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Reverse Logistics in Brazil: Barriers, Strategies, and the Role of the State

Logística Reversa no Brasil: Barreiras, Estratégias e a atuação do Estado

Logística inversa en Brasil: barreras, estrategias y el papel del Estado

Vanessa Souza
Federal University of Mato Grosso do Sul (UFMS)
Address: Avenida Senador Filinto Müller, 1555 - Vila Ipiranga
Postal Code: 79074-460
orcid.org/0000-0002-9474-2157
e-mail: souzavanessasvs@gmail.com

Adriano Marcos Rodrigues Figueiredo
Federal University of Mato Grosso do Sul (UFMS)
Address: Avenida Senador Filinto Müller, 1555 - Vila Ipiranga
Postal Code: 79074-460
orcid.org/0000-0002-3677-1291
e-mail: adriano.figueiredo@ufms.br

Abstract: *The objective was to identify the main barriers hindering the use of Reverse Logistics in waste management in Brazil. To this end, a systematic review method was employed, supported by the PRISMA review protocol. Data were collected from the Scopus, Web of Science, ScienceDirect databases, and the CAPES Portal (theses and dissertations). The final sample consisted of 21 studies. The extracted data were categorized using thematic content analysis. The presence of eight barriers hindering the use of Reverse Logistics in the country was identified, namely: (B1) government action; (B2) consumer participation; (B3) infrastructure and technology; (B4) low adherence by organizations; (B5) decline of the secondary market; (B6) economic and financial; (B7) lack of publicly available information; and (B8) lack of monitoring and oversight systems. Based on these findings, some improvement strategies for promoting RL in the country were suggested. Through this study, it was noted that the country has, over the years, established some norms to promote improved adherence to sustainable recycling; however, in practice, there are several barriers to be mitigated. Given this, there is a need for more effective state action to promote feasible strategies that meet the real needs of each party involved in the process. This study contributes to the debate on waste management in Brazil and offers insights for the formulation of more effective and sustainable public policies.*

Keywords: *Waste management. Public policies. Sustainability.*

Resumo: Objetivou-se identificar as principais barreiras que dificultam o uso da Logística Reversa na gestão de resíduos no Brasil. Para isso, utilizou-se o método de revisão sistemática, apoiada no protocolo de revisão Prisma. Os dados foram coletados nas bases de informações Scopus, Web of Science, Science Direct e Portal Capes (teses e dissertações). A amostra final analisada foi composta por 21 estudos. Os dados extraídos foram categorizados à luz da análise temática de conteúdo. Evidenciou-se a presença de oito barreiras que dificultam o uso da LR no país, a saber: (B1) atuação do governo; (B2) participação do consumidor; (B3) infraestrutura e tecnologia; (B4) baixa adesão das organizações, (B5) involução do mercado secundário de comercialização de produto reciclado; (B6) econômico-financeira, (B7) falta de informações publicamente disponíveis e (B8) monitoramento e fiscalização. A partir desses achados, sugeriram-se algumas estratégias de melhoria para promoção da LR no país. Por meio da condução desse estudo, notou-se que o país, ao longo dos anos, institui algumas normas para promover melhoria na adesão da LR; porém, na prática, há diversas barreiras a serem mitigadas. Frente a isso, constata-se a necessidade de uma atuação mais

efetiva do Estado, a fim de promover estratégias factíveis e que vão ao encontro da real necessidade de cada parte envolvida no processo. Este estudo contribui para o debate sobre a gestão de resíduos no Brasil e oferece insights para a formulação de políticas públicas mais eficazes e sustentáveis.

Palavras-Chave: Gestão de resíduos. Política Públicas. Sustentabilidade.

Resumen: *El objetivo fue identificar las principales barreras que dificultan el uso de la Logística Inversa en la gestión de residuos en Brasil. Para ello, se utilizó un método de revisión sistemática, con el apoyo del protocolo de revisión PRISMA. Los datos se recopilaron de las bases de datos Scopus, Web of Science, Science Direct y Portal CAPES (tesis y disertaciones). La muestra final analizada consistió en 21 estudios. Los datos extraídos se categorizaron mediante análisis de contenido temático. Se identificaron ocho barreras que dificultan el uso de la LR en el país: (B1) acción gubernamental; (B2) participación del consumidor; (B3) infraestructura y tecnología; (B4) baja participación organizacional; (B5) declive en el mercado secundario de productos reciclados; (B6) restricciones económicas y financieras; (B7) falta de información disponible públicamente; y (B8) monitoreo y cumplimiento. Con base en estos hallazgos, se sugirieron algunas estrategias de mejora para promover la LR en el país. A través de este estudio, se observó que el país, a lo largo de los años, ha establecido algunas normas para promover una mejor adherencia al reciclaje sostenible; sin embargo, en la práctica, existen diversas barreras que deben mitigarse. Por ello, se requiere una acción estatal más eficaz para promover estrategias viables que satisfagan las necesidades reales de cada parte involucrada en el proceso. Este estudio contribuye al debate sobre la gestión de residuos en Brasil y ofrece perspectivas para la formulación de políticas públicas más eficaces y sostenibles.*

Palabras Clave: *Gestión de residuos. Políticas Públicas. Sostenibilidad.*

Introduction

Population growth associated with technological advancement (Chiang et al., 2024), excessive consumption, and uncontrolled industrialization (Grutzmacher, Bonin, & Silva, 2024) has contributed to the exponential increase (in quantity and variety) of urban solid waste [USW] generation globally (Martins & Ribeiro, 2021). It is estimated that 2.1 billion tons of USW were produced worldwide (Global Waste Management Outlook, 2024) and 80.9 million in Brazil in 2023 (Associação Brazileira de Resíduos e Meio Ambiente [Abrema], 2024).

This volume is expected to rise, reaching a production of 3.8 billion tons on a global scale and 120 million tons specifically in Brazil by the year 2050, according to data presented by the Global Waste Management Outlook (2024) report. This condition constitutes a global concern, as the mismanagement of these materials negatively impacts human health and the environment (Rebehy, Lima, Novi, & Salgado Júnior, 2019), while exacerbating resource waste and excessive carbon emissions into the atmosphere (Grutzmacher et al., 2024).

Pressured by environmental and climate issues, several countries have enacted legislation focused on the management of this waste (Guarnieri, Cerqueira-Streit, & Batista, 2020). In Brazil, through the National Solid Waste Policy [PNRS], the implementation of Reverse Logistics [RL] was made mandatory, guided by the following priority order: "non-generation, reduction, reuse, recycling, solid waste treatment, and environmentally adequate final disposal" (Brazil, 2010, s.p.).

RL is defined by the PNRS as an instrument that encompasses "a set of actions, procedures, and means designed to enable the collection and return of solid waste to the business sector, for reuse, in its cycle or in other productive cycles" (Brazil, 2010, s.p. – free translation).

In general, the reverse model involves different operations, such as collection/sorting,

disassembly, classification, repair, resale, remanufacturing, and materials recycling (Kannan, Solanki, Darbari, Govindan, & Jha, 2023).

In Brazil, manufacturers, importers, distributors, and retailers are mandated to implement the RL system for the following products: (i) agrochemicals, (ii) batteries; (iii) tires, (iv) lubricating oils, their residues, and packaging, (v) fluorescent, sodium-vapor, mercury, and mixed-light lamps, (vi) electrical and electronic products and their components, and (vii) other products and packaging (Brazil, 2022; Brazil, 2010).

Although the implementation of RL has signaled progress in the country's environmental actions and has been in effect for over a decade (Abrema, 2024), in practice, its adoption has not yet been fully realized. Brazil has faced difficulties in ensuring the proper functioning of this management model, as well as its expansion to other sectors.

Data from the solid waste report published by Abrema indicates that over 41% of the USW generated in the country still receives environmentally inadequate disposal (Abrema, 2024). Because of this process, economic losses resulting from the non-recovery of recyclable materials are intensified, estimated at 2.5 billion dollars per year. Furthermore, expenses arising from health problems associated with the disposal of this waste in inappropriate locations are increasing. Between the years 2016 and 2021, these costs amounted to 1.8 billion dollars for the country (Associação Brazileira de Empresas de Limpeza Pública e Resíduos Especiais [Abrelpe], 2022).

This scenario of low adherence to RL delays the achievement of the objectives proposed by the PNRS, such as the elimination of open-air dumps in Brazil, for example (Brazil, 2010), whose closure deadline has been extended since 2014, albeit ineffectively.

Based on this context, there is a clear need for a more in-depth discussion of mechanisms to improve the reverse process in the country. Waste management is a social and environmental problem that has become increasingly critical considering the ongoing climate crisis, and it is likely to worsen unless countries promote sustainable and effective measures to address this situation.

In this context, RL emerges as a fundamental tool, as it is not limited to waste management, but rather fosters environmental preservation, the promotion of sustainability, and the achievement of the Sustainable Development Goals [SDGs] by the country, such as SDG 11 (sustainable cities and communities), SDG 12 (responsible consumption and production), and SDG 13 (climate action).

Considering this, the present research is motivated by the following question: what are the barriers that hinder the use of Reverse Logistics in waste management? Therefore, the objective was to identify the main barriers that impede the use of Reverse Logistics in waste management in Brazil.

To this end, a systematic review [SR] was conducted, since this tool allows for the identification and organization of the largest possible number of relevant studies on the subject, highlighting gaps, controversies, and existing consensuses in the literature (Santesso & Guyatt, 2025). Thus, it was possible for the authors to identify challenges that have already been documented, rather than merely gathering isolated opinions through interviews with local stakeholders, for instance.

Aware of the inherent limitations of an SR, including the possibility of bias and methodological heterogeneity among the studies, the researchers adopted rigorous inclusion and exclusion criteria, conducted searches in multiple databases to expand literature coverage, and subjected the selected studies to a critical quality assessment (Page et al., 2021).

It is evident that the theme of "reverse logistics" has been researched in academic literature, presenting different theoretical and analytical approaches. Some studies focus on discussing the RL of

specific waste categories, such as electrical and electronic equipment (Kawamoto, 2022; Santos & Ogunseitan, 2022; Cardoso, Rotolo, Valle, Ottoni, & Fernandes, 2021; Rocha, Teixeira, Vasconcelos, Gonçalves, & Servare Junior, 2020); batteries (Castro et al., 2022; Azadnia, Onofrei, & Ghadimi, 2021); fluorescent lamps (Leopoldino, Mendonça, Siqueira, & Borba, 2019), pharmaceutical waste (Silva et al., 2022; Silva, 2021), and agrochemical packaging (Marsola, Oliveira, Filassi, Elias, & Rodrigues, 2021). Other studies approach RL in a broader manner (Mallick, Salling, Pigosso, & McAloone, 2023; Guarnieri et al., 2020; Prajapati, Kant, & Shankar, 2019; Rebehy et al., 2019).

In order to contribute to existing research, the present review adopts a descriptive-analytical approach oriented towards identifying the main challenges inherent to reverse logistics, seeking to outline pathways and actions to address them, particularly to subsidize the formulation and improvement of public policies for Brazil.

This research is divided into five sections. The first comprises the introduction; the second, the literature review; the third, the methodological elements; the fourth, the results analysis and discussion; and the fifth, the final considerations.

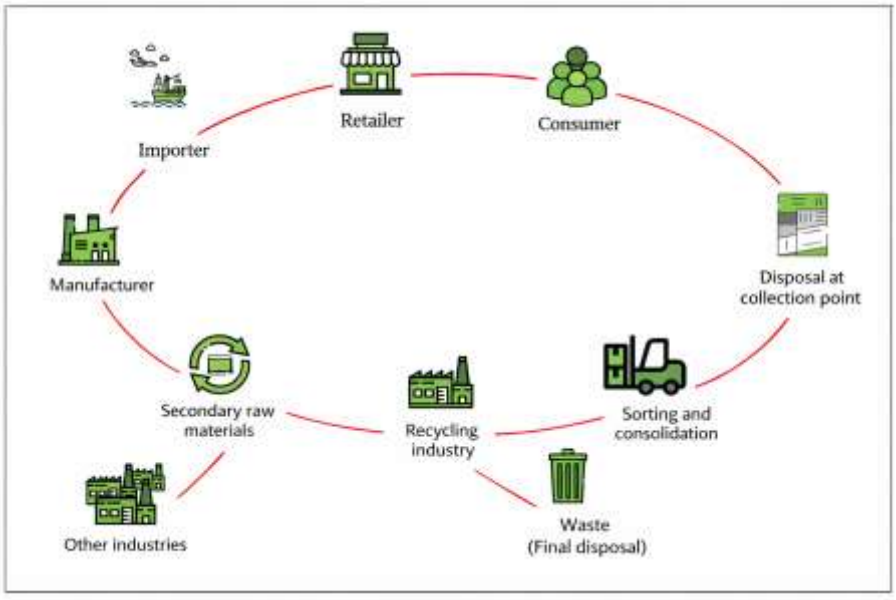
Current Regulatory Framework of RL in Brazil

The debate surrounding solid waste management took on global dimensions in the 1970s, but interest in this issue in certain developing countries is more recent. In Brazil, regulation on the subject was approved in 2010, through Law No. 12,305, called the National Solid Waste Policy (Costa & Dias, 2020).

This regulation established the principle of shared responsibility for the life cycle of products and RL as one of its main instruments, in order to relieve the burden on the holders of public urban cleaning and solid waste management services, based on responsibilities assigned to the private sector (Brazil, 2022).

According to the PNRS and ratified by the National Solid Waste Plan [Planares] through Decree No. 11,043/2022 (Brazil, 2022), the operationalization of RL (Figure 1) must adhere to the following phases: (a) disposal of the post-consumer product by the consumer at collection points; (b) receipt and temporary storage of the product by retailers; (c) transportation of the products to the concentration point for final disposal; and (d) environmentally adequate final disposal. The latter two stages are the responsibility of the manufacturers and/or importers (Brazil, 2022).

Figure 1. Reverse logistics system



Source: Sinir (2022 apud Brazil, 2022).

The PNRS and its regulatory Decree established three distinct instruments for the implementation of RL systems (Brazil, 2022), as evidenced below (Brazil, 2022a):

(i) Sectoral agreements: when the business sector (manufacturers, importers, distributors, and retailers) presents a formal proposal for the RL system, the Ministry of the Environment [MMA] makes this proposal available for public consultation for a period of 30 days and requests assessments on the matter from federal agencies with interests in the subject. Finally, the MMA returns with an acceptance, amendments, or refusal.

(ii) Regulations issued by the public authorities: the instrument is drafted by the MMA and made available for the appraisal of interested government agencies and for public consultation (Brazil, 2020).

(iii) Terms of commitment: this occurs when there is no sectoral agreement or decree in the same coverage area, or for the establishment of more restrictive targets. It is not preceded by a public consultation (Brazil, 2020).

If a business institution does not adhere to any collective agreement, it must operationalize its RL system directly, or through third parties, without the participation of management entities. In this context, they must provide adequate disposal for 100% of the collected products (Brazil, 2020).

In terms of penalties, non-compliance with the obligation to implement the RL system under the provisions of Law No. 12,305/2010 constitutes an environmental crime (according to Decree No. 6,514/2008). Regarding the consumer, in case of non-compliance with their obligations, there is initially a warning penalty; in the event of a repeat offense, fines with average values ranging from BRL 50 to BRL 500 are applied, which may be converted into environmental preservation and improvement services (Brazil, 2022).

To foster recycling and encourage companies to adhere to the reverse model, in 2023, the federal government instituted, through Decree No. 11,413, three certification formats: (i) the Reverse Logistics Recycling Credit Certificate [CCRLR], (ii) the General Packaging Structuring and Recycling

Certificate [CERE], and (iii) the Future Mass Credit Certificate.

These can be adopted voluntarily by manufacturers, importers, distributors, and retailers, for the purpose of demonstrating compliance with RL targets. The central idea consists of environmental compensation (Brazil, 2023).

It is clearly noticeable that Brazilian legislation has sought to impose upon each involved party its respective responsibility over the years. Through Decrees, the country has attempted to promote improvements in RL adherence; however, in practice, it is noted that the implementation of RL has been pointed out as incipient in dealing with the waste problem (Dias, Palomero, Cenci, Scarazzato, & Bernardes, 2022). According to Echegaray and Hansstein (2017, p. 181, free translation), this legal apparatus "remains largely unknown to consumers and poorly enforced, both by manufacturers and local authorities."

Thus, the need for the government to adopt strategies to promote improvements in this process is evident, since transforming legislation into efficient, continuous, and economically viable practice requires not only norms, but also actions that promote integrated management, considering the commitment and performance of all actors comprising the production and consumption chain.

Methodological elements of research

This study utilized a qualitative SR, based on Gough (2015), who mentions that when the objective of a given study is to understand challenges, barriers, contexts, and perceptions, qualitative synthesis is recommended.

Various tools can be used to conduct an SR; for the elaboration of this one, we opted to use the guidelines proposed by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA/2020), given that it is a widely adopted protocol in scientific studies due to its precise and clear approach (Page et al., 2021).

Based on predefined guidelines, PRISMA enables the researcher to "identify, select, appraise, and synthesize studies" (Page et al., 2021, p. 172) based on rigorous analysis, to reduce biases and allow the researcher to prepare more complete and accurate final reports (Page et a., 2021).

This review was guided by the following question: what are the barriers that hinder the use of Reverse Logistics in waste management? Data was collected between the months of August and December 2023, using the publication year filter (2019–2023).

This period reflects the elaboration phase of some political instruments, in an attempt to implement RL more systematically in different production chains in Brazil. Among them, we can mention the institutional negotiations (2019), which preceded the drafting of Decree No. 10,240 (2020). Despite being specific to the implementation of RL for electrical and electronic products, it represents an advancement in discussions on the subject.

Added to this is the institution of Decree No. 10,936 (2022), aimed at regulating the PNRS/2010, and the resumption of the environmental agenda at the federal level (2023), with an emphasis on fulfilling the 2030 Agenda for Sustainable Development.

The searches were conducted in national and international journals, through access to the Scopus, Web of Science, Science Direct, and Portal Capes (thesis and dissertations) platforms. These databases were selected given their scientific relevance and broad coverage of peer-reviewed journals.

Furthermore, the use of multiple databases allowed for an expansion of the search scope and a reduction in selection and publication biases, contributing to the reliability of the results of this SR.

To identify the studies related to the theme of interest, the following terms were used:

- (barrier OR challenge) AND "reverse logistics" AND Brazil, for searches on the Science Direct, Scopus, and Web of Science platforms.
- and (barreira OR desafio) AND "logística reversa" AND Brasil, for searches on the Portal Capes for theses and dissertations (which are mainly in Portuguese).

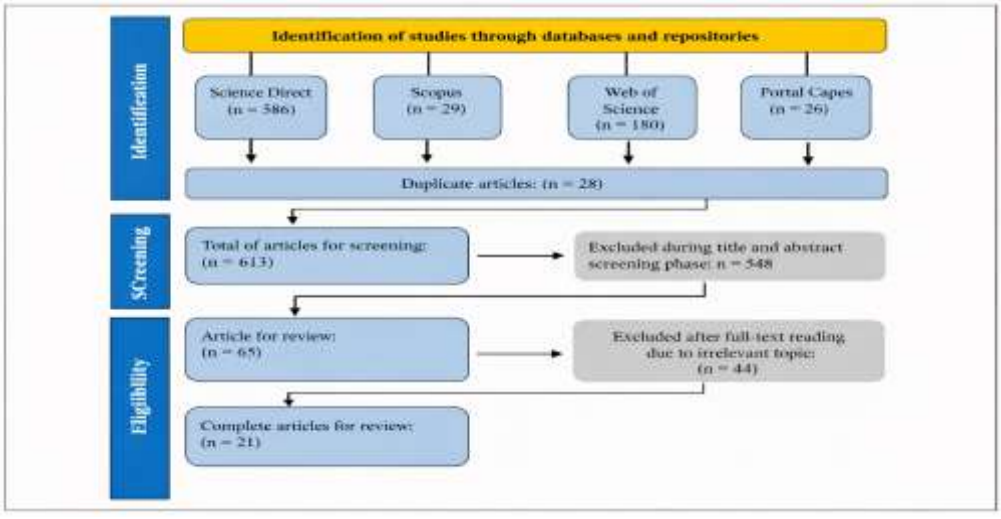
A total of 821 studies were obtained. After accounting for duplicates, 613 articles remained, which were submitted to the screening phase: titles, abstracts, and keywords were read with the aim of selecting scientific publications potentially adhering to the following inclusion criteria (eligibility): (a) encompass reverse logistics; (b) present barriers and/or challenges to the use of RL; and (c) be a full publication in English or Portuguese.

The exclusion criteria included: duplicated articles; articles unavailable in full; book chapters, conference papers, and monographs.

In this first stage, 65 studies met the inclusion criteria and were read in full; of these, 41 were excluded because they did not directly and systematically address the barriers and challenges related to RL, they presented a predominantly technical or operational focus without a critical analysis of the obstacles to its implementation, or they treated RL in an indirect, superficial, or secondary manner. The final sample included 21 studies (Figure 2).

The collected information was categorized through inductive content analysis, to allow the categories to emerge freely from the analyzed material. Three phases were followed, according to the premises of Bardin (2016). In the first phase, called pre-analysis, the authors conducted a floating reading, organized, and prepared the material (definition of the corpus). In the second phase, the coding of the material was carried out, in which relevant excerpts were grouped by thematic similarity; and, in the third phase, the categorized data were organized and analyzed in light of the adopted theoretical framework, thus enabling the interpretation of the findings.

Figure 2. Selection process for studies used in the systematic review



Source: Own elaboration (2023).

Eight categories of barriers emerged from the analysis: (B1) government action; (B2) consumer participation; (B3) infrastructure and technology; (B4) low adherence by organizations; (B5) decline of the secondary market; (B6) economic and financial; (B7) lack of publicly available information; and (B8) lack of monitoring and oversight systems.

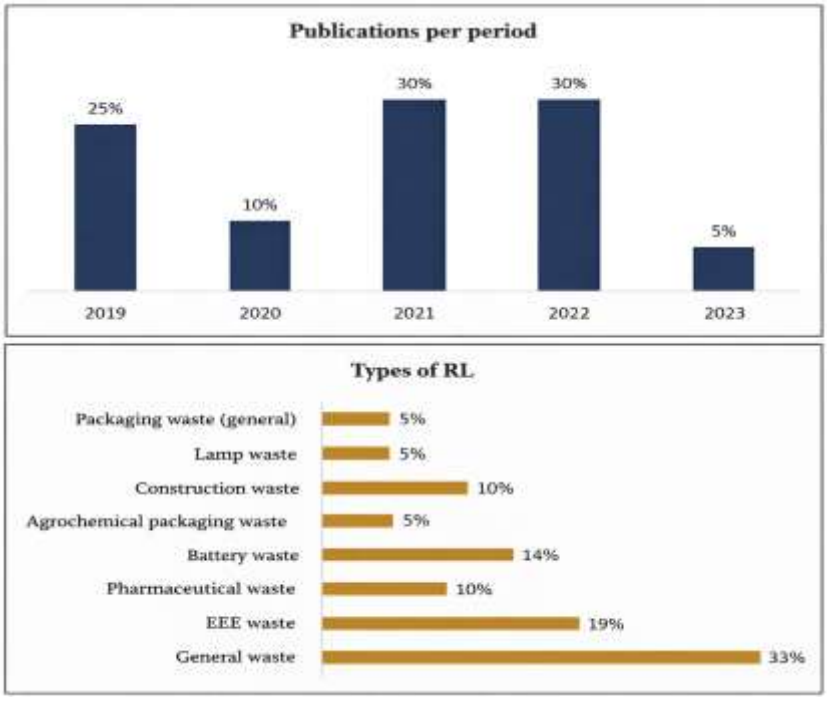
This research was not registered in the international register of SRs (PROSPERO), as indicated by the PRISMA guidelines, because the topic addressed herein does not require registration, according to information contained in the PROSPERO database. This database is primarily used for SRs in the healthcare field.

Results and discussion

This section begins with a brief descriptive analysis of the publications and is divided into two subsections. The first discusses the barriers, and the second suggests an improvement strategy for RL in the country.

Initially, a descriptive analysis (Figure 3) was conducted with the objective of detailing the publications by period and the themes discussed in the studies that comprised the corpus of this SR.

Figure 3. Publications per period and types of waste RL



Source: Own elaboration (2023).

From a content perspective, it is noted that the studies addressed a diverse range of topics. Some explored RL, focusing specifically on a particular waste, while others concentrated on RL in a broader sense.

Barriers to reverse logistics

In this research (Figure 4), the term "barrier" refers to the factors that restrict or hinder the performance of RL in any sector. Next, each barrier is presented and discussed.

The "**government action**" barrier is related to its poor performance in three main aspects. The first relates to the development of strategies that can assist municipalities in adopting collection practices, considering the slow pace of cities in establishing sustainable practices (Mallick et al., 2023; Castro et al., 2022).

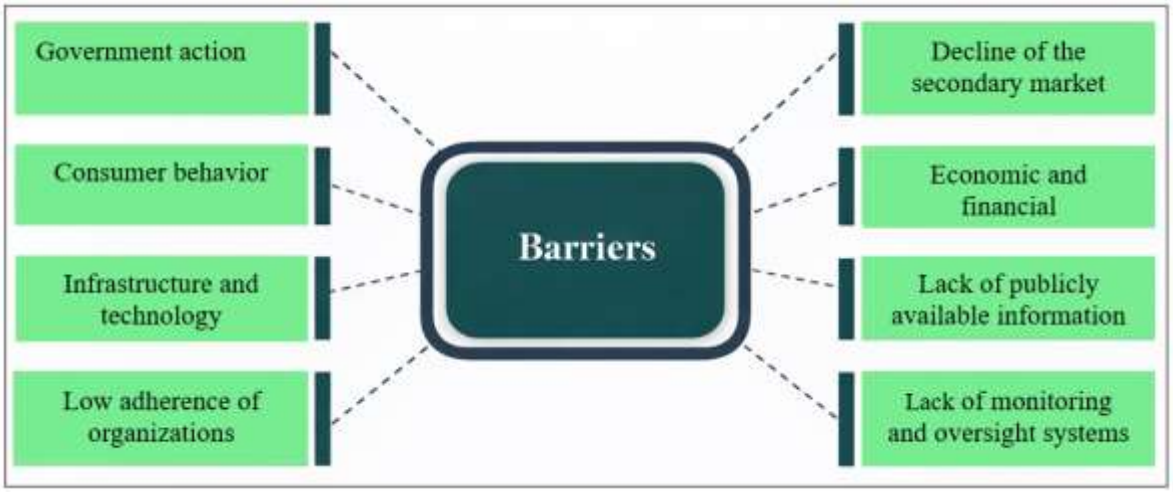
The second encompasses the formulation of applicable laws that involve incentives, enforcement, and penalization, creating synergy among the country's policies (Kawamoto, 2022), as the absence of clear and comprehensive policies "creates a regulatory vacuum, leading to varied interpretations and applications of existing laws" (Sonar et al., 2024, p.1).

Finally, the third concerns the creation of strategies to promote stakeholder engagement, including the participation of cooperatives or other forms of waste picker associations (Castro et al., 2022), so that each actor involved in the RL process properly fulfills their responsibility (Malick et al., 2023), since the integration of these stakeholders is considered one of the main challenges to be overcome.

One of the reasons for the low government efficiency stems from the lenient manner in which the Legislative Branch acts, thus demonstrating that the institutional process is shaped by interests and does not always translate into effective action (Prokopiuk, Barcellos, & Pougy, 2024).

Because of this, there is a noticeable incipient participation of municipalities in developing actions to promote RL in their territory; and, with this, the abstention of stakeholders from fulfilling their duties under the legislation (Mallick et al., 2023). Based on this, it is evident that RL, despite being a normatively established strategy, presents limited practical effectiveness.

Figure 4. Existing barriers to RL across sectors in Brazil



Source: Own elaboration (2023).

The "**consumer behavior"** barrier is associated with factors that limit or hinder their participation in the process of discarding end-of-life products at collection points. Among the reasons listed for this are: lack of knowledge about product disposal and recyclability (Castro et al., 2022); lack of knowledge

about the environmental damage resulting from improper disposal; difficulty in accessing collection centers (Marsola et al., 2021), and lack of financial incentives (Helinski, Englisch, Westmattelmann, & Schewe, 2024).

As a reflection, it is noted that a large part of the products consumed worldwide are not recycled. Globally, about 33% of the generated USW is dumped irregularly, burned, or uncollected (World Bank, 2023). In Brazil, this percentage reaches 41% (Abrema, 2024).

The "**infrastructure and technology**" barrier relates to the lack of physical infrastructure (Mallick et al., 2023; Guarnieri et al., 2022) and adequate technologies to enable the return and proper final disposal of products (Mallick et al., 2023).

Among the factors associated with this barrier are transportation difficulties, lack of infrastructure, limited number and unequal geographical distribution of collection points (Castro et al., 2022; Leopoldino et al., 2019), lack of technical knowledge for recycling, and lack of adequate technology, among others (Mallick et al., 2023; Prajapati et al., 2019).

This scenario reflects on the efficiency of take-back and market withdrawal mechanisms for products (Brkljač et al., 2024). Furthermore, the lack of technology hinders the complete implementation of collection, sorting, and recovery processes for recyclable materials (Olipp, Schwarze, & Woschank, 2025). In light of this, it is important that recycling processes already used in other countries can be economically evaluated to be used here in Brazil, considering our local reality (Santos & Ogunseitan, 2022).

The barrier of "**low adherence by organizations**" to the RL process encompasses the lack of interest of companies in investing in RL practices. In general, this is influenced by different reasons, such as a lack of trained labor, incipient financial and investment incentives (Silva, Santos, Silveira, & Barros, 2025), managers' resistance to institutional changes, and low commitment of business managers to RL, among others (Silva et al., 2022).

As a result of this scenario, companies fail to leverage the residual value of post-consumer products, present lower efficiency in waste management, and contribute to an increase in improper disposal, generating negative environmental impacts instead of promoting the reinsertion of materials into productive cycles (Silva et al., 2025).

The "**decline of the secondary market**" refers to the absence of a structured market to receive, commercialize, and/or reuse post-consumer products. It is identified as a barrier that needs to be discussed, given the various obstacles that hinder its expansion and efficiency. Among these are the lack of a well-structured secondary market, consumers' low perception regarding the quality of the recycled product, and the difficulty of commercializing this product (Mallick et al., 2023; Prajapati et al., 2019).

This limitation prevents returned products from being directed to efficient commercialization and valuation channels (Arroyo, Barreto, Vasquez, & Nicola, 2023) and, consequently, discourages organizations interested in investing in this market.

The "**economic and financial**" barrier is associated with the operational cost of the reverse flow and economic unfeasibility (Guarnieri et al., 2022), as large-scale economies for RL are still incipient. Costs differ across countries and are associated with a series of elements, which are subdivided into collection and recycling/handling costs (Rebehy et al., 2019).

In Brazil, transportation constitutes the main expense of RL, due to factors such as the country's territorial extension and the autonomy of the states, which allows each state to institute specific taxes

within its jurisdiction (Rebehy et al., 2019).

These factors act as inhibitors of investments in activities aimed at RL, especially when the expected return is low, diminishing investors' expectations regarding financial and operational gains (Brkljač et al., 2024).

The "**lack of publicly available information**" refers to the incipient amount of available information and the supply of outdated information. The federal government, through the Ministry of the Environment [MMA], created a platform called the National Solid Waste Management Information System [SINIR]. This initiative aims to collect data and provide information that helps in the formulation of actions, monitoring, and evaluation of the PNRS (Brazil, 2022). Although it is the main source of data on waste, the system is outdated and presents little information. Its last update occurred in 2019.

The lack of updated information prevents studies on strategies related to the generation, reuse, recycling, and final destination of waste from advancing in Brazil (Castro et al., 2022), making it impossible to discuss new mechanisms in the country that would facilitate the adoption of RL.

Finally, the barrier associated with the "**lack of monitoring and oversight systems**" in the process as a whole is highlighted. The deficiency in monitoring, for example, negatively impacts the tracking, quantification, and efficient management of waste. In the absence of proper monitoring, problems arise such as a scarcity of reliable information and difficulty in enforcing the responsibilities of the parties involved, since the traceability of waste is fundamental to ensure that manufacturers and other stakeholders comply with their obligations in RL.

The lack of enforcement, in turn, favors the emergence of an illegal market for the commercialization of equipment waste, especially electronics, due to the presence of materials with high value in the recycling sector (Kawamoto, 2022).

Although the barriers have been discussed separately in order to provide the reader with a greater understanding of the factors that impact each one, it is pertinent to mention that there is an interrelation among them, as mentioned in the study by Soares, Paço, Braga, and Arantes (2025). Inevitably, they interact with each other (Xu & Zou, 2020).

Low government action, for example, impacts the low participation of the various stakeholders. In addition, the lack of government incentive influences the incipient adherence of organizations to the reverse model, which ends up inhibiting the expansion of the secondary market.

Economic barriers, such as high costs and low expected financial returns, are frequently associated with technological limitations and the lack of adequate infrastructure, since the lack of resources makes investments in collection, sorting, and processing systems unfeasible (Silva et al., 2025).

Similarly, the lack of clear public policy causes stakeholders to abstain from their responsibilities, since the current policy (PNRS) presents an absence of mechanisms to "enforce the law" (Santiago, Marotti, Pugliesi & Gonçalves, 2023). From this finding, it is possible to infer that, among the various barriers mentioned, "government action" presents the highest degree of latency, as its action impacts the presence of the other identified barriers. Therefore, this is the most critical barrier to be overcome so that RL can advance in Brazil.

Necessary Improvements for RL in Brazil

Based on the reading conducted in the materials analyzed in this SR, some important actions to be implemented by public authorities are suggested to promote improvements in RL in the country. These include mechanisms to stimulate consumer participation, the provision of incentives, discussion on pricing models, the establishment of monitoring and enforcement mechanisms, and regulatory adjustments, among others.

The "promotion of consumers' active participation" in the disposal process can be achieved through the establishment of incentives, such as discounts on the purchase of new products, generally of the same type, tax benefits, and discount coupons, among others (Mallick et al., 2023). In conjunction with this, it is important to facilitate the disposal of unusable equipment by offering door-to-door collection — a strategy already adopted by countries like Germany and Japan (Sheoran & Gupta, 2023) — reducing the distance to collection centers, or expanding the level of collection service (Flygansvaer, Samuelsen, & Stoyle, 2021).

The promotion of "**environmental education actions**", according to the prerogatives contained in the 2022 National Solid Waste Plan (Brazil, 2022), can occur through informative campaigns on how, where, and when to return products, as well as the dissemination of information through product labels, and advertisements on TV, radio, the internet, and other channels (Mallick et al., 2023).

In order to ensure that equipment can be properly disposed of, the government needs to "invest in monitoring and enforcement mechanisms." According to Sheoran and Gupta (2023), this can be done by tracking the product using radio-frequency identification (RFID) tags. These tags would be activated at the time of product acquisition and would remain active until the product was delivered to an appropriate recycling facility after its use.

With the objective of encouraging the contribution of the different actors involved in the process and making the RL system viable, it is fundamental that the State "develop pricing strategies." These strategies can be determined by (i) the free-market system, (ii) through manufacturer responsibility, or (iii) through the implementation of a service fee (Lagarinhos & Tenório, 2013).

Along with this, there is a need to institute public policies focused on the "provision of economic incentives" so that firms engage in the projects (Silva, 2021), for example, through subsidies to make RL actions scalable (Silva et al., 2022). These incentives should also be designed to stimulate the secondary market and may involve tax incentives and credit lines for recycling companies (Couto & Lange, 2017).

In an attempt to reduce the illegal recycling market and promote better participation of waste pickers, given that they are important actors in waste management, the country can direct its efforts toward the "formalization of informal recycling," following strategies already implemented in nations such as China and India (Santos & Ogunseitan, 2022). For Rebehy et al. (2019), it is paramount that policymakers "review Brazilian legislation," focusing especially on the discussion of economic and tax incentives, as well as transportation.

To assist in the "reduction of transportation costs," the government can institute tax exemption policies on waste from the RL system (Rebehy et al., 2019). In addition to this, it is important that "resources be invested in Research and Development (R&D) projects," with the purpose of promoting efficiency in RL and reducing costs. It is pertinent to mention that the strategies to be adopted by the public authorities need to be aligned with the economic and socio-environmental interests of the stakeholders (Rebehy et al., 2019) to meet the real needs of all involved parties.

Furthermore, it is mentioned that this list of strategies is illustrative; the intention was not to

exhaust the discussion, but rather to present strategies that can be discussed and included for any sector that utilizes RL, given that some barriers, such as low consumer participation, are common to all sectors that utilize RL in Brazil.

It is known that RL can be applied to various sectors; however, given the specificity of each equipment, it is expected that each sector, in accordance with the guidelines of the PNRS/2010, will establish its own regulations to make the operationalization of its process feasible. Some sectors, such as agrochemical packaging, already have them; others, such as photovoltaic equipment, are currently under discussion, according to a study developed by Souza, Figueiredo e Espejo (2024).

Final Considerations

The objective of this research was to identify the main barriers that hinder the use of Reverse Logistics in waste management in Brazil. Based on the elaboration of an SR, using the PRISMA/2020 method, the existence of eight important barriers that need to be mitigated was found, namely: (B1) government action; (B2) consumer participation; (B3) infrastructure and technology; (B4) low adherence by organizations; (B5) decline of the secondary market; (B6) economic and financial; (B7) lack of publicly available information; and (B8) lack of monitoring and oversight systems.

Based on these barriers, it was possible to list some improvement strategies that include mechanisms to stimulate consumer participation, the provision of incentives, discussion on pricing models, the establishment of monitoring and enforcement mechanisms, regulatory adjustments, the reduction of transportation costs, and investment in Research and Development projects, among others.

From conducting this study, it was observed that the country, over the years, has instituted some norms to promote improvement in RL adherence; however, in practice, there are several barriers to be mitigated. In light of this, there is a clear need for more effective action by the State in order to promote feasible strategies that meet the real needs of each party involved in the process.

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