foundations for implementing waste reduction interventions to improve population health outcomes and environmental sustainability [52, 53]. Below, we present key initiatives addressing these fundamental issues as the country's experience offers valuable insights for other Member States seeking similar goals.

- **Producer responsibility collection systems**

Belgium has established a comprehensive, free-of-charge medicines collection system jointly managed by pharmacists, distributors, the pharmaceutical industry, and regional authorities [54]. These schemes follow EU guidance and are financed through extended producer responsibility frameworks [55]. Municipal recycling centres (Recyparks) and hazardous waste collection points (PROXY CHIMIK) complement this scheme to ensure broad territorial coverage [54]. The Federal Agency for Medicines

and Health Products provides regulatory guidance for the proper disposal of medicines, emphasising environmental and public health protection, following guidance on environmental risk assessment for medicines from the European Medicines Agency [56, 57]. This approach demonstrates how multi-stakeholder collaboration within existing regulatory frameworks can create an accessible, effective collection infrastructure that protects both public health and the environment.

- **Medication review services**

Belgium has piloted intermediate medication review services in community pharmacies in collaboration with university departments [58]. During the testing phase, 68% of participating pharmacies successfully implemented reviews for approximately 450 patients. Qualitative research revealed considerable enthusiasm amongst pharmacists and physicians, and improved interprofessional collaboration. However, persistent barriers emerged, including time constraints, difficulties accessing patient laboratory data and medical information, and requirements for adequate reimbursement and training for long-term sustainability. Patient feedback generally proved positive but indicated communication improvements were needed regarding service purpose and structure [59, 60]. Belgium's experience illustrates that successful medication review programs require not only clinical protocols but also organisational support, reimbursement mechanisms, technical infrastructure enabling data access, and multi-stakeholder engagement strategies. These findings underscore the importance of creating enabling conditions, including appropriate resourcing and clear professional role definitions, that allow healthcare professionals to deliver comprehensive medication management within their existing practice settings.

- **Deprescribing initiatives**

The Belgian case is an important example of the adaptation of deprescribing initiatives. Belgium's participation in the Network of European Researchers in Deprescribing (NERD) facilitates knowledge exchange and collaborative evidence generation whilst adapting international best practices to the Belgian context. Due to high benzodiazepine usage in Belgium, the D-PRESCRIBE Canadian intervention was adapted to Belgian community settings, developing culturally appropriate patient education materials and pharmacist-prescriber communication tools [61]. Applying STOPP criteria during hospitalisation doubled the reduction of inappropriate medications in frail older adults, with sustained effects highlighting the policy value of structured deprescribing and stronger coordination with primary care [62]. Belgium's experience demonstrates that successful implementation of deprescribing requires not only clinical tools but also attention to local prescribing cultures, patient expectations, and professional relationships.

- **Automation and digital health**

Belgian hospitals have implemented automated dispensing systems integrating with electronic prescribing and patient records [63]. Belgian healthcare professionals perceive these systems as improving effectiveness and safety, particularly reducing dose errors. However, electronic prescribing implementation in community pharmacies faces challenges, including variable satisfaction and regional rollout disparities, with concerns regarding system readability and interoperability [64-66]. These findings underscore that technical infrastructure requires sustained investment,

standardisation, and stakeholder engagement to achieve full potential. The Belgian experience highlights the importance of ensuring digital health solutions are user-centred, appropriately supported during implementation, and designed with interoperability as a core principle rather than an afterthought.

- **Clinical pharmacy and regulation**

Belgium has progressively developed clinical pharmacy services, including Best Possible Medication History protocols [67], physician-requested medication reviews using validated tools [68], and patient education programs [69]. A geriatric ward pilot implementing full medication review processes identified both successes, including community pharmacist engagement and strong therapeutic relationships with patients, and sustainability requirements, including pharmacist training, communication standardisation, and recognition of community pharmacists' roles in continuity of care [65].

Belgium also recently approved policies enabling patients with chronic conditions to select a family pharmacist supporting treatment follow-up, providing updated medication lists, and maximising adherence [70]. These policies recognise community pharmacists' central role in medication waste prevention through continuity of care. Furthermore, with its positive reimbursement list system that requires pharmaceutical companies to demonstrate clinical value, cost-effectiveness, and budget impact [71], Belgium's policies create opportunities for integrating medication waste considerations into value assessment and pricing negotiations.

In conclusion, Belgium's approach to medication waste demonstrates how comprehensive producer responsibility systems, innovative medication review pilots, evidence-based deprescribing initiatives, and progressive clinical pharmacy development can work synergistically. The Belgian experience highlights that successful waste reduction requires robust infrastructure, sustained stakeholder engagement, adequate reimbursement models, and strong interprofessional collaboration. Moving forward, Belgium is well-positioned to scale proven interventions, address remaining barriers in digital health interoperability, and further integrate medication waste considerations into policy frameworks. These efforts not only promise environmental and economic benefits but also contribute to enhanced patient safety and therapeutic outcomes across the healthcare system

- **Automated Dose Dispensing (ADD) systems**

Current publicly accessible material indicates that Belgium has formal guidance on ADD issued by the Federal Agency for Medicines and Health Products, under which individual medication preparation for automated dispensing is recognised and governed by national guidance. This framework permits structured ADD within the scope of personalised medication preparation for patients, notably in long-term care and other institutional contexts, with specific operational instructions set out by the regulator. However, there is limited published information on formalised, nationwide extended ADD services that bridge long-term care and primary care settings, such as systems that would continuously supply community-based patients directly from hospital or institutional ADD infrastructures. While studies and professional reports discuss the implementation, benefits and challenges of ADD systems in Belgian nursing homes – highlighting how unit-dose packaging via automated systems can improve efficiency and

safety in long-term care environments – these primarily relate to in-institution use rather than integrated service models extending into primary care. In contrast to dedicated national programmes found in some Nordic health systems, there appears to be no widely documented Belgian model in public sources where ADD services for long-term care are routinely expanded into primary care delivery for community patients. This gap suggests an opportunity for further development of cross-setting ADD frameworks that leverage automation to optimise medication management across the care continuum.

Case Study: The Netherlands

Precise national figures on pharmaceutical waste in the Netherlands remain limited, but the country has developed collection infrastructure and centralised medication management systems that provide an advantageous starting point for waste reduction initiatives [72]. With approximately 20% of the population aged 65 or over, and many patients with multiple chronic conditions and complex medication regimens, optimising medication use presents both challenges and opportunities [73]. Below, we address key initiatives that position the country at the forefront of this area, as their experience suggests that it is possible to integrate systemic approaches to medication management within existing healthcare delivery models.

- **Reimbursement system and dose-dependent payment**

The medicine reimbursement system in the Netherlands shapes prescribing and dispensing practices through market-based mechanisms whilst ensuring access. This system clusters interchangeable medicines into groups on positive reimbursement lists, with reimbursement levels calculated based on reference prices, creating strong incentives for cost-effective prescribing [74]. Insurers reimburse only registered prescription drugs included in this system, with maximum out-of-pocket payments for patients capped at €250 annually [75]. This approach demonstrates how financial frameworks can align incentives for appropriate prescribing and dispensing whilst maintaining patient access and choice, offering insights for Member States considering reimbursement reforms.

- **ADD implementation**

The Netherlands has widely implemented ADD technologies, integrated with electronic prescribing and patient records, packing medications into patient-specific pouches with barcodes enabling full traceability from prescription to administration [76-78]. The country also operates a nationwide central medication incidents registration system that monitors medication incidents related to ADD technologies, enabling continuous quality improvement [79, 80]. Reimbursement frameworks support ADD by covering only dispensed doses rather than full packages, aligning financial incentives with waste reduction, and addressing the pack size mismatch problem that generates substantial waste [27, 28]. The Dutch experience demonstrates that successful technology adoption requires not only technical infrastructure but also appropriate quality assurance mechanisms, professional training, and reimbursement models that support rather than hinder innovation.

- **Medication review programs**

The Netherlands has implemented large-scale clinical medication review programs in community pharmacies, demonstrating the potential to reduce medication-related errors and improve the quality of drug therapy, with implementation rates that reached up to 70% [81, 82]. The Dutch Multidisciplinary Guidelines for Polypharmacy in the Elderly and the Amsterdam Tool for Clinical Medication Review provide structured frameworks for medication reviews as primary strategies for medication management [83, 84]. The country has also addressed issues derived from the traditional separation between general practitioners and community pharmacists, creating opportunities for collaboration and better continuity of care. Clinical pharmacists can be part of general practice teams, with training programs that allow them to develop critical clinical medication review skills and hold patient consultations for medication-related problems [85, 86]. This integration demonstrates how professional roles can evolve to meet contemporary healthcare needs whilst respecting existing competencies and responsibilities.

- **Digital health and interoperability**

The Netherlands operates a National Exchange Point enabling doctors and pharmacists to access patient medical history information across different healthcare providers' databases [87]. This interoperability is fundamental to support medication reconciliation, reduce duplications, and enable more informed prescribing decisions. Furthermore, the Dutch emphasis on digital health infrastructure, including widespread electronic prescribing, integrated patient records, and decision support systems, created an enabling environment for evidence-based medication management and optimisation [88]. This strategy demonstrates how investment in interoperable systems can create foundations for improved care quality, patient safety, and resource efficiency across the healthcare system.

The Netherlands' approach demonstrates that comprehensive medication waste reduction requires coherent policy integration across multiple domains including reimbursement systems that align financial incentives with waste reduction, advanced digital infrastructure enabling data sharing and clinical decision support, widespread adoption of automated dose dispensing technologies with appropriate quality assurance, robust medication review programmes embedded in routine practice, interprofessional collaboration platforms, and continuous quality improvement through systematic monitoring. The Dutch experience illustrates how these elements can be brought together within market-based healthcare systems whilst ensuring equity of access and quality of care. Regardless, moving forward in terms of implementation requires sustained investment, stakeholder engagement, and continuous adaptation and monitoring.

Policy recommendations

Medication waste is a complex, multi-dimensional problem that cannot be solved through isolated efforts. Building on the evidence presented in this paper, we propose an integrated framework of policy recommendations for EU institutions and Member States. These recommendations recognise the need for differentiated approaches based on consensus levels among stakeholders, with some areas ready for immediate action while others require sustained dialogue and iterative approaches:

1. **Establish EU-wide medication waste surveillance mechanisms and integrate them into pharmaceutical policy.** The European Commission should develop standardised medicine waste measurement methodologies across Member States by 2030 and ensure ongoing pharmaceutical legislation (Critical Medicines Act, Pharmaceutical Package revision) explicitly addresses waste reduction to strengthen supply resilience, environmental sustainability, and health system efficiency.
2. **Support medication optimisation programmes and strengthen professional capacity.** EU institutions should facilitate knowledge exchange platforms for implementing medication reviews, deprescribing, and adherence programmes by 2030, whilst Member States integrate medicine waste reduction mechanisms, adherence enhancement and deprescribing into healthcare professional education.
3. **Promote innovative technologies.** The European Commission should establish harmonised standards and reimbursement frameworks for automated dose dispensing and digital health technologies by 2030. By 2030, Member States should use standardised indicators to measure progress and identify areas requiring targeted intervention in the national healthcare context.
4. **Urges pharmaceutical manufacturers to take concrete responsibility in reducing medication waste** by addressing two well-documented structural drivers: mismatched pack sizes and the limited availability of medicines in bulk formats suitable for automated dispensing. Manufacturers are therefore called upon to design and supply pack sizes that better reflect clinical practice and to expand the availability of bulk, automation-ready formats that enable safe and efficient unit-dose dispensing. Such measures would directly reduce medication waste, lower system costs, and significantly decrease plastic and packaging use, thereby aligning pharmaceutical supply with both health system sustainability objectives and broader environmental commitments of the European Union.
5. **Foster multi-stakeholder collaboration.** EU institutions and Member States should establish collaborative platforms with healthcare professionals, industry, patients, and civil society by 2027 to co-develop solutions and support research programmes to ensure coordinated action across all stakeholders.
6. **The Critical Medicines Act represents a timely and strategic opportunity to address medication waste** as a structural challenge affecting the sustainability, resilience, and efficiency of European health systems. While the current draft published by the European Commission rightly focuses on security of supply, manufacturing capacity, and access to critical medicines, it does not yet sufficiently recognise medication waste as a contributory factor to shortages, avoidable costs, and environmental burden. In this context, the following amendments are proposed to ensure that medication waste

prevention, monitoring, and reduction are explicitly embedded within the regulatory framework of the Critical Medicines Act, in line with the objectives of health system sustainability, patient safety, and strategic autonomy.

Proposal for a Regulation, Article 30 – paragraph 2

Original	Amended
/	(c) Whereas the Union continues to face recurrent shortages of critical medicines while significant quantities of unused medicinal products are wasted due to low adherence, frequent treatment changes and manual medication-management processes; whereas the use of Automated Dose Dispensing (ADD) have been shown to reduce waste, improve adherence and generate substantial efficiency gains; whereas supporting such innovations can strengthen the resilience and sustainability of the Union's medicines supply chain. (d) Member States shall promote the deployment of Automated Dose Dispensing (ADD) systems at national and regional levels, in outpatient, home, long-term care, and institutional healthcare settings, where clinically appropriate, with the aim of improving patient adherence and medication safety, reducing leftover medicines and pharmaceutical waste, and mitigating the mismatch between medicine shortages and surplus stocks across the Union. (e) Member States shall review and, where necessary, adapt their national regulatory frameworks and reimbursement systems to enable and facilitate the implementation of ADD systems, ensuring interoperability with electronic prescribing and medication record infrastructures, and compliance with relevant Union standards on data protection and patient safety. (f) The objective shall be to ensure the implementation and operational use of ADD systems in all Member States by 2030, accompanied by the establishment of national strategies and measurable milestones. (g) Member States shall submit periodic reports to the Commission, within the framework of the monitoring and reporting obligations established under this Regulation, including information on: • the level of deployment of ADD systems and their coverage across care settings, • measurable impacts on medicine adherence, leftover reduction, and waste prevention, • incentives, funding schemes, and policy instruments used to promote adoption, • and any identified barriers or best practices in implementation. (h) The Commission shall, in cooperation with Member States and relevant stakeholders, develop guidance and benchmarks for the safe, effective, and interoperable use of ADD systems, and may facilitate Union-level funding and technical assistance to support their deployment, particularly in under-resourced regions or health systems.

Proposal for a Regulation, Article 17 – paragraph 1 (b)

Original	Amended
Text proposed by the Commission /	1b. Member States shall monitor and reduce the discharge of antibiotic residues into the environment, recognising the contribution of avoidable pharmaceutical waste to antimicrobial resistance, and the role of Automated Dose Dispensing (ADD) systems in improving antibiotic adherence and reducing waste.

Proposal for a Regulation, Article 18 – paragraph 4

Original	Amended
Text proposed by the Commission 4. This Article shall not preclude contracting authorities from using additional qualitative requirements, including in relation to environmental sustainability and social rights.	4. This Article shall not preclude contracting authorities from using additional qualitative requirements, including in relation to environmental sustainability and social rights. The Commission shall develop EU guidance on medication optimisation, including polypharmacy management, structured medication reviews, deprescribing and patient adherence interventions, with the objective of improving clinical outcomes, reducing avoidable medication waste and lowering system costs.

The challenge of medication waste demands collective action. Success requires sustained collaboration across sectors, professions, and regions, united by shared commitment to sustainable, effective, equitable healthcare. The evidence demonstrates that comprehensive approaches yield benefits for patients, health systems, and the environment simultaneously.

Conclusions

This paper on medication waste in Europe tries to signal challenges in how healthcare systems deliver oversupply of pharmaceuticals, which can have a great deal on polluting the environment, and paradoxically coexist with critical medicine shortages. Evidence suggests that medication waste stems from interconnected systemic, behavioural, and organisational factors requiring coordinated, multifaceted responses.

The implications for European healthcare are great. Addressing medication waste offers a rare policy opportunity where economic, environmental, clinical, and equity objectives align. Reducing waste through improved adherence, optimised prescribing, systematic medication reviews, appropriate deprescribing practices, and the adoption of digital health technologies and automation solutions would simultaneously reduce preventable morbidity and mortality, particularly amongst vulnerable elderly populations. It would also generate substantial healthcare system savings that can be reinvested in frontline services and innovation. It would diminish pharmaceutical pollution, protecting ecosystems and public health.

The case studies from Belgium and the Netherlands illustrate that comprehensive waste reduction is achievable when health systems invest in appropriate

infrastructure, align financial incentives, foster interprofessional collaboration, and deploy evidence-based technologies. However, these examples also reveal that transformation requires sustained political commitment, adequate resourcing, stakeholder engagement, and willingness to challenge established practices.

As Europe faces mounting healthcare challenges, with ageing populations, the rise of chronic disease burden, constrained budgets, environmental degradation, and medicine supply vulnerabilities, optimising medication use is seen as an important action, not optional. This position paper creates traction for thinking about medication waste and optimisation of medicines, with the policy recommendations highlighting the areas where EU-level coordination, harmonisation, and knowledge exchange would add value.

Critically, medication waste reduction must not be perceived as simply a cost-containment exercise but as an integral component of high-quality, patient-centred, sustainable pharmaceutical care. The 200,000 premature deaths annually associated with non-adherence, the €80-125 billion in preventable costs, and the pollution associated with pharmaceutical residues all demand urgent, comprehensive responses. Failing to do so would represent a missed opportunity to enhance the effectiveness, sustainability, equity, and resilience of European healthcare systems. The evidence is clear, proven solutions exist, and the imperative for action has never been stronger. European policymakers, healthcare professionals, industry, and civil society must now translate this evidence into transformative action.

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This position paper has been developed by the European Health Management Association (EHMA) as part of a project sponsored by Becton, Dickinson and Company (BD). However, BD has had no influence or editorial control over the content of this paper, and the views and opinions reported in this paper are of the authors are not necessarily those of BD.