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Medical Waste Effects and Management: Overview and Future Directions

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Abstract

For the first time, in this paper are mentioned the effects of the medicines in the environment, including mostly human, animal and fish health and curiously there are not so many studies as it should be expected due to the increasing importance of medical waste management in the last century. Many developed nations have medical waste legislation, where are reported all the practices related to waste management, including the common sources, governing legislation and handling and disposal methods., though there is lack of enforcement and clarity including the European Union (EU) countries. Furthermore, this reports a comparison of cases in the Western Balkan region, where some of the countries (like Croatia) have a good legislation, but a law level of law enforcement, while it is observed a big difference on the medical waste management practice level at the comparison between Serbia and Albania, as EU candidates. It concludes that a better education and specialization of healthcare workers, standardized sorting of medical waste streams together with subventions methods could be crucial for finding sustainable solutions.

Keywords: Health waste; Incinerator; Autoclave; Western Balkans

Environmental Negative Effects of Medicines

Medicines have an important role in the treatment and prevention of disease in both humans and animals. Although the side effects on human and animal health are usually investigated in thorough safety and toxicology studies, the potential environmental impacts of the manufacture and use of medicines are less well understood. Some pharmaceuticals can cast effects on bacteria and animals well below the concentrations that are usually used in safety and efficacy tests [1]. In addition, breakdown products and the combination of different biologically active compounds may have unanticipated effects on the environment. A wide range of human medicines, including antibiotics, statins or cytotoxins used in cancer treatment, are produced and used, some in the range of thousands of tons per year [1]. It is hard to obtain information on the amount of human medicines used, but recent data from Canada indicates that high-use drugs include acetaminophen, acetylsalicylic acid, ibuprofen, naproxen and carbamazepine [2]. Large amounts of veterinary medicines, such as antibacterials, antifungals and parasiticides from aquaculture and agriculture, may also contribute to the stress on the environment, particularly as they often find their way directly into soils and surface waters unlike human medicines, which usually go through a water treatment plant first.

Comparative analysis of the amounts of antimicrobials, especially quinolones, consumed in salmon aquaculture and in human medicine in Chile robustly suggested that the most important selective pressure for antibiotic resistant bacteria in the country was the excessive antibiotic use in this industry [3]. The commonality of antibiotic resistance genes and the mobilome between environmental aquatic bacteria, fish pathogens and pathogens of terrestrial animals and humans suggests that horizontal gene transfer occurs between the resistome of these apparently independent and isolated bacterial populations. Thus, excessive antibiotic use in the marine environment in aquaculture is not innocuous and can potentially negatively affect therapy of bacterial infections of humans and terrestrial animals.

All human and veterinary therapeutics are released to the environment by various routes (Figure 1). Residues released during the manufacturing process may ultimately enter surface waters [1]. After administration, human medicines are absorbed, metabolized and then excreted to the

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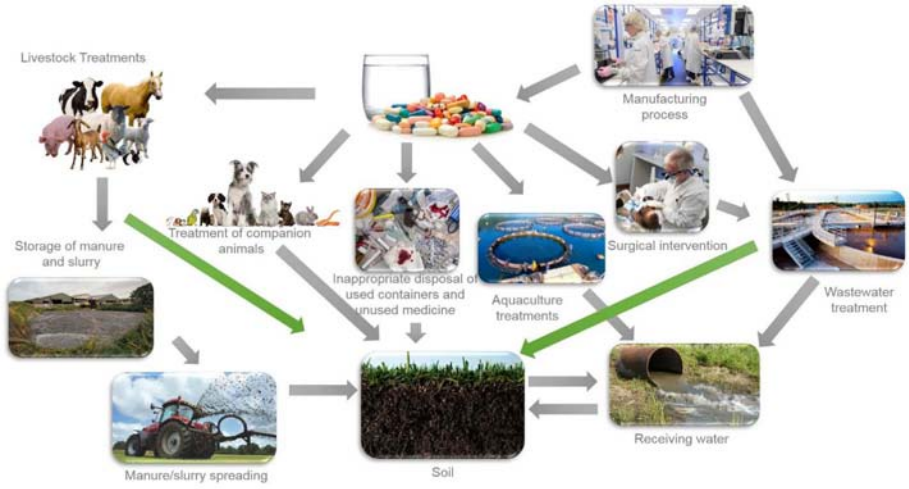

Figure 1: Routes of medicines entering in the environment.

sewer system. They usually go through a treatment works before they find their way into receiving waters or land by the application of sewage sludge [1]. Antibacterials for the treatment of fish or shrimp in aquaculture are directly released to surface waters [1]. Veterinary medicines used to treat pasture animals are excreted to soils or surface waters. In intensive livestock treatments, these medicines are likely to enter the environment indirectly through the application of slurry and manure as fertilizers. Other minor routes of entry include emissions to air and through the disposal of unused medicines and containers. Although pharmaceuticals have been released into the environment for decades, researchers have only recently begun to quantify their levels in the environment [1].

Analytical techniques, such as liquid chromatography coupled with tandem mass spectrometry (LC-MS-MS), have allowed us to develop a better understanding of how medicines behave in the environment and to determine concentrations in wastewater treatment plants, soils, surface waters and groundwaters. Once released into the environment, pharmaceuticals will be transported and distributed to air, water, soil or sediment. The degree to which a pharmaceutical is transported between the different environmental media primarily depends on the sorption behaviour of the substance in soils, sediment-water systems and treatment plants, which varies widely across pharmaceuticals. Moreover, unlike other organic substances, such as pesticides and industrial chemicals, the sorption behaviour of many pharmaceuticals cannot be simply derived from the substance's hydrophobicity or the organic carbon content of the solid material [4]. Pharmaceutical substances may also be degraded by biological organisms in treatment systems, water bodies and soils as well as abiotic reactions. Generally, these processes reduce the potency of medicines; however, some breakdown products have similar toxicity to their parent compounds [5]. Furthermore, degradation varies significantly depending on chemistry, biology and climatic conditions.

Not surprisingly, recent monitoring studies have detected low levels of a wide range of pharmaceuticals, including hormones, steroids, antibiotics and parasiticides, in soils, surface waters and groundwaters [6,7]. The reported concentrations are generally low—usually less then 1µg/l in surface waters—but what is more worrisome is that many therapeutic substances have been found across a wide variety of hydrological, climatic and land-use settings, and many of the substances have been detected throughout the year. These findings have raised questions about how this mixture of veterinary and human medicines abundant in soils and surface waters has an impact on beneficial organisms in the environment and on human health. Comparison of these data with therapeutic dose information, drinking water limits and health advisories indicates that the concentrations of therapeutic compounds in surface waters are well below levels that would be of concern to human health [7-9].

The impacts on environmental health are more difficult to assess and risks corresponding to other routes of exposure (such as uptake from soils into crops and biomagnification through the food chain) have yet to be quantified and cannot be ruled out completely. Since 1980, the US Food and Drug Administration (FDA) requires environmental risk assessments of human and veterinary medicines on the effects on aquatic and terrestrial organisms, before they allow a product to the market [10,11], and the EU introduced similar requirements in 1997.

These environmental impact studies investigate the potential negative effects on fish, daphnids, algae, bacteria, earthworms, plants and dung invertebrates. Much of the data are publicly accessible many of the environmental assessments are published on the FDA's web site—and provide a reasonable body of data for further study [1]. However, there are valid questions about the real-world value of these studies. Risk assessments usually use standard ecotoxicity tests, which are often short-lived and focus predominantly on mortality as the endpoint. Moreover, aquatic tests tend to focus on the water compartment and do not take into account pharmaceuticals residing in sediments. In general, the effects observed in these studies occur at much higher concentrations than those that are measured in the environment. What is less known are the more subtle effects that therapeutically active substances can have on organisms in the environment, such as growth, fertility or behaviour?

Pharmaceutical compounds are designed either to be highly active and interact with receptors in humans and animals or to be toxic for many infectious organisms, including bacteria, fungi and parasites, but this does not mean that they affect only these living forms. Many lower animals have receptor systems similar to humans and animals used in agriculture and many groups of these organisms that affect human and animal health, which are targeted by pharmaceuticals,

have a crucial role in the functioning of ecosystems [1]. It is therefore possible that pharmaceuticals may cause subtle effects on aquatic and terrestrial organisms that are not detected in standard studies. And as human medicines are almost continuously released to the environment.

Several scientific disciplines researchers have begun to look into some of the more subtle effects caused by long-term, low-level exposure to pharmaceuticals, based on the fact that wildlife organisms are exposed for much longer durations than those used in standard tests. A wide range of subtle impacts has been reported, including effects on oocytes and testicular maturation, impacts on insect physiology and behaviour, effects on dung decomposition, inhibition or stimulation of growth in aquatic plant and algae species, and the development of antibacterial resistance in soil microbes [1]. Steroids from contraceptives are strongly suspected to affect the fertility and development of fish, reptiles and aquatic invertebrates.

Laville and colleagues (2004) performed an *in vitro* study as a first approach in the toxicity assessment of human drugs on fish and nine pharmaceuticals (clofibrate, fenofibrate, carbamazepine, fluoxetine, diclofenac, propranolol, sulfamethoxazole, amoxicillin and gadolinium chloride) were tested on two fish hepatocyte models, represented by the primary cultures of rainbow trout hepatocytes (PRTH) and PLHC-1 fish cell line. Fenofibrate, Carbamazepine, Diclofenac, Sulphamethazole and Clofibrateexcerted inhibition of basal EROD activity in cultures of rainbow trout hepatocytes, while the treatment with propranolol showed to be a weak EROD inducer in cultures of rainbow trout hepatocytes [12]. Research in environmental toxicology involving pharmaceuticals and personal care products (PPCPs) has increased greatly over the last 10-15 years. Much research has been focused on the endocrine-disrupting potential of PPCPs, as they relate to negative population impacts of aquatic organisms, where the majority of individual PPCP studies demonstrate negative effects on fish fecundity [13].

Equally, antibiotics from human and veterinary use have an effect on soil microbes and algae. Macrocyclic lactones can affect invertebrate larvae in dung at fairly low concentrations; earthworms appear sensitive to the parasiticides used in veterinary medicine and plants may be sensitive to many sub-lethal responses in dung invertebrates, such as reduced feeding, disruption of water balances, reduction of growth rate, inhibition of pupation and the disruption of mating (Boxall et al., 2004). As dung from livestock contains diverse fauna and provides a fruitful foraging habitat for other species, macrocyclic lactones may therefore indirectly affect other species by depleting the quality and quantity of their food source.

Furthermore, pharmaceutical substances are not the only contaminants in environmental systems. Aquatic and terrestrial organisms are exposed to a mixture of medicines and other substances, including pesticides, biocides and general industrial chemicals [9].

As current environmental risk assessments focus on single substances, it is possible that these assessments are underestimating the impacts. When we begin to consider these interactions, it is important that we do not just focus on toxicological endpoints. It is also possible that the environmental behavior of a substance could change in the presence of other substances. Antibacterials, for example, have been shown to affect soil microbes, which have an important role in breaking down pesticides. For example, studies indicate that veterinary antibacterials may affect sulphate reduction in soil and inhibit the decomposition of dung [14]. If a veterinary antibacterial were to be applied in slurry to an agricultural field before the application of a pesticide, it is quite possible that the environmental impact of the pesticide could be radically changed.

Various approaches have been advocated, including the control of pharmaceuticals at the source, the segregation of sources, the treatment of waste products to remove pharmaceutical compounds, the introduction of husbandry practices and the improvement of disposal systems for out-of-date medicines and waste containers [15]. Source controls include labelling, controlled disposal and urine separation. Segregating sources of pharmaceuticals, such as hospital wastewater, which is likely to be heavily contaminated with pharmaceuticals and antibiotic resistance bacteria, should make it possible to focus treatment resources on the most contaminated waters. Pharmaceuticals can be removed when treated through physical processes, such as sorption or volatilization, biological degradation or chemical reactions, for instance, through treatment with ozone.

Medical Waste

Medical waste (MW) is classified by the World Health Organization (WHO) as “waste that is generated in the diagnosis, treatment or immunization of human beings or animals”. Medical waste that is not properly handled and disposed of represents a high risk of infection or injury to healthcare personnel, as well as a lesser risk to the general public through the spread of micro-organisms from healthcare facilities into the environment [16,17]. Medical waste disposal is an issue of considerable scale. As the world's top medical waste producing nation, the United States alone creates over 3.5 million tonnes of medical waste per year with an average disposal cost of $790 per tonne[18]. Medical waste production in the developing world is rising quickly due to improved access to medical services, which allow evergreater numbers of people to receive modern medical care. The trend away from multi-use medical devices towards safer, single use medical devices is further adding to the production of medical waste in developing nations. These combined trends are causing a rapid increase in the amount of medical waste that requires safe disposal in developing nations [19]. In the developed world, a rapidly aging population is the major driver of increasing medical system usage, and this rising medical system usage is producing a corresponding increase in medical waste production [20]. It is estimated by the World Health Organization (WHO) that 20 percent of these medical wastes can be classified as hazardous materials that may be infectious, toxic, or radioactive [16]. However, there is no globally agreed upon definition of medical waste, which poses a challenge from a comparative standpoint, as changing definitions make a meaningful comparison between countries, or even between regions within countries, quite difficult.

Further, the absence of a standard definition of medical waste has led to a lack of standardization of medical waste streams and disposal receptacles, as discussed later in this review [21]. Generally, there are four terms used when discussing medical waste, and all are often used interchangeably, with no universally accepted definition for each term [22]. These are: hospital waste, medical waste, regulated medical waste and infectious medical waste. It is extremely important to note that the term medical waste should be used to refer to all waste that is generated at any healthcare or healthcare-related facility, which is consistent with the definition of medical waste given by the United States Environmental Protection Agency [23]. The term infectious

Table 1: Comparison of medical waste production (total), to GDP, health GDP, and healthcare system ranking.

Country	GDP per capita (USD)	GDP spent on healthcare (USD)	WHO ranking of health system performance	Total healthcare waste generation (kg/bed-day)
Norway	99,636	8,967	11	3.9
United States	51,496	9,218	37	10.7
United Kingdom	41,054	3,939	18	3.3
France	40,908	4,786	1	3.3
Spain	28,993	2,783	7	4.4
Croatia	13,236	1,030	43	1.6
Brazil	11,320	1,053	125	3.25
Turkey	10,661	672	70	70
South Africa	7,314	644	175	-
Bulgaria	7,198	533	102	-
Serbia	5,659	560	106	-
Jordan	4,909	481	83	6.1
Albania	4,248	240	55	2.5
Vietnam	1,755	116	160	-
Pakistan	1,252	39	122	2.07
Tanzania	609	43	156	0.14

Notes: in the table are reported the data from Windfeld and Brooks [26], while the data for Serbia, Albania and Croatia were calculated by us based on the data reported from World Bank 2012 database.

medical waste will refer to the subset of waste generated at healthcare facilities that is unsuitable for disposal in a municipal solid waste system due to pathogenic concerns.

MW Generation and Current Legislation

The quantity [24] and composition of medical waste generated is dependent on many factors, with a medical waste study focusing on Italian hospitals finding that the type of sanitary service offered greatly impacts the amount of infectious waste produced [25]. The study found that as much as 52% of overall infectious medical waste production comes from short-term patients in rehabilitation service, followed in descending order by analytical laboratories (23%), surgeries (14%), dialyses (7%) and first aid (4%). A similar study done in Taiwan found the dialysis unit to generate the greatest amount of infectious medical waste (23%), flowed by the intensive care unit (17%), the emergency care unit and the outpatient clinic (12% each) [24]. In evaluating medical waste generation, it is helpful to use a common basis for quantification, so that data from different regions can be compared.

The selection of an appropriate metric for comparing healthcare facilities and medical waste production levels is challenging. The most common metric for quantifying the amount of medical waste generated at a hospital is reported as kg/bed-day, which is generally accepted that kg/bed-day is the best available basis for hospital waste production comparison, with studies finding that the number of beds in service strongly relates to the amount of medical waste produced at similar hospital facilities [25].

Table 1 details the average healthcare waste production in total for hospitals in 16 countries around the world and presents these values alongside data showing each country's nominal gross domestic product (GDP) per capita, healthcare spending per capita, and each country's healthcare system rank in the WHO's 2000 millennium healthcare assessment, mostly based on the [26].

Furthermore, it crucial to give an overview of the legislation governing the classification, collection, transportation and disposal of medical waste for the United States (U.S.), the United Kingdom (UK), the European Union (EU), some of the Western Balkan representative countries (Albania, Croatia and Serbia) and developing nations. It should be noted that the United States, Canada, and the United Kingdom are all wealthy G7 member countries with developed economies, while the European Union is a group of nations (including the UK) and includes some countries that are classified as upper middle income nations, rather than high income nations like the U.S. and UK [27] (UN, 2012) [26].

Medical waste is highly regulated in the United States, with the main piece of legislation governing American medical waste being the Medical Waste Tracking Act (MWTA) of 1988. The MWTA was passed by Congress as an amendment to the Solid Waste Disposal Act, itself written in 1965 to address how to safely dispose of large volumes of industrial and municipal solid wastes (U.S. EPA, 2013). Many see the MWTA as a product of the media attention received by medical waste during the late 1980s, when large amounts of improperly disposed of medical waste were routinely found washed up on beaches, creating public outrage [28]. The MWTA of 1988 came into effect on June 24, 1989, and has been the basis for medical waste classification, handling, transportation, treatment and disposal in the United States ever since [29].

In addition to governing the collection and transport of medical waste, the MWTA also required the United States Environment Protection Agency(EPA) to examine various treatment technologies available at the time for their ability to reduce the disease causing potential of medical waste (U.S. EPA, 2012b). The technologies that EPA examined in 1990 included incinerators, autoclaves, microwave units and various chemical and mechanical systems (U.S. EPA, 2012b). The EPA continues to conduct research on improving infectious medical waste treatment methods. Incineration is the most common method of medical waste disposal in the United States, and until recently the only limitation placed on incineration facilities was that they could not cause nuisance to nearby areas. This was generally

interpreted to mean that they could not create detectable odours and had to operate within prescribed opacity limits [30]. In 1997, the United States EPA enacted regulations regarding the emission limits of existing and new waste incineration facilities [31]. These regulations required existing incinerators to be equipped with air pollution control devices to comply with the new legislation requirements, which were too expensive for many on-site waste incineration facilities and resulted in the closure of more than five thousand medical waste incinerators [31]. Issues relating to the incineration of medical waste in the United States are discussed further in Section 6, which focuses on incineration emissions and regulations.

In the European Union, the European Commission (EC) sets directives for waste regulations and standards, and then member nations are responsible for enacting legislation that complies with and serves to fulfill these EC directives. As such, the EC has directed countries in the European Union to classify their waste according to chapter 18 of the European Waste Catalogue (EWC), in which the EC has established a list of waste descriptions for the different components of medical waste. The EWC itself was established by European Commission Decision 2000/532/EC in the year 2000 [21]. Underlying chapter 18 of the EWC is European Commission decision 94/904/EC, which on December 22, 1994 established a list of hazardous wastes to be used by member EU countries [32]. Since 1994, the Directory on Hazardous Waste (94/ 904/EC) has regulated hazardous waste in the European Union, defining and governing most types of hazardous waste, including medical waste. Adoption of the Directory on Hazardous Waste is mandatory for all EU member nations, but national classifications and definitions are still used for a considerable portion of government data collection and compliance enforcement (Bertram et al., 2002). This use of national definitions makes it difficult to draw valid comparisons among data from different countries, as the classification systems can differ significantly between countries, despite the direction of the EWC. A lack of adequate description of what constitutes hazardous waste within the Directory on Hazardous Waste helps to explain this variation in national definitions [33]. In 2000, the European Union enacted stricter emission limits for medical incineration facilities. This has caused a trend towards the shutdown of waste incineration facilities in favor of nonincineration methods of treatment, such as autoclave sterilization. However, Europe has not been as quick to adopt these new technologies as the United States [31].

Even when a developing nation has enacted medical waste legislation, there is often a marked disconnect between the thoroughness of the legislation and the reality of medical waste management in that country. For example, Botswana enacted a clinical waste code of practice in 1996 which defines clinical waste, details collection and handling hazards for the waste, and requires the waste to be carefully separated into color-coded waste streams. However, studies have found that the majority of healthcare workers in Botswana are not aware that this waste management legislation exists in their nation [34].

Current Practices in Developed Nations

At hospitals and other healthcare facilities, waste is generally sorted into color-coded bins or bags, with each receptacle denoting a different waste stream or waste type. The color selected for each waste type, along with what types of waste go into each stream, varies from region to region, with some using the source of the waste as a basis for sorting, while others use the likelihood of an objects pathogenicity to determine its disposal waste stream [35]. This lack of standardization makes effective waste sorting difficult for healthcare workers, and causes workers to err on the side of caution, disposing objects in the infectious waste stream and causing unnecessary infectious waste generation [36]. Another issue with medical waste disposal is ensuring that persons do not come into contact, whether accidentally or on purpose, with disposed-of infectious items. In most jurisdictions, healthcare facilities have a legal responsibility to ensure that patrons and staff do not come into contact with infectious waste once it has been placed in a disposal bin [37]. Studies, focused mainly on the UK, have found that hospitals do not have adequate safeguards to prevent these contacts with hazardous medical waste, and that safe-handling procedures are frequently neglected [37]. This inadequacy is both a source of infection and a legal liability for hospitals, should patients become ill from poor waste management practices. Further reinforcing the need for adequate safeguards in healthcare facilities, the EPA has concluded that the disease-causing potential of medical waste is greatest at the point of generation and naturally tapers off after that point. Thus, safeguarding of infectious medical waste within healthcare facilities ought to be made a top waste management priority.

Medical waste transportation refers to the haulage and handling of waste from inside healthcare facilities to treatment sites, which can either exist *on-site* at a hospital or be a central *off-site* facility. A second transportation phase typically occurs when the treated waste residual, typically ash from an incinerator or waste sterilized through autoclaving or microwaving, is moved to a landfill for final disposal [38]. It is common practice for healthcare facilities to have their infectious waste stream transported by a third-party firm, contracted to take the waste from the healthcare facility to an appropriate waste depot [16]. These firms typically collect the waste from a few central points in a healthcare facility and then transport the waste to a disposal facility that is able to safely handle medical waste. However, there are issues with the process of contracting out waste disposal. The use of third party disposal firms poses a challenge from an incentives point of view, as the waste disposal firms, or the individuals who work for them, can pocket large sums by improperly disposing of the waste. Disposal fees for medical waste in developed countries are very high, with hospitals in the UK frequently paying in excess of £450 per tonne for contractors to dispose of their medical waste and hospitals in the United States typically paying $790 per tonne for medical waste disposal [37,38]. These high prices create an incentive for third-party medical waste haulage firms to dispose of the medical waste without treatment in unregulated and less expensive ways, rather than transport the waste to a proper treatment facility for sterilization. In Ireland, waste truck operators can pocket over $2000 by illegally dumping a truck full of medical waste rather than taking it to a regulated disposal site, thus creating a very strong incentive for illegal dumping [16]. Developed nations increasingly have to grapple with the problem of illegal medical waste dumping, which can be particularly chronic if the country has a weak infectious medical waste tracking system. Illegal dumping is a significant issue, as these untreated infectious waste deposits present a health risk to the public due to potential for pathogen release, and a drain public fund as cleanup costs for medical wastes are extremely high [16]. Another problem relating to illegally disposing of infectious medical waste occurs in developing countries such as India, where governments are grappling with disease outbreaks due to third-party firms receiving medical waste from healthcare facilities and then reselling items such as sharps on the black market for re-use [39]. Indeed, a study by the

Indian Clinical Epidemiology Network in 2004 found that almost 10% of health facilities in India sold their used syringes to waste-pickers, who manually sort the medical waste in search of any items that can be reused and sold to healthcare facilities. The recovered sharps are not subjected to any sort of sterilization process before being reused, thus these objects present considerable scope for infection of healthcare patients through transmission of a blood-borne pathogens from the previous patient [39]. It should be noted that medical experts do not allow infectious medical waste to be reused or recycled, regardless of the use of a sterilization process [40].

Safe disposal of infectious medical wastes is a problem of considerable scope, with the WHO stating that "at present, there are practically no environmentally friendly, low-cost options for safe disposal of infectious wastes" [16]. In the United States, studies have found that 60% of medical waste is incinerated, 37% is autoclaved, and 5% is treated by other technologies [40,41]. However, concerns over air pollution have raised questions about the suitability of incineration as treatment method. Further, medical waste contains a significantly higher plastic content than typical municipal solid waste, and as a result, the combustion of medical waste leads to the formation of polychlorinated dibenzo-p dioxins (dioxins) and polychlorinated dibenzofurans (furans), both highly toxic substances [18]. This has led to an increased focus on alternate treatment methods such as autoclaving and microwaving to kill any pathogens present. The leading method of disposing infectious medical waste in developed nations is through incineration, whereby the wastes are burned at very high temperatures so that nothing but a residual ash remains. This ash is then sent to a landfill facility to be buried. Incineration has the advantage of ensuring sterilization by reducing the infectious waste to an unrecognizable ash, and of reducing waste volumes which reduces transport and landfill impacts and costs [42]. However, a major drawback of the medical waste incineration process is the release of undesirable toxins into the atmosphere. Because of its composition, infectious healthcare waste produces toxic gases in meaningful quantities when incinerated, and thus incinerator emissions are tightly regulated in most developed nations. The three toxins that are of greatest concern with medical waste incineration are dioxins, furans, and mercury [21].

Management of Medical Waste in Western Balkan Countries

In this section we will present an overview from some representative countries in the Western Balkan region [43]. In Croatia (an EU member country), according to national legislation [44], hazardous medical waste is classified, based on its properties and the place of production, as: pathological waste, infectious waste, pharmaceutical waste, chemical waste, sharp objects, containers under pressure, and radioactive waste that is subject to separate regulations. WHO in its definition of hazardous waste defines two additional categories: genotoxic waste and waste with a high concentration of heavy metals? Genotoxic waste contains cytostatics, used in oncology for chemotherapy, as immunosuppresses during transplants, and in some other fields of medicine. Other genotoxic and radioactive chemicals, and contaminated materials like packaging and body fluids (urine, feces, and vomit) from patients treated with cytostatics are treated as genotoxic waste as well. In specialized hospitals, this sort of waste can account for as much as 1% of the overall medical waste [45]. Waste with a high content of heavy metals includes mercury (mostly from broken medical equipment) and from dental offices, cadmium (from batteries), lead and arsenic [45]. In Croatia, these two categories of medical waste are treated as other pharmaceutical and chemical waste. According to Croatian law [46], all medical waste should be sorted at the point of generation and packed into containers according to its properties, amount, transportation and treatment before final disposal. The packaging for various categories of medical waste differs by color, shape and size. Red color marks infectious waste, red with a black stripe indicates pathological waste, yellow indicated chemical waste, green is used for pharmaceutical waste, and black and blue indicate communal (general) waste. All packages should be labeled as "Hazardous medical waste" [47,48]. In 2002, Croatia ratified the Directive on the management of waste produced during healthcare [44]. The Directive describes an overall system of waste management: sorting at the point of generation, collection, transportation, storage, and treatment. According to the Directive, every hospital must have a 5-year plan for waste management. Hazardous waste management depends on the waste category. Thus, pathological waste, consisting of the recognizable (amputated parts, fetuses) and unrecognizable (tissue samples, blood) body parts, should be treated separately. For ethical reasons, the first group is incinerated in crematoria or buried in cemeteries, whereas the second is incinerated with other infectious waste. For the treatment of the infectious waste including sharp objects, there are two acceptable methods: the first one is sterilization and landfilling, and the second one is incineration. After sterilization sharp objects made of metal can be recycled as secondary raw material. Chemical and pharmaceutical waste should be incinerated as well, and the remaining ashes should be disposed at a landfill. If waste has to be stored before treatment, it should be placed in adequate, properly labeled packaging, and deposited in an area intended for that purpose only. Such space should be out of the reach of patients and staff, properly marked and accessible only to authorized personnel. It is important to keep in mind that the storage time for hazardous waste is limited. If the waste has to be transported to larger incinerators, trucks must be properly marked and often officially escorted [49].

Medical waste management in Croatia is regulated by three laws and legal documents: Law on waste [46], Regulations on waste type [48], and Directive on management of the waste produced during health care [44]. Furthermore, there is a "Strategy for waste management" describing the principles of integrated waste management from the point of generation to final disposition, based on the principles of sustainable development [50]. The Ministry of Environmental Protection, Physical Planning and Construction operate the Registry of emissions into the environment. The Registry contains data relating to all sources, types, amounts, ways and places of disposal or discharge of harmful substances into the environment. The data should be collected by the county or municipal services for environmental protection (Republic of Croatia, 1996a). In spite of the legal obligation, only a small number of medical institutions report their waste to the Registry. That points to the weakness of the Registry function, and suggests a need for the introduction of penalties. Besides the necessary improvements, the existing legislation should be brought in line with the European Union legislation.

Data from the WHO show that the amount of medical waste production depends on the size and the type of the medical institution, but also that it differs from country to country based on their national income or the level of development. Highly developed countries have a larger production of medical waste than middle developed and developing countries. Highly developed countries produce

1.1–1.2 kg per capita, 0.4–0.5 kg of which is hazardous waste; middle developed countries produce 0.8–6 kg per capita, 0.3–0.4 of which is hazardous waste; and developing countries produce 0.5–3 kg of waste per capita [45]. In Croatia annual waste production per capita is 1.2 kg, out of which 0.16 kg is hazardous medical waste. Comparison of world data shows large differences in daily medical waste production between affluent and poor regions. North America produces 7–10 kg of waste per hospital bed daily, Western Europe 3–6 kg, whereas South America produces 3 kg, and Eastern Europe 1.4–2 kg per bed [45]. The difference in quantities results from the fact that developed countries invest much more money in health systems, leading to larger amounts of medical waste generation. The Croatian health system is financed from primary and secondary health insurance from the state budget, resulting in scarce investment and economizing. Meanwhile, reforming the health care organization following the models of other transitional states is very slow. Larger amounts of chemical waste were reported in Dubrovacko-neretvanska, Sibensko-kninska, and Zadar, whereas the largest amount of pharmaceutical waste was reported in Splitsko-dalmatinska, resulting from the storage of old war donations. Previously, such waste was incinerated in the only incineration plant in Zagreb with financial support of the II World Bank Health Project [47]; today the final solution is postponed by storage, often in inappropriate conditions. It has been brought to our attention that large amounts of needles from the drug harm-reduction program are improperly stored at the Red Cross facility in Zagreb. While the Ministry of Health and Social Welfare provided financial support secured by the World Bank [47], that waste has been managed along with waste from hospitals. No data are available on the amounts of such waste and its management in other cities where the program is being implemented. There is no available data on waste composition in Croatia, because sorting is not implemented. Communal waste accounts for around 80% of the total medical waste (paper, plastic, glass, metal, and other), and if it were sorted systematically, most of it could be recycled or processed more economically. Regarding hazardous waste, including medical waste, Croatia does not have sufficient facilities for its treatment. There are 21 state authorized companies that collect hazardous waste and 13 that are authorized for storage. According to the Basel Convention [49], certain hazardous wastes, such as nickel–cadmium (Ni–Cd) batteries, cyanide waste, and condensers with polychlorinated biphenyls (PCBs), should be exported to the EU for treatment. The solution for most of the hazardous waste lies in incineration under strictly controlled conditions. Thus, waste oils, mud, pharmaceuticals or tires could be burned in cement furnaces, but this does not solve the need for special waste treatment plants. Building several small incinerators located in regions with larger productions of hazardous waste, including hazardous medical waste, would be a good solution for Croatia. This would reduce the requirement for long-distance transportation of hazardous waste, along with the risk of road accidents leading to spills and causing environmental and health problems. The number and the locations of such incinerators should be based on accurate data on amounts and locations of hazardous waste production. Given that Zagreb produces about 50% of total medical waste, it is necessary to build an incinerator with a large enough capacity that would, along with the incinerator in the biggest Clinical Hospital, meet the needs of Zagreb and its surroundings. Along with the Zagreb region, such a plan should be developed for other Croatian regions, taking into account intensity and amount of waste produced, and the optimum incinerator capacity. Strategic placement of incinerators in major centers such as Rijeka, Split, Osijek, which are the largest producers of medical waste in their regions, would economize management and avoid long-distance transportation. Plants should be built in accordance with existing world and European standards, taking into account possible effects on the environment obtained by conducting planning studies, and other valid documents. To enable safer and easier handling, it is desirable to transform hazardous waste into a less dangerous form at the place of its production. A suitable procedure would be sterilization/disinfection by mobile devices. Their number and capacity would be determined according to the needs of the medical institution, and the vicinity of incinerator that would be used for final treatment. Improper handling of medical waste, especially of infectious streams, puts medical professionals, other employees in medical institutions and even patients at risk. Also, disposal of such waste at landfills without pre-treatment poses risks for communal workers. Professional injuries of healthcare workers are divided into six categories and the risk regarding medical waste is included in the category which describes contact with objects and equipment and exposure to infectious and toxic substances. For example, Stone et al. [51] showed that among healthcare workers, nurses are the most exposed population, but it is very hard to estimate the actual number of injuries and infections connected with handling of medical waste. There are similar reports from the Czech Republic about occupational diseases of health care workers that indicate a low level of hygiene and education about proper waste handling [52]. Nurses and cleaners who handle contaminated needles and other sharp objects are especially at risk of blood transmitted infectious diseases such as hepatitis B and C, and HIV, but also of gastroenterological, respiratory and skin infections [45,53]. Furthermore, in Red Cross harm-reduction programs, there is no information on health risk education for volunteers, except in Zagreb. Handling and transporting waste around the healthcare sites vary greatly between newly constructed and old hospitals. In Croatia 30% of hospitals were constructed in the 19th century without possibilities for modern waste management. In newer hospitals and healthcare centers, constructed in the mid 1980s, there are distinguished so called "clean" and "soiled" pathways. Most of the healthcare facilities in Croatia, including hospitals, were built between the early 1930s and 1960s [54] and until today they are under constant reconstruction due to the lack of space and the need for modernization. In those healthcare sites, the situation varies from department to department but in most of cases waste "travels" along with patients, visitors and staff through the same corridors. A condition to make the system work, and the law to be implemented, is to make education an important component. Education of all subjects in waste management should be increased, in particular, education of persons responsible for the organization of waste management and those who handle it. The general population should constantly be instructed about waste sorting, recycling, composting and ways of disposing the waste. The final goal is a system that is in harmony with sustainable development, and protects the environment and human health.

In the Republic of Serbia, the key legal framework for healthcare waste management comprises of the Law on Waste Management and various Rulebooks, including a Rulebook on Healthcare Waste Management [55]. This Rulebook on healthcare waste management details the methods of managing hazardous healthcare waste, including proposed safe methods for pharmaceutical waste management. According to the Serbian Rulebook, healthcare waste is waste generated in the course of providing healthcare services to humans and it comprises hazardous and non-hazardous waste categories defined and classified in the [56] Serbian Waste Catalogue.

Serbian Waste Catalogue is developed in line with the [57] EU Waste Catalogue. According to the Rulebook on Healthcare Waste Management, the provisions for hazardous healthcare waste prescribe special handling of path anatomical waste, sharps, pharmaceutical, cytotoxic and cytostatic waste, wastecontaminated by blood and body fluids, infectious waste and other hazardous healthcare waste (chemical waste, waste with a high heavy metal content and waste pressurized containers).Pharmaceutical waste stream management is influencing the quality of HCWM in every healthcare facility, particularly in hospitals because of the quantity of waste generated. According to the Rulebook, this waste stream includes all remnants of medication, including their primary packaging, as well as all devices used for their administration, which a healthcare worker providing healthcare services to the population is in possession of, and which have become unusable due to expiration of their expiration date, non-compliance with the prescribed quality standards, contamination of their packaging, spills, medications that have been prepared and then not used, those returned by the end users, or those that cannot be used for any other reason. This type of waste can be potentially hazardous pharmaceutical waste (i.e. waste representing a risk in case of improper handling and requiring handling according to procedures prescribed for hazardous waste) and hazardous pharmaceutical waste, which is the waste originating from medicines and disinfectants comprising heavy metals, as well as medicines with undetermined contents, which requires special treatment methods. Unused cytotoxic and cytostatic medications is considered as a hazardous healthcare waste and it's composed of medications and primary packaging and all devices used in preparation of such products for cancer chemotherapy.Cytotoxic and cytostatic medicines are toxic substances with carcinogenic, mutagenic and/or teratogenic effects. Cytotoxic drugs are most often used in specialized departments, such as oncology and radiotherapy units, whose main role is cancer treatment [58]. As the guideline of WHO "Safe management of waste from healthcare activities" clearly states, pharmaceutical waste includes expired, unused, spilt and contaminated pharmaceutical products, prescribed and proprietary drugs, vaccines and sera that are no longer required, and, due to their chemical or biological nature, need to be disposed of carefully [59]. The category also includes discarded items heavily contaminated during the handling of pharmaceuticals, such as bottles, vials and boxes containing pharmaceutical residues, gloves, masks and connecting tubing. Healthcare waste management in healthcare facilities in total pertains to a group of measures encompassing collection, segregation, packaging, labelling, storage, transport, treatment and safe disposal of healthcare waste. One of the most important tasks for the staff of healthcare facilities that is appointed to be in charge for proper HCWM is prevention of generation of large quantities of hazardous healthcare waste including pharmaceutical waste and achievement of total healthcare waste minimization. However, procedures for proper labelling of segregated pharmaceutical waste are also their tasks and it's of great importance for safe pharmaceutical waste management in hospitals. In Serbia segregated pharmaceutical waste is packed in the red containers or red bags, while cytostatic waste is packed in purple containers or bags. Infectious waste is packed in yellow bags or containers; and other hazardous waste (chemical) - in red containers. In the most EU countries there is the same colour coding system since Serbian model for colour coding of healthcare waste streams is taken from the EU countries experience and practices. The treatment of pharmaceutical and cytotoxic waste goes on by using physical and chemical procedures, or by incineration in facilities licensed for hazardous waste treatment [58,60]. After segregation and collection pharmaceutical and cytostatic and cytotoxic wastes are stored in hospitals prior to their export. Pharmaceutical waste containing psychoactive controlled substances and precursors is treated in line with the laws regulating the field of psychoactive controlled substances and precursors, law regulating medications and law regulating waste management. This waste stream is generated in minimal quantities. All hospital personnel dealing with healthcare waste should be trained for HCWM. After training, staffs become familiar with the main categories of healthcare waste and required procedures for their handling. As a minimum, managers responsible for healthcare waste system in hospital should conduct audit activities throughout the facility, to identify where these waste streams are produced, to obtain an initial estimate of the types and quantities of waste generated, and to assess how the waste is handled and disposed by the producers.

Based on the paper methodology [61] 60 hospitals, located in 4 regions of the Republic of Serbia (Belgrade, Vojvodina, Šumadija and Western Serbia and Southern and Eastern Serbia) at secondary and tertiary levels of healthcare were included in the research. The persons responsible for HCWM in hospitals filled in the questionnaire. For the purpose of the research each hospital was represented by one filled out questionnaire. Of the 60 analyzed questionnaires, 47 were from secondary-level hospitals, while 13 were tertiary healthcare institutions. Data analysis has shown that Clinical centers generated the largest quantity of pharmaceutical and cytostatic waste in all regions. Belgrade was the region with the largest amounts of pharmaceutical and cytostatic waste generated per year (generated by the Clinical Centre). Special hospitals in Vojvodina and Belgrade regions did not produce cytostatic waste at all. The smallest amount of pharmaceutical waste (44.4 kg/ year) was generated in the Special Hospital in Vojvodina. More cytostatic waste was generated per year than pharmaceutical waste. The largest amount of cytostatic waste was generated in Belgrade, in the Clinical Centre, while Clinic in Belgrade produced the smallest quantity of this waste stream (5kg/year). Tertiary healthcare level hospitals produced statistically significantly larger quantities of healthcare waste than secondary level hospitals.

Anyway, it is crucial to mention that promotion of proper handling and disposal of pharmaceutical waste is an important activity for each hospital. Segregation of pharmaceutical and cytostatic waste immediately after administration of medications including anti-cancer therapy is a very important daily practice in hospitals [59,61]. In Serbia, cytostatic and cytotoxic waste is more often segregated at the point of generation, in special departments for cancer treatment [59]; this waste stream combines two hazards in a single waste type, infectiousness and toxicity. This waste must be separated for proper handling by a special permitted [62] incinerator. Primary waste legislation is the key instrument for the improvement of pharmaceutical waste management in many countries. Since pharmaceutical waste includes expired, unused, split and contaminated pharmaceuticals, drugs, vaccines, and sera that are no longer required, it needs to be disposed of appropriately. This category also includes discarded items used in the handling of pharmaceuticals, such as bottles or boxes with residues, gloves, masks, connecting tubing, and drug vials. Recommendations and guidelines from WHO and UN are of upmost importance for the establishment of proper healthcare waste management in healthcare facilities, including proper waste management plan and pharmaceutical waste management [63]. Research shows that hospitals in Serbia generate significant quantities of pharmaceutical waste. Research

also underlined that there is a direct correlation between the number of hospital days, number of outpatient services and quantity of segregated cytostatic and pharmaceutical waste. For decades in Serbia, pharmacies were recognized as the main generators of pharmaceutical waste. In the last 20 years, new practices of healthcare professionals concerning HCWM brought about changes in pharmaceutical waste management in the world. Since 2009, these practices came to Serbia in a more organized manner. As research shows, hospitals in Serbia became significant generators of pharmaceutical and cytostatic waste as well. Training for Healthcare Waste Management in Serbia takes place as external training, as continual medical education, organized by the Institute of Public Health of Serbia and as an internal training program organized by hospitals. Results from the research show that there is a direct correlation between the number of trained personnel and pharmaceutical waste management, which is currently measured by the quantity of generated waste. Knowing the types and quantities of waste produced in a healthcare facility, including hospitals, is an important first step in safe waste disposal. Waste-generation data are used in estimating the needs for the proper waste management including capacities for containers, storage areas, and transportation and treatment technologies. Waste generation data can be used to establish baseline data on waste generation rates in different medical fields and for procurement specifications, planning, budgeting, calculating revenues from recycling, optimization of waste-management systems, and environmental impact assessments. These measures are partially present in Serbia, but still it is the beginning of proper pharmaceutical waste management in hospitals which requires further improvement. Further improvement of pharmaceutical waste management is to be achieved through more frequent training opportunities and, consequently, a larger number of specialists trained in the field of pharmaceutical waste management. The Public Health Institute of Serbia "Dr Milan Jovanovic Batut" has to propose a training plan for all hospitals based on training needs. Relicensing HCW managers and technicians, including additional modules on pharmaceutical and cytostatic waste management should be made mandatory in Serbia and published in the new regulations, aimed at achieving further improvement of healthcare waste management. The annual revision of dealing with pharmaceutical waste within a facility might be a great way to improve HCWM in general.

In the framework of the important reforms applied to the Administrate of the Republic of Albania for creating a straight relationship with the European Union countries, it was possible to develop a laws package for the management of the medical wastes, alternatively named health wastes. This Law Package was developed based on the European Directive about Wastes (2008/98/EC) and it continues to be amended by the parliament of the Republic of Albania, while the relative law acts are included in it. It is important to mention the Law n.9323, 25. 11. 2004 "About the drugs and the pharmaceutical service". The aim of this law is to determine the regulations for the production, import, export, marketing, description, use and quality control together with the relative activity inspections, which are related to the drugs for human use in the Republic of Albania. The other law is represented by the Law n. 9537, 18. 5. 2006 "About the Management of Hazard Wastes", which aims to determine all the regulations for the safe management of the hazard wastes, sorting, transporting, conservation, treatment, eliminating, importing and exporting of these wastes. Based on this Law, the management of hazard wastes is realized without concerns for the human health or the environment and these wastes treatment is performed by using processes, which don't influence negatively the environment; not dangerous for the air, water, earth, plants and animals. The person who is producing hazard wastes is obliged by the Law to pay the costs of transport, recuperations and elimination. It is prohibited to mix the hazard wastes with other wastes, exept the case when the mixing brings benefits into the processes of transport, recuperation and eliminations. The Law n. 10, 11. 05. 2009 "About the public health" aims the protection of human health and the promotion of a healthy population in the Republic of Albania by performing well-organized actions, which influence is equally shared between all the groups of the population and this law determine all the public health services, the role of each relative institution together with the role of the government in providing all these services. The last important national law is represented by the Law n. 10431, 09. 06. 2011 "About the protection of environment", which aims the high level protection of the environment, its conservation and improvement, the prevention and reduction of the health risks, the improvement of the life quality for the actual and future generations together with the providing the necessary conditions for a sustainable development of the country; this Law is linked with the medical wastes, because if these wastes are not properly treated by the relative authorities, these wastes directly influence on the earth, air and water pollution, which consequently has a negative impact on the human health. In the Republic of Albania exists tow important Ministries Court Decisions (MCD), where one of them is represented by the MCD n. 99, 18. 02. 2005 "For the Albanian Catalogue about the Wastes Classification Approval" and it is supports the Article 100 of the National Constitution and the point 3, article 3 of the Law n. 9010, 13.2.2003 "For Environmentaly Management of the Solid Wastes", with the proposal of the Minister of Environment. In this MCD are classified all the Albanian produced wastes and these are listed based on the category. Based on these catalogue information, these wastes are categorized in hazard and non-hazard wastes. The most important chapter is represented by the Chapter 18, where all the medical wastes are listed with the corresponding index number.

The other MCD corresponds to n.798, 29. 09. 2010 for the approval of the regulations "About the Management of the Medical Wastes". This MCD supports the Law 100 of the National Constitution, the points 3 and 4 of the Article 42 of the Law n.10.138, 11.5.2009 "For the Public Health", Article 3 of the Law n .9010, 13.2.2003 and the Articles 26 and 27 of the Law n. 9537, 18.5.2006, with the proposal of the Minister of Environment and Minister of Health. These regulations determine the all the regulations and the technical standards for the management of the medical wastes for protecting the human and environment health. In the chapters of this regulation are listed the obligations of the medical waste producers, the medial waste treatment, the monitoring and their management, together with their control and punishments.

It would be recommended a National Strategy for the Medical Waste Management, which could help on the Laws enforcement and the improvement of the sectors related to the management of these category wastes, but unfortunately it doesn't exist yet, though it was drafted a similar document in 2000.

In this review we will present some preliminary results of the report indicating the management practices of medical wastes in 78 producers of health wastes, which have been operating in the se di service from 1945 till 2014 [63]. It is important to mention that no other effort has been done till now from the Ministry of Health and

the Government of the Republic of Albania for improving the health waste management.

There are 53 of these producers, which don't have the permission from the Albanian Agency of Environment Protection and 21 of them never had it from the establishment. This is a significant number of producers (about 27%), because 21 health waste producers have not respected the law obligation for getting the environment permission based on MCD n.798, 29. 09. 2010 for the regulation approval "For the Management of Medical Wastes", though 68 of them knew about the obligations given by the Law. 78 of the producers use several methods for medical waste management. Just 25 of the producers have a contract with other private companies for the sorting and treatment of the medical wastes. The majority of them, 50 medical waste producing companies (64%) chose the illegal ways for managing these hazard wastes, like putting them in the normal waste containers, burning or dumping them, where at least 22% of these wastes are collected in the normal public waste containers. This survey was performed by the network of the non-for profit organizations (NGOs) named "Një Sy për Mjedisin" in the framework of the Program Senior-A (supported by REC and Sweden Embassy in Albania). This survey included 5 cities (Shkodër, Fushë-Krujë, Elbasan, Berat, Vlorë), which represented most parts of Albania; with a high diversity in terms of economic and social aspects. It emerged out that the situation is very similar in the comparison between all the considered cities/towns and it is really a chaotic situation for each of them. These facts suggested a general lack of law enforcement at the national level, which is further transmitted at the local level.

Generally, there is a lack of transparency and all the necessary information is not available for all the interested institutions or available for public use. It was not possible to respect the human wright to be informed by all involved institution and most of these institutions don't have a web page and in the official web page of the other institutions there are not available online contacts for contacting them. 87% of the health waste producers know the National Laws and all the relative obligations, though most of them never respect the laws, where 64% of them never do the medical waste management and it is done intentionally, thought there are few initiatives, which are trying to do their best on the management of these wastes and they represent just 32% of all the producers [63].

In the Republic of Albania there at least 10 companies licensed for the medical waste treatment, where 5 of them belongs to the State, 4 are private companies and 1 is considered as a joint investment from the state and the private sector. In the case of the hospitals, though it is a private or a state hospital, just some categories are treated by the hospitals and the remaining medical wastes are treated by the contracting private companies. The pharmaceutical wastes are not treated by any of the companies licensed and specialized for medical waste treatment. It can suggest that the pharmaceutical wastes are dumped or discharged in normal waste containers.

The contracting service for medical waste treatment was established in 2004 and most of the contracts were signed by the contracting parties between 2011 and 2014, thought the producing companies begun the medical waste production from the 1940s. MediTelSh.p.kis one of the biggest companies in Albania, which is covering most of the country area by providing this service, where most of the producers change the contracting partner from time to time [63]. The contracting producer are provided with specialized containers according to the WHO standards and these companies personnel have had all the necessary instructions for sorting, disposing and transporting the medical wastes. The other producers use a general container for putting hazard and other wastes and the containers are not according the WHO standards. It is important to mention that most of the producers don't have the proper conditions for conserving the medical wastes till the moment of their transport, where 18% register and report these wastes to the proper institutions or the relative companies specialized for the medical waste treatment [63].

The cost of the service for the medical waste treatment is depended on the quantity of the produced medical wastes, thought in the case of the private companies it has been fixed a monthly cost of at least 150 USD.

In Albania, the citizens are sensitized by these facts and most of the population (from the interviews) opinion is that there is no proper management of the medical wastes from the relative producers. In these conditions urgent actions need to be performed by the government and the first action would be the training of the inspectorate and the establishment of the subventions system in the private and state health system.

Improving Management Practices

Studies indicate that incentives for better waste management at hospitals are capable of reducing the amount of waste generated, with a study of five hospitals in five different European countries illustrating the point particularly well [35] and it suggests that the implementation of incentives, monetary or otherwise, for hospitals to improve sorting practices will encourage management to implement better waste sorting practices. Current disposal strategies involve sorting waste at the point-of-disposal within healthcare facilities, and then transporting the infectious medical waste to a safe disposal site, where it is treated by incineration or autoclaving and the residual product landfilled. Both incineration and autoclave treatment methods have drawbacks, with incineration neither creating undesirable atmospheric emissions, which cause adverse health and environmental impacts, and autoclave treatment not able to handle all types of waste nor producing a treated product that is universally accepted at landfills. The best way to control the impact of medical waste is to produce less, and one of the most effective ways to do this is to ensure that only infectious medical waste is sent for treatment. This could be accomplished through better training of healthcare workers along with the implementation of standardized medical waste streams and disposal bin colors. Further, there are a number of moves that governments could make to reduce the problems of excess infectious medical waste generation and to improve treatment and disposal of all types of medical waste. Firstly, governments should provide highly explicit, standardized definitions of infectious and non-infectious medical waste and should tightly regulate the disposal of infectious waste to prevent illegal dumping of waste. Secondly, governments should provide healthcare facilities with incentives, monetary or otherwise, to reduce medical waste production. These incentives will help convince local healthcare facility management to make waste reduction, particularly infectious medical waste production, a priority. Finally, governments should seek to increase research in the area of medical waste reduction and treatment though research grants and industry research partnerships. In particular, priority should be given to research with medical equipment suppliers to develop and produce products that release negligible amounts of dioxins or mercury when incinerated. These products will be particularly valuable to developing

nations where many waste disposal facilities lack the advanced pollution control technologies used in the developed world to prevent the release of toxic substances produced by waste incineration. As such, these incineration-safe medical products reduce the risk of exposing populations in developing nations to the harmful emissions produced by the incineration of infectious medical waste.

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