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Management of hazardous medical waste in Croatia

Natalija Marinković [a,*], Ksenija Vitale [b], Nataša Janev Holcer [b], Aleksandar Džakula [b], Tomo Pavić [c]

[a] Medical School University of Zagreb, Department for Chemistry and Biochemistry, Šalata 3b, 10 000 Zagreb, Croatia
[b] "Andrija Štampar" School of Public Health, Medical School University of Zagreb, Rockefellerova 4, 10 000 Zagreb, Croatia
[c] Ministry of Health and Social Welfare, Ksaver 200, 10 000 Zagreb, Croatia

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Abstract

This article provides a review of hazardous medical waste production and its management in Croatia. Even though Croatian regulations define all steps in the waste management chain, implementation of those steps is one of the country's greatest issues. Improper practice is evident from the point of waste production to final disposal. The biggest producers of hazardous medical waste are hospitals that do not implement existing legislation, due to the lack of education and funds. Information on quantities, type and flow of medical waste are inadequate, as is sanitary control.

We propose an integrated approach to medical waste management based on a hierarchical structure from the point of generation to its disposal. Priority is given to the reduction of the amounts and potential for harm. Where this is not possible, management includes reduction by sorting and separating, pretreatment on site, safe transportation, final treatment and sanitary disposal. Preferred methods should be the least harmful for human health and the environment. Integrated medical waste management could greatly reduce quantities and consequently financial strains.

Landfilling is the predominant route of disposal in Croatia, although the authors believe that incineration is the most appropriate method. In a country such as Croatia, a number of small incinerators would be the most economical solution.

1. Introduction

In modern societies almost everything (materials, devices, objects, etc.) sooner or later become a waste. And while nature, in constant cycling of matter and energy reuses its waste, man has developed a series of synthetic materials that are difficult to recycle. These synthetic materials pile up, disrupt the natural equilibrium, and create economic, ecological and health problems for society.

Based on its properties, waste can be inert (non-hazardous) or hazardous. A definition of hazardous waste was established for the first time in the USA at the beginning of the 1980s. It encompasses all substances that are hazardous to human health and the environment (New York State Department of Health, 1991). In order to protect the public and the environment, most industrialized societies have established laws that regulate various emissions of harmful substances. Although, many countries adopt the recommendations of the World Health Organization (WHO) as their standards, very often the standards of USA Environmental Protection Agency (EPA) are used as well.

2. Medical waste

Medical waste includes materials that are produced in the course of health protection, medical treatment and scientific research; it forms a separate category – medical or health care waste (Capak, 2001; Republic of Croatia, 1996b;2004; Ropeik and Gray, 2002). The major sources of this type of waste are hospitals, clinics, health centers, diagnostic and research laboratories, autopsy centers, transfusion and hemodialysis centers, nursing homes and mortuaries. Medical waste also is produced in smaller

* Corresponding author. Tel.: +385 1 4566 747; fax: +385 1 4590 236.
E-mail address: nmarinko@snz.hr (N. Marinković).

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medical units, such as general practitioner and dental offices, chiropractors, acupuncture, at-home patient care, harm reduction programs for drug addicts and undertakers.

A portion of the medical waste is similar to household waste and consists of paper, cardboard packaging, glass, food remains and other inert substances. The other portion is considered hazardous waste and contains toxic, harmful, carcinogenic and infectious materials (Republic of Croatia, 2004).

According to Croatian legislation (Republic of Croatia, 2000), 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 immunosuppressors 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 (Pruss et al., 1999).

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 (Pruss et al., 1999). In Croatia, these two categories of medical waste are treated as other pharmaceutical and chemical waste. According to Croatian law (Republic of Croatia, 2004), 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" (Capak, 2001; Republic of Croatia, 1996b).

In 2002, Croatia ratified the Directive on the management of waste produced during healthcare (Republic of Croatia, 2000). 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-y 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 (Republic of Croatia, 1994).

This paper aims to explain the situation in Croatia concerning medical waste in general, the amounts, handling and potential harmful effects on the environment and the health of people working in healthcare facilities or in the collection process and on the general population. It also aims to point out possible solutions for the management of hazardous medical waste.

3. Data sources and research methods

We have used publicly available data which the Croatian Ministry of Environmental Protection, Physical Planning and Construction routinely collects on waste management. Another source was the survey of medical waste management in Croatia, conducted by the Ministry of Health and Social Welfare at the end of 2003. The questionnaire covered medical institutions in 21 Croatian counties, and was designed to give answers on the amount of various categories of medical waste generated, to what extent it is treated at its own facilities, to what extent it is improperly disposed, and what part is transferred to authorized companies for waste treatment. Further questions were related to the sorting of waste at the point of generation, the usage of appropriate packaging, and the availability of a hazardous waste storage facility. Also, we asked if the Five-year Waste Management Plan requested by law has been prepared and followed.

The questionnaire was sent to 75 state-owned (that care for 4.5 millions inhabitants of Croatia) health care centers (clinics, clinical hospital centers, county hospitals, special hospitals, sanatoriums, health institutes), and 76 private practices, mostly family medicine and dentists. The response from state-owned institutions was very high (93%). However, only 18 (24%) of the private practices responded to the survey. Thus the sample represents 84% of all interviewed medical institutions in Croatia (Croatian National Institute of Public Health, 2003). Health care institutions that do not have contracts with the Croatian Institute of Health Insurance (HZZO) were not included in the survey.

4. Results

Based on the Report of the Croatian Ministry of Environmental Protection, Physical Planning and Construction for 2005, it can be estimated that Croatia produces about 13.2 million tons of various wastes per year, which is about 2.97 tons per citizen per year. This amount consists of mostly agricultural, construction and communal waste, but it also contains close to 0.1 tons of hazardous waste (Republic of Croatia, 2005). In addition, approximately 34.5 million m^3 of waste is accumulated in about 3000 thousand open dumps scattered around the country with only 281 being official landfills. Out of those 281, only 8 are sanitary landfills (Republic of Croatia, 2005). The amount of waste scattered in the woods, fields, rivers and the sea is significant. Croatia had only one open type incineration plant that operated from 1999 to 2002 when it burned down, causing an acute environmental disaster.

The data obtained by the survey revealed that medical institutions produce 210,840 kg of waste weekly, which amounts to 10,064 tons per year. Inert waste accounts for 86%, and hazardous medical waste accounts for 14%. Within the hazardous waste, almost 80% is considered infectious waste, sharp objects constitute 8%, chemical waste 5%, pathological waste 3%, pharmacological waste (without cystostatics) 2%, and cytostatics with their contaminated packaging constitute 2% of the total hazardous waste. In addition, the newly formed hazardous waste medical institutions store significant amounts of old medical waste, of which 3900 kg is pharmaceutical waste, 2500 kg is infectious waste, 1250 kg is cytostatics with contaminated packaging and about 1400 kg is chemical waste. This is a consequence of the lack of facilities for waste processing and final disposal.

By comparing the data related to the amounts and types of medical waste for 21 Croatian counties, it is evident that the major producer is the city of Zagreb with 817 tons per year. Over one-fifth of the Croatian population lives in the capital, Zagreb. Zagreb has the highest number of medical institutions, and large numbers of patients from other counties also seek medical treatment in Zagreb. The second largest producer of hazardous medical waste (86 t/y) is Brodsko-posavska County, although it is only the tenth largest county based on the number of inhabitants. It is followed by Karlovac County with 82 t/y, Varazdin County with 66 t/y and Zadar County with 52 t/y. Categorization of the hazardous medical waste produced shows that infectious waste accounts for the largest amount (Table 1). There is a significant disproportion between the amount of waste categories produced by smaller counties and the amounts produced in the city of Zagreb. Thus, Dubrovacko-neretvanska and Sibensko-kninska County reported 13 t/y of chemical waste, Zadar County 21 t/y, whereas the city of Zagreb, Croatian largest county, reported 17.5 t/y.

Zagreb leads in discarded cytostatics (17 t/y) because most patients who require them are treated in Zagreb. By far the largest amount of pharmaceutical waste was reported by Splitsko-dalmatinska County (26.5 t/y), whereas in the city of Zagreb that category amounts to only 2.6 t/y.

Data collected by the survey (Table 2) showed that only 50% of the medical institutions that completed the questionnaire produce pathological waste, and that they treat it properly. Four institutions (11%) incinerate pathological waste but without a license, whereas the others use the service of an authorized contractor, who incinerates (50%) or buries the waste at the graveyard (39%). Infectious waste is produced by 90% of larger medical institutions in Croatia. Out of them, 11 (17.5%) incinerate it in their own incinerators, even though only the county general hospital in the city of Vinkovci has a valid permit. Some institutions (9.5%) pre-treat infectious waste by sterilization and dispose of it at communal waste disposal sites. A majority of institutions use the services of specialized companies, which incinerate (1.6%) or pre-treat (63.5%) and landfill infectious waste. Five institutions dispose infectious waste together with communal waste without prior sterilization. Sharp objects are treated in the same way as infectious waste.

Pharmaceutical waste is produced by half of the institutions surveyed. However, a number of hospitals have very large amounts of outdated pharmaceutical products remaining from donations during the war. At the moment there is no official procedure for the management of pharmaceutical waste so most of the hospitals provisionally store it. There is a similar situation with cytostatics and packaging. For the institutions that produce chemical waste (more than 50%), 27 use the services of authorized waste management companies and the rest are pre-treating, diluting and discarding it into the sewage system or just landfilling it.

Although, all medical institutions are obliged to report the amount of hazardous medical waste produced to the Registry of Emissions into Environment, only a small number of them (28) are doing that. The Ministry of Health and Social Welfare in 2003 reported that 56 medical institutions, out of 70 surveyed, had a 5-y waste management plan. Most of them use appropriate packaging, 65 sort the waste at the point of generation, and 58 have secondary storage for hazardous waste.

At the time of the survey there were 21 authorized waste management companies reported to have contracts with health care institutions, but only 13 publicly revealed their capacity for treatment and safe disposal. For the others we can only assume that they manage the hazardous waste according to the law and professional guidelines. However, it is difficult to estimate the actual amount of untreated medical waste that is disposed daily at communal landfills. At the communal landfill in Zagreb the control of incoming waste, including that from hospitals is visual, with periodical visual inspections of random samples (40 samples per year). It is questionable how accurate the visual inspection is. Such practice emphasizes the necessity of implementing integrated medical waste management practices with strict

Table 1
Annual production of hazardous medical waste by category in Croatian counties

County	Pathological waste	Infectious waste	Sharp objects	Pharmaceutical waste	Cytostatic drugs	Chemical waste
	t/bed (tons per year)					
Bjelovarsko-bilogorska	0.62	18.25	5.73	0.00	0.00	0.52
Brodsko-posavska	2.08	*78.00*	3.64	0.00	1.82	0.52
Dubrovacko-neretvanska	0.36	29.12	0.42	0.08	1.82	*13.00*
Grad Zagreb	*14.67*	*706.07*	*58.95*	*2.6*	*16.9*	*17.49*
Istarska	1.56	41.61	*10.56*	0.00	0.00	0.00
Karlovacka	0.39	*74.36*	2.08	0.00	0.00	5.46
Koprivnicko-krizevacka	1.04	36.40	0.78	0.00	0.00	0.31
Krapinsko-zagorska	0.57	37.28	3.12	0.00	0.00	2.71
Licko-senjska	0.21	1.30	0.13	0.00	0.00	0.00
Medjimurska	1.04	0.00	*15.60*	0.26	0.00	0.16
Osjecko-baranjska	*6.03*	3.64	4.13	0.00	0.00	0.13
Pozesko-slavonska	1.87	20.15	1.74	0.00	0.10	0.85
Primorsko-goranska	3.17	1.70	1.61	0.04	0.00	2.87
Sisacko-moslavacka	1.56	40.56	3.12	0.00	0.00	0.68
Splitsko-dalmatinska	2.63	13.52	1.43	*26.52*	0.00	0.00
Sibensko-kninska	0.86	10.92	0.55	1.09	0.78	*13.00*
Varazdinska	1.56	59.46	0.7	0.00	*3.91*	0.00
Viroviticko-podravska	0.78	26.00	3.64	0.00	0.00	0.00
Vukovarsko-srijemska	1.08	15.91	1.13	0.00	0.00	2.60
Zadarska	1.04	27.46	1.01	0.00	1.25	*21.01*
Zagrebacka	0.00	0.00	0.10	0.05	0.00	2.08
Total	43.13	1.241.71	120.17	30.64	26.59	83.38

Table 2
Disposal practice of different categories of medical waste in healthcare institutions in Croatia

Disposal practice	Category of waste					
	Pathological waste	Infectious waste	Sharp objects	Pharmaceutical waste	Cytostatic drugs	Chemical waste
	Number of health institutions					
Incineration in inadequate facility	4	10	11	2	2	1
Incineration in adequate facility		1				1
Hand out to the contractor	32	41	43	6	1	27
Disposal at local landfill after pre-treatment		6	7			
Disposal at local landfill without pre-treatment		5	7	4	4	
Storage within own premises				20	16	
Disposal in the sewer after treatment						4
Disposal in the sewer without treatment						3

control and recordkeeping, along with the education of all subjects in the waste stream.

5. Discussion

Waste and its management has lately become a pressing topic in Croatia. The European Commission stated that waste management is the largest single problem in the environmental protection sector (European Commission, 2004). The lack of sanitary landfills and incinerators represent not only environmental and health problems, but also political concerns. Communal landfills receive both communal and other waste including hazardous medical waste. That means that a large quantity of various wastes ends up in the environment due to negligence, but also due to the lack of integrated waste disposal solutions. Local governments are legally responsible for waste management but they often do not have developed projects for waste management or have scarce financial resources for their implementation.

Medical waste management in Croatia is regulated by three laws and legal documents: Law on waste (Republic of Croatia, 2004), Regulations on waste type (Republic of Croatia, 1996b) and Directive on management of the waste produced during health care (Republic of Croatia, 2000).

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 (Republic of Croatia, 2005). The Ministry of Environmen-

tal Protection, Physical Planning and Construction operates 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. Even more importantly, enforcement of the existing legislation and directives should be ensured. Fig. 1 illustrates our proposal of the system of waste management that should be implemented in medical institutions.

Data from the World Health Organization 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 (Pruss et al., 1999). In Croatia annual waste production per capita is 2.4 kg, out of which 0.34 kg is hazardous medical waste. That puts Croatia in the rank of middle developed countries. When the total amount of medical waste is divided by the number of hospital beds (27,005), which has decreased by 25% in the last 10 years (Croatian National Institute of Public Health, 1999), and the number of days in a year, daily production in Croatia is 1.2 kg per bed, out of which 0.16 kg is hazardous. 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. Asia also presents differences between developed and less developed countries, so richer countries produce 2.5–4 kg per bed daily, and poorer 1.8–2 kg (Pruss et al., 1999). 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

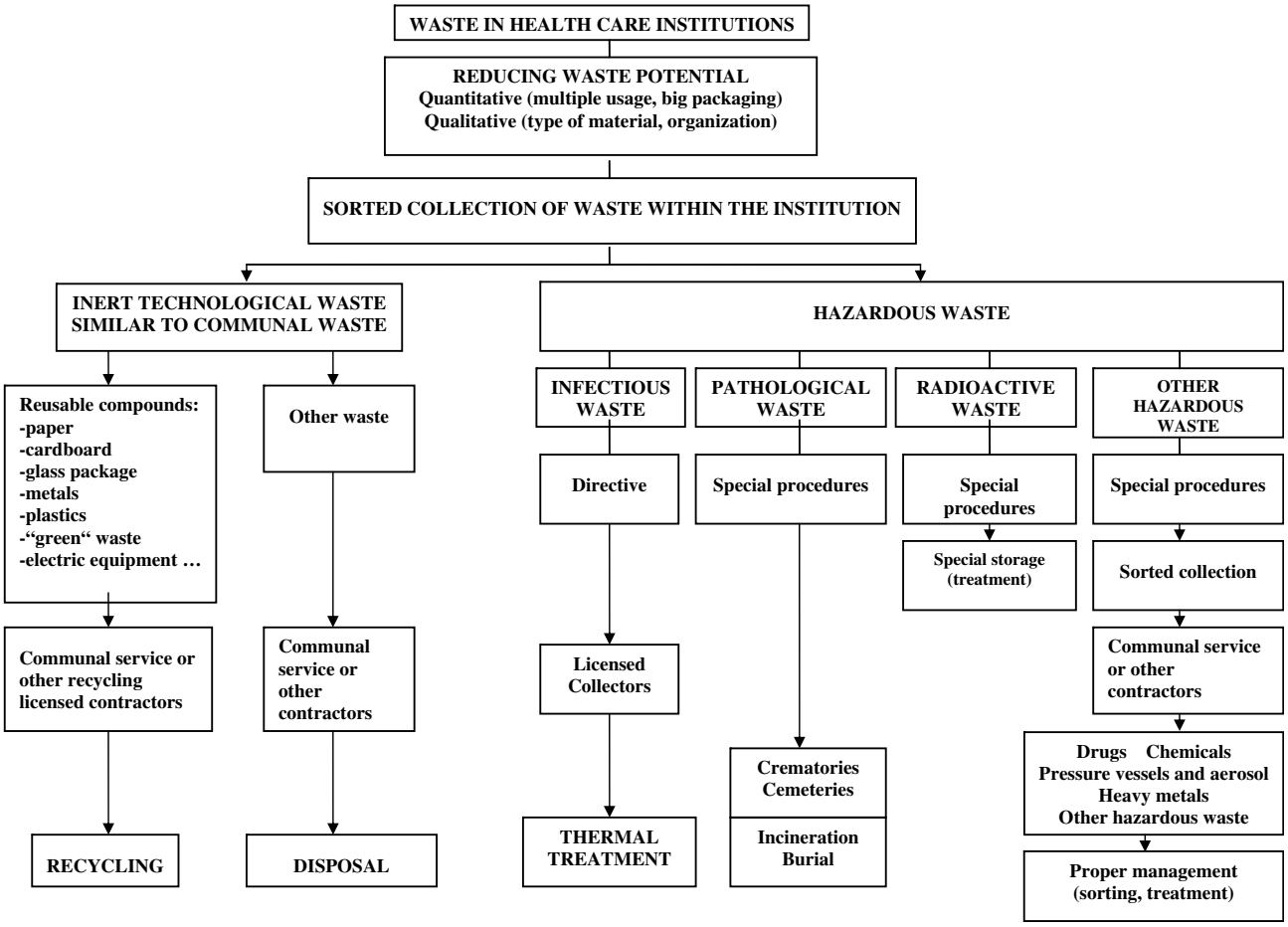

Fig. 1. Proposal for waste management in health care institutions.

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. According to the WHO data, clinical hospitals, maternity hospitals, and general hospitals produce the largest amounts of medical waste, while psychiatric and geriatric hospital units produce smaller amounts (World Health Organization, 1985). The above data refers to the amounts produced in the 1980s; however, the trend remains the same today. Even though geriatric units produce the smallest amounts of medical waste, the waste contains diapers, and should be treated as infectious waste. However, most of the times it is disposed with other communal waste (Nadakavukaren, 1990).

The differences between counties in the amounts and types of hazardous medical waste are expected, while on the other hand a complete lack of data for some types of waste in some counties is not realistic. This could be explained by insufficient knowledge of the differences between pharmaceutical and chemical wastes, as well as lack of sorting. The only exception could be citostatyc drugs because some of smaller county hospitals do not perform procedures that include such drugs.

Larger amounts of chemical waste were reported in Dubrovacko-neretvanska County, Sibensko-kninska County, and Zadar County, whereas the largest amount of pharmaceutical waste was reported in Splitsko-dalmatinska County, 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 (Capak, 2001); 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 (Capak, 2001), 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.

In more developed waste management systems, discarded objects are sorted according to the material they are made of. Data on waste in American hospitals, based on nine Los Angeles hospitals with annual waste production of 3.1 tons per bed, consisting of: paper 53%, food and other organic material 17.5%, plastic 14.6%, diapers 3.5%, metal 2.6%, glass 1.8%, cleaning remains 1.6%, and other 4.5%, shows that sorting system enables recycling of almost all waste (Business Resource Efficiency, 1999). Data collected in 10 major hospitals in India show that waste sorting is implemented to some degree; however, unsorted waste accounts for 53.3%, consisting of food, packaging, cleaning remains, and other (Pruss et al., 1999). 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 (Republic of Croatia, 1994), 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. Estimated mortality as a result of professional exposure including infections of healthcare workers in the United States is 17–57 cases per million employees (Sepkowitz and Eisenberg, 2005). Stone et al. (2004) 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 (Fenclova et al., 2005).

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 (Pruss et al., 1999; Centre for Disease Control and Prevention, 2002). Data from the USA indicate that, during 2001, 57 HIV infections of medical staff, caused by sharp objects injuries or transmissions through skin and mucous membranes were registered (Centre for Disease Control and Prevention, 2002). Data from Japan indicates that the probability of HIV infection after needle injury is 0.3%, of hepatitis B 3%, and of hepatitis C 3–5% (Pruss et al., 1999; Wilburn and Eikemans, 2005).

According to the head of the service for epidemiology of contagious infectious diseases of the Croatian Institute of Public Health (personal communication), there were no cases of HIV infections among medical staff in Croatia as a result of professional exposure. However, among medical professionals an increased risk for hepatitis B infection was observed. Therefore compulsory vaccination against hepatitis B was introduced for the population at risk.

Although, there is awareness of healthcare risks for the staff handling medical waste and the detailed instructions for handling waste that exist in every laboratory or hospital department, there is no feedback about the level of understanding of those instructions especially among the technical staff. Unfortunately, interactive education programs do not exist. 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 (Vodicka, 1994) 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.

6. Conclusion

The Croatian national strategy for environmental protection and national action plan for the environment adopted in 2002 stated that inadequate waste management presents a serious problem for environmental protection, and becomes a growing public health concern (Republic of Croatia, 2002). Our analysis pointed out that medical waste management also needs better organization, adequate facilities and strict surveillance with recordkeeping. In a geographically specific country such as Croatia, a large number of small incinerators may be a more economical solution. From the public health point of view, prior to any decision on the location of a landfill and type or installation of a new technology, a human health risk assessment study should be conducted. Care for medical hazardous waste should be evidence-based, and compared with the data obtained by laboratory research and population studies, advanced treatment and control methods. Legislation should emphasize prevention of effects that are harmful to health and that degrade the environment. In addition, the insufficiency of legislation in the area of penalties needs correction.

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.

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