

MODELING THE DISPOSAL OF DOMESTIC DRUG WASTE THROUGH CAUSAL LOOP DIAGRAM

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Abstract

The ease of access of the sick individuals to the drugs cause an increase in drug consumption with the development of the health sector. The incomplete information of the patients about the drug use causes the treatment to be incomplete and the drugs to become waste medicine. Increasing and improper disposal of drugs that are not used at home threatens human health and the environment.

There is an urgent need for the correct disposal process for drug waste in homes. In order to prevent the wrong disposal of these drugs, solutions are produced within the scope of reverse logistics and green supply chain activities.

The aim of the study is to understand the system structure in the process of disposal of domestic pharmaceutical waste in Istanbul and to establish a mental link between the structure of the system and the behavior obtained as a result of the system. In the study, the processes of reverse logistics activities in the Turkish pharmaceutical industry in domestic drug waste were examined and a system dynamics model was created..

Keywords: *Reverse logistics, System dynamics approach, Domestic drug waste, Causal loop diagrams*

1. Introduction

Today, it is known that people use natural resources uncontrollably to meet their needs. The most important of the resources that people provide uncontrolled use in this regard is natural resources. The fact that people use natural resources uncontrollably causes the loss of natural resources and the environmental order to deteriorate. For this reason, it is thought that people use natural resources without saving, it is thought that famines will be experienced and the natural resources will be depleted in the life process. It is stated by researchers that the shortage of natural resources and raw materials is on the way for future generations. For all these reasons, reverse logistics, recycling practices, separation of materials that do not have any benefit in nature and sending them for recycling have been an important step in the protection of natural resources. (Keskin, 2008). With the effect of globalization, the population growing continuously, the increase in the level of welfare, the increase in urbanization rates, and an increase in waste types and waste amounts are observed. There is a need for waste management based on the waste problem in the country. Various factors such as recycling waste, correct waste disposal, recycling energy, and a hierarchy of waste are at the core of the integrated waste management. In order to act more consciously as a citizen in waste management, we need to have knowledge about waste management and firstly apply the waste in our own homes and environment (Ç.Ş.B., 2019). Wastes are examined in three parts.

Wastes are generally evaluated as medical waste, hazardous waste and nonhazardous waste. Hazardous waste is generally industrial wastes that endanger the environment and human health caused by technological products. Industrial wastes are hazardous and harmful. Toy industries, pharmaceutical factories, some refineries and power plants generate hazardous waste.

On the other hand Nonhazardous wastes are radioactive or chemical originated wastes that have occurred due to biological events that do not pose a physical hazard. These wastes generally originate from hospitals or similar medical institutions. These wastes are dangerous in terms of causing some diseases. Nonhazardous wastes are also examined in 3 groups; Infectious wastes are expressed as breaker piercing wastes and pathological wastes.

The issue of waste management has gained importance in terms of endangering human health and the environment due to the wastes occurring in hospitals and the drugs that patients do not use. Hospital wastes have recently started to pose an important problem with the increasing number of populations and the tendency of people to the hospital. For this reason, it is possible to say that the amount of waste generated by the health institutions when it takes up less space, although it occupies less space. They coordinate the municipal and hospital management disciplines for waste management. These studies include the processes of collection and disposal of medical wastes in accordance with the rule. Reverse logistics methods have become important for waste management in order to prevent medical waste or normal waste from being harmed by humans and the environment.

General waste management regulations on medical waste, including its activities in 1991 were carried out in Turkey. These arrangements were arranged in line with the European Union Legislation and in accordance with the conditions of the country. In this regard, wastes occurring in hospitals were put into practice by the Ministry of Environment and Urbanization in 2005, under the medical waste control regulation. In 2008, the regulation on control of hazardous wastes came into effect with the waste management action plan. In the regulation on general management of waste, it is reported that in 2010 it covers articles related to the regular storage of waste.

Istanbul Metropolitan Municipality has undertaken waste management in Istanbul. This institution generally works to eliminate medical wastes and wastes occurring in hospitals. Disposal procedures are generally carried out using sterilization and incineration methods. The presence of drugs in the environment, especially in water resources, has been confirmed by various reports (EPA, 2019). Medicines and contaminated foods are suggested to affect living things through water. It proposes the incineration of domestic drug waste collected according to 2012 to the EPA.

Medicines that are not used by domestic and expired should be put in the process of disposing of medical waste. However, end consumers dispose of their waste by either throwing them away or pouring them into the toilet. In a survey conducted with the participation of 398 people in Ireland, 72% of respondents (281) stated that they disposed of the drugs. 72% (202) did this in an environmentally unsuitable manner. In the responses given to the questionnaire, it was shown that the unused drugs were disposed of 51% with domestic waste, 29% with a sink or 14% with a toilet (Vellinga et al. 2014).

In the families in a study conducted in the Çukurova region, it was investigated for which reasons the drugs were out of use and it was stated that the drugs were not used because of the frequent expiration of the patients, the interruption of the treatment process of the patients, and the doctor recommending another drug (Köse et al. 2013).

In another study, it has been determined that the people of the villages in Thailand have waste medicines in the houses and that they are thrown to the trash as the most common method (Arkaravichien et al., 2014).

Trashed drugs pose a serious problem to the environment and human health. Disposing of unused drugs with domestic waste can cause wastewater leakage and cause environmental problems (Bound and Voulvoulis, 2005). These harmful drug wastes, which are poured into the toilet and reach the sea from sewage, undoubtedly affect the sea creatures. There is also evidence that the presence of antibiotics in the waterways affects existing bacteria and can lead to antibiotic resistance (Costanzo et al, 2005). In addition to the direct environmental effects of pharmaceuticals, the presence of antibiotics in wastewater has the potential to break down antibiotic-resistant organisms and disrupt wastewater treatment processes (Bound et al., 2006).

Reverse logistics applications have gained importance in terms of medical waste management in order to reduce the harm of wastes and prevent their negative effects on the environment. Metropolitan municipalities manage this process in a controlled manner for the proper collection and disposal of medical waste from public and private health institutions. In Istanbul, this process is carried out by the Metropolitan Municipality Waste Management Department. This institution eliminates the medical waste of private and public health institutions across Istanbul in a controlled manner. This process is completed by sterilizing medical waste and by burning it. There are some studies to collect medications that are not used at home or that have expired. One of these is the study of using genetic

algorithms to model the reverse logistics process in the project of collecting household drug waste. In the study, reverse logistic network design was used in the disposal of domestic drug wastes (Kırda, 2013)

The research is to answer the question of how to dispose of household drug waste in a controlled way. The aim of this study is to determine the effects of domestic pharmaceutical waste in the process of disposal in Istanbul. It is a methodology and computer technique used to identify and understand problems with complex system dynamics. In this study, a model proposal was developed with the help of the system dynamics approach, the Vensim PLE program, for the disposal of medical waste and domestic drug waste. The model was applied by considering the disposal process of domestic pharmaceutical waste in Istanbul.

2. Literature Review

Since many countries do not have standard drug disposal protocols, there is a lot of confusion about how drugs should be disposed of (Tong et al, 2011).

In Lithuania, most people throw or burn unwanted drugs (Krupiene and Dvarioniene, 2007). Research in countries such as the UK, Sweden, and New Zealand has shown that people dispose of drugs in ways that can harm the environment (Braund et al. 2009). These studies have also shown that if patients are aware of the effect of drugs on the environment, it is more likely to return their medication for proper disposal and disposal (Tong et al. 2011).

In Sweden, more than 50% of the population participated in a national and public system used to dispose of unused drugs through pharmacies (Persson et al. 2009). In Sweden, 73% of people have been shown to return unused drugs to the pharmacy if a formal and continuous system is available for the disposal of unused drugs (Persson et al., 2009). Pharmacies in Lithuania are used as drug collection stores (Krupiene and Dvarioniene, 2007).

In a study carried out in India, 65.5% of 145 people emphasized that the municipality should collect unused waste drugs and 88% of them discarded unused or expired drugs (Loges et al, 2019).

Cork and Kerry have worked to safely dispose of unwanted and unused medicines in the counties of Ireland and to implement a structured system (Council, 2011).

In Hong Kong in 2015-16, 1865 people were researched on using and disposing of unused drugs at home. It was determined that three quarters of the population had unwanted medication at home and on average, 138.4 g of medication was stored in each household. The leading type of drug is cold medicine (Chung & Brooks, 2019).

A system designed by the Spanish National Pharmaceutical Industry Association (Farmaindustria) was designed in 2002. Data published by the Entegre Packaging Management and Collection System (SIGRE) show an annual increase in the number of medicines that customers return to dispose of them in accordance with their local pharmacy. For example, more than 1,700 tons of packages were collected in 2004 (Sigre, 2019).

Patients who are familiar with the effects of drugs on the environment were more likely to return drugs for proper disposal and disposal (Tong, et al., 2011). Municipalities may be more effective in the disposal of domestic drug waste. However, a survey conducted in Kuwait found that municipalities are unlikely to collect domestic drug waste. It may be more cost-effective to use pharmacies as collection points in reverse distribution (Abahussain & Ball, 2007).

Medicines in the home are handed over to the collectors by the public as a takeback day event in America. The application, which is carried out twice a year, allows safe disposal of unused drugs. The weight of the medicines collected in October 2019 as part of take back activities was 441.5 tons (T.B.D, 2020). In our country, there are currently certain studies to collect and dispose of household drug waste. These are generally the studies that pharmacists have taken steps by forming organizations in different cities. On the other hand, there is a working model that municipalities run together through public institutions. Çekoop is an organization organized for the disposal and disposal of 'domestic waste drugs' by pharmacists who are directly responsible for the drug in 2010 in İzmir. It is the disposal of expired or unused domestic waste drug collected from the domestic through members who have been expired, broken or degraded in pharmacies and voluntary domestic, without harming the environment. It is destroyed by burning according to the practices determined by the World Health Organization. Another study was launched in 2015 with the coordination of Gaziantep Provincial Health Directorate, "Disposal of Domestic Waste Drug Project". During this study, Gaziantep Metropolitan Municipality plays an important role in the social awareness study. With this study, which was initiated 4 years ago, awareness of public employees, relatives and the public was created in some districts. In this way, it is ensured that the medicines are collected and disposed

of. During the study, awareness raising increased due to awareness raising activities. At the end of the training, questionnaires were made and the data of the questionnaire were compared among the drugs collected. The collected drugs are divided into pharmaceutical groups. It has been determined that the project is permanent with the training, survey and collection activities. It was determined that 46% of the collected drugs were discarded without any use (T.C.İ.B., 2020).

3. Conceptual Framework

Reverse Logistics is known as the retrieval and evaluation of used or unwanted products from users and disposal of products without added value. Businesses also undertake various initiatives in this field for reasons such as reducing the costs of reverse logistics activities, respectability, legal obligations and environmental responsibility.

Reverse logistics draws a great deal of attention because of the potential for appreciation of used products. In addition, legislation and regulations, consumer awareness and social responsibility towards the environment are also important factors in the interest of logistics in reverse (Pokharel & Mutha, 2009).

Waste is expressed as low value, expiring and useless residues (Öztürk et al, 2015). It is all of the items that appear at all stages from production to consumption and are no longer useful for the user (TDK, 2019).

In another definition, waste is called any substance that is thrown into the environment or left by the producer or the person who actually owns it, or that must be disposed of (Ç.Ş.B., 2019).

According to the World Health Organization, waste and byproducts cover a wide variety of materials. Infectious waste; waste transmitted by blood and other body fluids, cultures and stocks of infectious agents from laboratory studies, or waste from infected patients are bandages and disposable medical devices. Pathological waste is human tissues, organs or fluids, body parts and contaminated animal carcasses. Cutting waste, syringes, needles, disposable scalpels and knives, etc. Chemical waste are laboratory preparations, disinfectants, sterilates, and solvents and reagents for heavy metals found in medical preparations (such as mercury in broken thermometers). Pharmaceutical waste is expired, unused, and contaminated drugs and vaccines. Cytotoxic waste is waste containing genotoxic properties (ie highly dangerous substances that are mutagenic, teratogenic or carcinogenic), such as cytotoxic drugs and their metabolites used in cancer treatment. Radioactive waste is products contaminated by radionuclides, including radioactive diagnostic material or radiotherapeutic materials. Nonhazardous or general waste is waste that does not pose a specific biological, chemical, radioactive or physical hazard.

The main reason for the disposal of medical wastes is to get rid of the harmful effects of the wastes and to turn them into a nonhazardous state by protecting them from harm to human and environment. Various methods are used for the disposal of medical waste. Among these, methods such as chemical disinfection, microwave radiation, incineration, and autoclaving are used. For pathological wastes, disposal methods such as incineration and burial are used. Disposal method varies according to the characteristics of medical wastes (WHO, 2018).

4. Methodology

System dynamics approach, while analyzing the structure of a system and developing the system, leads people to think critically about the problems they face. The most important one is that with a system dynamics approach, a person can establish a mental link between the structure of the system and the behavior achieved as a result of the system. The aim of this study is to understand the system structure in the process of disposal of domestic pharmaceutical waste in Istanbul, and to establish a mental link between the structure of the system and the behavior obtained as a result of the system.

The system is a set of interrelated elements whose boundaries are determined. The interaction of system elements with each other and the system environment leads to the unique behavior of the system (Sezen & Günal, 2009). The system can be defined as a series of interconnected components that are consistently organized to achieve something (Meadows, 2008). System dynamics is an approach that aims to understand complex systems and develop policies that allow them to be changed in the desired direction. It deals with feedback and delayed responses that affect system behavior. System thinking is an approach that takes into account all aspects from a wide perspective and focuses on the relationships between different parts of the problem. In line with this approach, the group of physical

and nonphysical elements, which are related to a specific purpose, is called "system". Thanks to these relationships, the lower parts unite and form the whole. In this case, the system forms a whole with integral parts (Tecim, 2004). It is a methodology and computer technique used to identify and understand problems with complex system dynamics. System dynamics approach, while analyzing the structure of a system and developing the system, leads people to think critically about the problems they face. The most important one is that with a system dynamics approach, a person can establish a mental link between the structure of the system and the behavior achieved as a result of the system. In this study, a model proposal was developed with the help of the system dynamics approach of disposal of medical wastes and domestic pharmaceutical wastes, with the help of the Vensim PLE program.

4. Results and Discussion

Causal loop diagrams are an effective tool to show the feedback structure of the system. Loop diagrams consist of variables linked by arrows that show causal effects. Arrows show the relationship between the variables. The arrows on the arrows indicate the direction of the relationship between the variables.

4.1. Drug Use Stock and Flow Diagram

According to the World Health Organization, the drug; It is defined as a substance or pharmaceutical product that can be used to alter or examine physiological systems or pathological conditions for the benefit of the area. (W.H.O., 2019). The use of the drug is a matter to be considered. Unconscious use of drugs increases the amount of unused domestic drug. This increases drug use again. The drug use stock and flow diagram is shown in Figure 1 below.

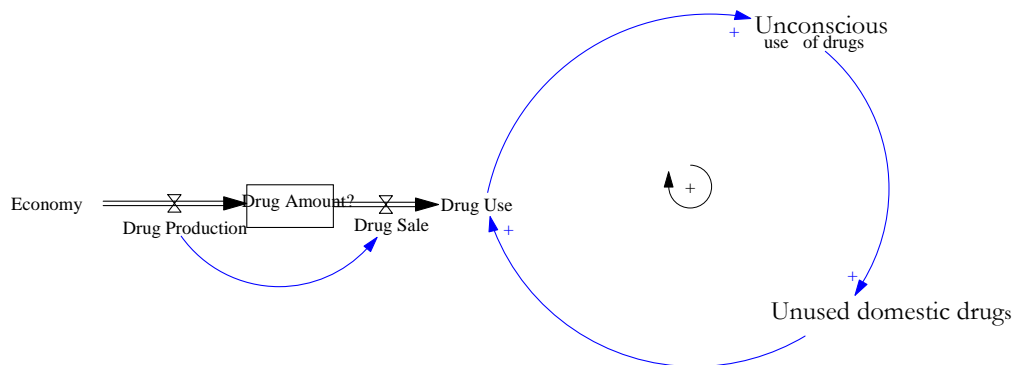


Figure 1. The drug use stock and flow diagram

4.2. Unused Domestic Drug Stock and Flow Diagram

Unused domestic drug stock and flow diagram in Figure 2 is given below. Domestic drug that are not used in homes become waste by expiring over time. Drugs that become waste at home are disposed of by wrong methods. As a result, it has a negative effect on the marine life either by throwing it away or by pouring it into the toilet. The negative impact of marine life affects the environment and human health. As human health is adversely affected, the demand for health service will increase. Thus, by increasing the production of drugs, it affects drug sales in the same direction. If drug sales increase, unconscious drug use increases. Unconscious drug use will also increase the amount of unused domestic drug.

Variables affected by the amount of domestic unused drugs ; the number of pharmacies, drug use, expired household drug waste and medical waste Variables that affect the amount of domestic unused drugs are drugs with unconscious drug use and side effects.

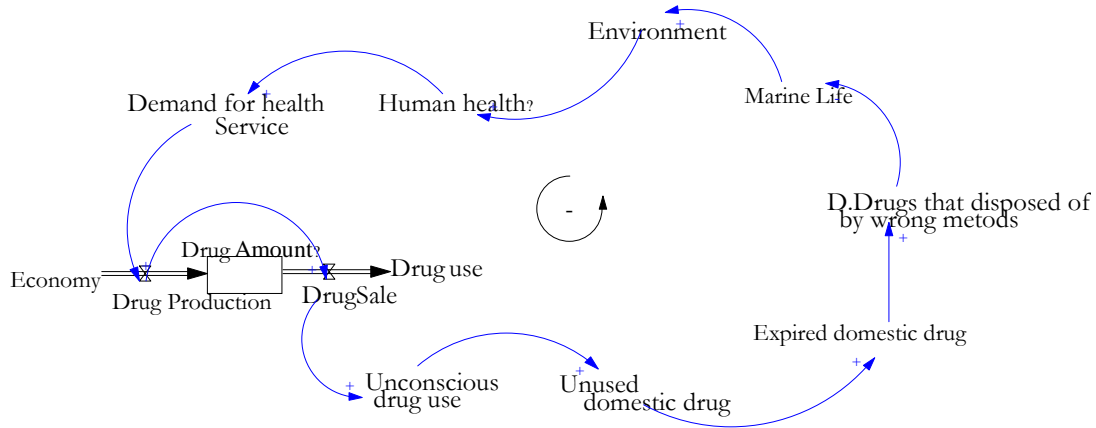


Figure 2. Unused Domestic Drug Amount Stock and Flow Diagram

4.3. Unused Domestic Drug Amount Stock and Flow Diagram

The suggestion proposal for the problem of disposal of domestic drug waste in our model is shown in Figure 3 below.

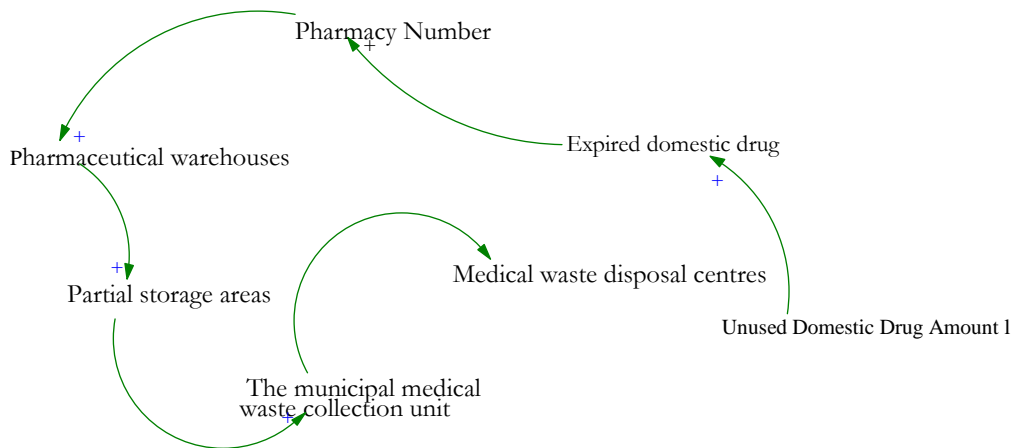
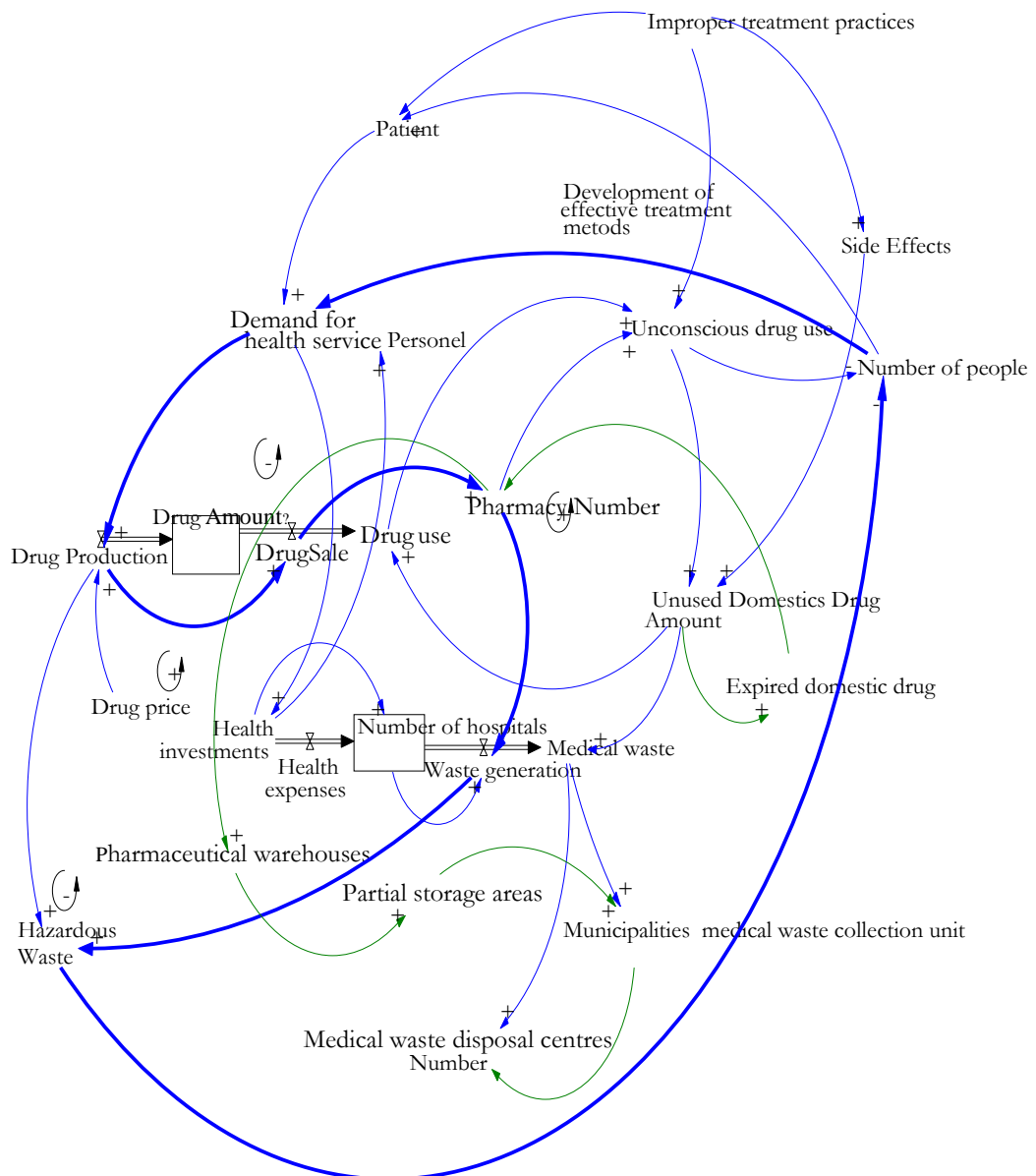


Figure 3. Proposed Causal Loop Diagrams for the Disposal of Domestic Drug Waste

Unused domestic drugs quantity increase in over time. As a result, it increases domestic drug waste that has expired. The disposal process of unused drugs at home or whose use has expired is initiated by leaving them to pharmacies. They collect these drugs accumulated in pharmacies while the delivery vehicles of the pharmaceutical warehouses return to the warehouse. These drugs to be disposed by the pharmaceutical warehouses are stored in partial storage areas. Disposal is terminated by taking the drugs that are kept in partial storage areas and the municipal medical waste collection unit to these waste drugs regularly to the medical waste disposal centres. Thus, a positive contribution is made to both the environment and human health

One of the variables that make up our model is the drug sales variable. As the amount of drug sales increased, it has a positive effect on the number of pharmacies, causing pharmacies to increase. Increasing the number of pharmacies increases the waste generation as it will cause the drugs to be destroyed. Waste causes an increase the amount of hazardous waste. This has a negative impact on human health. Decreased human health leads to increased demand for health. As a result, health demand has a positive (+) effect on drug production. And so it increases the sales of drugs again.

The system dynamics model of the study is shown in Figure 4 below.



5. Conclusion

There are various studies in the field of domestic drug waste collection and reverse logistics applications in the literature. But this study also theoretically contributes to the researches in this field as modelling the process by using the system dynamics model in order to understand the system structure in the process of disposal, and to establish a mental link between the structure of the system and the behaviour achieved as a result of the system.

System dynamics approach, while analysing the structure of a system and developing the system, leads people to think critically about the problems they face. The most important one is that with a system dynamics approach, a person can establish a mental link between the structure of the system and the behaviour achieved as a result of the system. The purpose of this study is to understand the system structure in the process of disposal of domestic pharmaceutical waste in Istanbul, and to establish a mental link between the structure of the system and the behaviour obtained as a result of the system.

In this study, as a result of the causal cycle analysis revealed by the system dynamics model, the need to eliminate domestic drug wastes in a controlled manner through competent institutions and organizations has been introduced. In this way, it is envisaged to reduce the negative effects of drugs that are expired or not used on the environment and human health. Thus, cooperation between private and public institutions in this process is ensured. We can say that the process will be managed correctly, fast, beneficial and effective for human health. By this model, it can be said that disposal of domestic pharmaceutical waste throughout the country can be contributed to its solution through the contributions of municipalities, pharmacies and pharmaceutical warehouses and their work in a fully integrated system.

The study only covers the process of disposal of household drug waste. Medicine used in medical institutions and organizations are excluded. Further research can be done by taking coverage in this regard. In the study, due to insufficient data, disposal scenarios could not be created and further analyses could not be made. In future studies, scenario analysis can also be included in the study.

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