



COMPOSITION AND QUANTITY OF MEDICAL WASTE AND ITS IMPACT ON THE ENVIRONMENT BEFORE AND DURING THE COVID-19 PANDEMIC

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Medical waste is generated in healthcare institutions and can be of different types. According to its properties, it can be classified as hazardous medical waste or non-hazardous medical waste. Due to its potentially dangerous properties, it is necessary to manage medical waste in accordance with the provisions of the Waste Management Act and the Ordinance on Medical Waste Management (1, 2). In the period from 2015 to 2019, the amount of medical waste grew annually by an average of 8%. In 2020, 7.014 tons of medical waste were generated, of which 74% was hazardous and 26% was non-hazardous medical waste. Compared to 2019, this was an increase of 28%, which can be attributed to the increased consumption of medical products due to the COVID-19 pandemic. The amount of hazardous medical waste increased by 18%, and the amount of non-hazardous medical waste by 67% (3). The aim of this work was to investigate the differences in the amount, composition, and treatment of medical waste in the pre-pandemic and pandemic period during the COVID-19 pandemic in health care institutions of the Split-Dalmatia County. The increased use of additional protective equipment in the work of healthcare professionals during the COVID-19 pandemic caused the generation of three times more infectious waste. The paper highlights the importance of proper handling, collection, processing, and disposal of infectious medical waste to prevent direct or indirect transmission of infection and harmful effects on human and/or animal health.

Keywords: MEDICAL WASTE, COVID-19 PANDEMIC, MEDICAL WASTE MANAGEMENT

INTRODUCTION

Proper management of hazardous medical waste is an important segment not only in the functioning of the waste management system and environmental protection, but also in the protection of human health, i.e., the preservation of public health. About 85% of medical waste is categorized as non-hazardous (municipal waste), while approximately 15% may be infectious, toxic, or radioactive. The risks are multiple, and represent a potential danger for the entire community (4).

Medical waste is the waste generated in healthcare institutions. According to its properties, it is divided into hazardous and non-hazardous medical waste. Due to its potentially dangerous properties, it is necessary to manage medical waste in accordance with the provisions of the Waste Management Act and the Ordinance on Medical Waste Management (1). Hazardous medical waste is divided into infectious, sharp objects, pharmaceutical, chemical, cytotoxic, amalgam and other similar ones (2). The largest share of hazardous medical waste consists of infectious waste.

Infectious waste contains pathogenic biological agents that, due to their type, concentration, or number, can cause disease in humans. This category refers to all possibilities in which the discarded item is inoculated with infectious material. When disposing of this type of waste, chemical-physical, biological, and thermal waste treatment can be used (5).

For all quantities of infectious waste, it is necessary to introduce and implement strict supervision and records from the place of origin to its final disposal. In each health care facility, certain types of waste should be systematized, with a special emphasis on hazardous medical waste, as well as defining the procedures for its processing and disposal at a communal landfill (6). In this sense, there is a growing concern for the negative effects of infectious medical waste accumulated during the pandemic, as well as the risks of contamination associated with its management. Studies have shown a double increase in infectious waste within the first year of the pandemic, and the growth is correlated with an increase in confirmed Covid-19 cases (7).

The pandemic caused by the Covid-19 virus, in addition to the illness and death it caused, in its beginning affected the rationality and dynamics of everyday behaviour within healthcare institutions

Table 1.
Frequencies and percentages of waste generated at the Split-Dalmatia County Health Centre facility, 2019-2021.

Variable	F	CF	%	C%
Medical waste (kg)				
2019	38.585	38.585	32.95	32.95
2020	38.917	77.502	33.24	66.19
2021	39.598	117.100	33.81	100.00
COVID waste (kg)				
2019	0	0	0	0.00
2020	73	73	4.04	4.04
2021	1734	1807	95.96	100.00

Legend: F - frequency; CF - cumulative frequency, % - percentage, relative value; C% - cumulative percent value, relative.

around the world. Among other things, it contributed to the generation of a series of challenges in the management and disposal of medical waste. In addition to the amount of waste, the pandemic affected the type and composition of waste, as well as its timing and distribution (2).

At the peak of the pandemic, medical waste management failed to reduce the harmful impact on the environment. Aggregate information shows a variable trend of decreasing or increasing waste material, depending on the measures implemented in the states (8). The aim of this work is to investigate the differences in the quantity, composition, and treatment of medical waste in the pre-pandemic and pandemic period during the COVID-19 in the health institutions of the Split-Dalmatia County.

METHODS

The study was conducted in two health facilities in Split-Dalmatia County, the Health Centre, and the Institute of Emergency Medicine, between 2019 and 2021. The facilities submitted records of infectious and COVID waste for the specified calendar years. In the empirical part of this thesis, the research hypotheses were tested using quantitative methods. Tabular and graphical methods of presentation were used. The frequency and percentage values of the amount of waste in the facilities are shown using tabular and graphical presentation methods.

RESULTS

The main objective of this paper was to examine the differences in quantity, quality, and procedures in the disposal of medical waste in the pre-pandemic and post-pandemic COVID-19 period in different health facilities in Split-Dalmatia County using data from the health centre and emergency department. All data are from 2019, 2020 and 2021.

As for the data from the Health centre, 38.585 kg of medical waste was generated in 2019. In the next 2 years, there was a significant increase in medical waste, with 38.917 kg in 2020, and in 2021, even more medical waste was produced, 39.598 kg. Considering the pandemic, in

the last 2 years, some of the medical waste belongs to infectious COVID waste, of which in 2020 there were 73 kg and in the following year there was a massive increase in the amount, where there were 1734 kg of infectious waste, which is a significant increase in the numbers. The reason for this is that in 2021 the health centres took over the responsibility of handling COVID waste, thus relieving the tertiary level of health care and the Public Health Teaching Institute (Table 1, Figure 1).

The Split-Dalmatia County Emergency Department generated 1902 kg of medical waste in 2019, 1518 kg in 2020 and 1630 kg in 2021. The current pan-

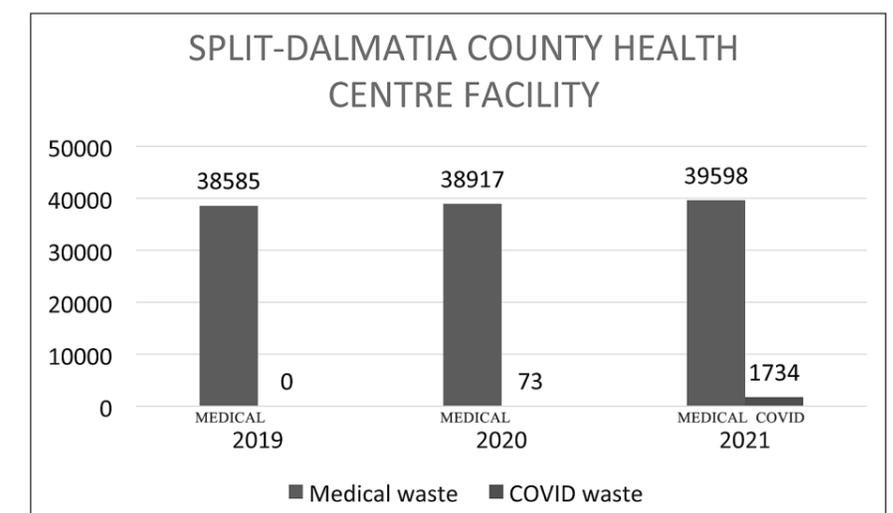


Figure 1.
Graphical representation of the results of the collected waste of Split-Dalmatia County Health Centre facility, 2019-2021.

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Table 2.
Frequencies and percentages of waste generation in the Institute of Emergency Medicine of Split-Dalmatia County, 2019-2021.

Variable	F	CF	%	C%
Medical waste (kg)				
2019	1902	1902	37.67	37.67
2020	1518	3420	30.06	67.73
2021	1630	5050	32.27	100.00
COVID waste (kg)				
2019	0	0	0	0.00
2020	8456	8456	67.12	67.12
2021	4143	12.599	32.88	100.00

Legend: F - frequency; CF- cumulative frequency, % - percentage, relative value; C% - cumulative percent value, relative.

demic has also left its mark on the Department of Emergency Medicine, where 8456 kg of COVID waste was accumulated in 2020, and in 2021 there was almost a twofold decrease in the amount to 4143 kg, precisely because of the above-mentioned shift to tertiary healthcare (Table 2, Figure 2).

DISCUSSION

In the study by the author A. Hanedar and others, an insight into the amount and type of medical waste disposal is presented in the city of Tekirdag, which has a population of about 1.107.491. In this study, the authors collected data on the amount of medical waste generated

in 12 public and 8 private medical facilities and found that a total of 79.027 kg of medical waste was generated before the pandemic and 116.714 kg during the pandemic. More specifically, 0.86 kg of medical waste per bed was recorded before the pandemic, while during the pandemic the figures were 0.96 kg per day in 2019 and 1.34 kg per day in 2021 (9).

Interestingly, the authors point out in the article that this amount of waste was calculated and predicted for the year 2040. However, one of the consequences of the pandemic is that the previously calculated amount of waste was reached in only two years instead in 2040. Therefore, the authors concluded that the capa-

city of medical waste sterilisation plants should be increased by at least 50% and that it is extremely important to have and maintain their flexibility to respond to unexpected events and an increase in the amount of waste (9). On the other hand, the Croatian authors concluded that the construction of numerous smaller incinerators is the most appropriate measure for the disposal of this type of waste (10).

The increase in medical waste caused by the pandemic COVID-19 is a global problem. This is also confirmed by the data of the survey conducted in 5 hospitals in Iran, which shows that the production of medical waste has increased by 1022%. This increase has occurred in both public and private hospitals. The article shows that before the pandemic, the Institute of Emergency Medicine COVID-19 produced 28 kg of infectious waste per day, while during the pandemic it produced 32 kg of waste. Before the pandemic, the Institute of Emergency Medicine produced 8 kg of other medical waste per day, as opposed to 11 kg produced during the pandemic (11).

Spain was perhaps one of the countries most affected by the virus. As of 14 July 2020, Spain had registered 255.953 cases of COVID-19 with 28.406 victims. As the number of infected people grew, so did the amount of infectious medical waste. The Waste Agency of Catalonia in March 2020 recorded a massive increase of medical equipment and waste such as gloves, face masks, protectivesuits, and personal protective equipment (PPE)

350%. With the help of municipal waste incinerators, Spain was able to dispose of 700 tonnes of medical waste out of a total of 1200 tonnes by 15 April 2020. Considering the sudden and violent attack that COVID had on Spain, such a response to combat the pandemic and the associated increase in infectious medical waste cannot be neglected (12).

CONCLUSION

These examples show that each country had problems not only in combating the virus itself, but also in coping with the sudden increase in medical waste. Just as there are differences in the people affected by COVID-19, there are also differences in how countries were affected and how they kept the virus in check. Many countries had different approaches and solutions to the accompanying circumstances, some were more successful, others less so. Importantly, these data provide a pool of knowledge and highlights the importance of collective work and global data results. By implementing the ideas and treatments learned, our society and quality of life can be improved.

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LITERATURE

1. NN 84/2. Odluku o proglašenju zakona o gospodarenju otpadom. (Internet). Zagreb: 2021. Dostupno na: https://narodne-novine.nn.hr/clanci/sluzbeni/2021_07_84_1554.html.
2. NN 50/2015. Pravilnik o gospodarenju medicinskim otpadom. (Internet). Zagreb: 2015. Dostupno na: https://narodne-novine.nn.hr/clanci/sluzbeni/2015_05_50_989.html.
3. Bulat V. Pregled podataka o gospodarenju medicinskim otpadom za 2020. godinu. (Internet). Republika Hrvatska: Ministarstvo gospodarstva i održivog razvoja. Zagreb: 2021. Dostupno na: https://www.haop.hr/sites/default/files/uploads/dokumenti/021_otpad/Izvjescja/ostalo/OTP_Pregled_medicinski2020_FINAL%20web%20verzija_0102.pdf.
4. Borowy I. Medical waste: the dark side of healthcare. Hist Cienc Saude Manguinhos. 2020 Sep; 27 (suppl 1): 231-51. English, Portuguese. doi: 10.1590/S0104-59702020000300012. PMID: 32997065.
5. Marinković N, Vitale K, Afrić I, Janev Holcer N. Javnozdravstveni aspekti gospodarenja opasnim medicinskim otpadom (Hazardous medical waste management as a public health issue). Arh Hig Rada Toksikol. 2005 Mar; 56 (1): 21-32. Croatian. PMID: 15969205.
6. NN 50/2000. Naputak o postupanju s otpadom koji nastaje pri pružanju zdravstvene zaštite. (Internet). Zagreb: 2000. Dostupno na: https://narodne-novine.nn.hr/clanci/sluzbeni/2000_05_50_1119.html.
7. Maalouf A, Maalouf H. Impact of COVID-19 pandemic on medical waste management in Lebanon. Waste Manag Res. 2021 Jun; 39 (1 suppl): 45-55. doi: 10.1177/0734242X211003970. Epub 2021 Apr 2. PMID: 33794685.
8. Fan YV, Jiang P, Hemzal M, Klemeš JJ. An update of COVID-19 influence on waste management. Sci Total Environ. 2021 Feb 1; 754: 142014. doi: 10.1016/j.scitotenv.2020.142014. Epub 2020 Aug 26. PMID: 32920389; PMCID: PMC7448788.
9. Hanedar A, Çiğçi Dİ, Zafer N, Görgün E. The impact of COVID-19 pandemic in medical waste amounts: a case study from a high-populated city of Turkey. Journal of Material Cycles and Waste Management. 2022; 24 (5): 1760-7.
10. Marinković N, Vitale K, Janev Holcer N, Dzakula A, Pavić T. Management of hazardous medical waste in Croatia. Waste Manag. 2008; 28 (6): 1049-56. doi: 10.1016/j.wasman.2007.01.021. Epub 2007 Apr 23. PMID: 17451931.
11. Kalantary RR, Jamshidi A, Mofrad MMG, Jafari AJ, Heidari N, Fallahizadeh S, Hesami Arani M, Torkashvand J. Effect of COVID-19 pandemic on medical waste management: a case study. J Environ Health Sci Eng. 2021 Mar 18; 19 (1): 831-6. doi: 10.1007/s40201-021-00650-9. PMID: 33758671; PMCID: PMC7970745.
12. Ilyas S, Srivastava RR, Kim H. Disinfection technology and strategies for COVID-19 hospital and bio-medical waste management. Sci Total Environ. 2020 Dec 20; 749: 141652. doi: 10.1016/j.scitotenv.2020.141652. Epub 2020 Aug 12. PMID: 32822917; PMCID: PMC7419320.

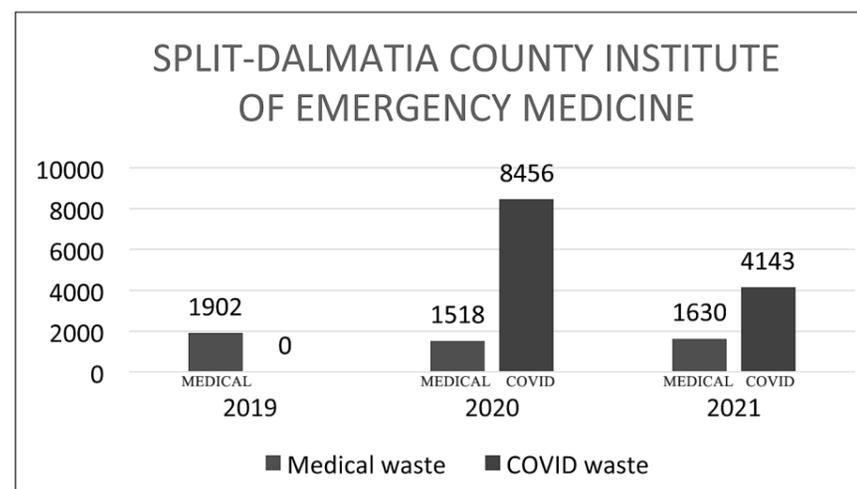


Figure 2.
Graphical representation of the results of the collected waste Split-Dalmatia County Institute of Emergency Medicine, 2019-2021.

Sažetak

SASTAV I KOLIČINA MEDICINSKOG OTPADA TE NJEGOV UTJECAJ NA OKOLIŠ PRIJE I ZA VRIJEME PANDEMIJE COVID-19

Antonela Matijaš, Maja Firić, Duje Donadić, Ivan Plenković, Ante Obad, Mario Podrug

Medicinski otpad je otpad koji nastaje u zdravstvenim ustanovama i može biti različitih vrsta, a prema svojstvima može biti opasni medicinski otpad i neopasni medicinski otpad. Zbog potencijalno opasnih svojstava nužno je gospodarenje medicinskim otpadom provoditi sukladno odredbama Zakona o gospodarenju otpadom i prema Pravilniku o gospodarenju medicinskim otpadom. U razdoblju od 2015. do 2019. godine količina medicinskog otpada rasla je godišnje u prosjeku za 8%. U 2020. godini, nastalo je 7.014 tona medicinskog otpada od čega je 74% opasnog i 26% neopasnog medicinskog otpada. U odnosu na 2019. godinu, riječ je o porastu za 28% što se može pripisati povećanoj potrošnji medicinskih proizvoda uslijed COVID-19 pandemije. Količina opasnog medicinskog otpada povećala se za 18%, a količina neopasnog medicinskog otpada za 67%. Cilj ovoga rada bio je istražiti razlike u količini, sastavu i postupanju medicinskim otpadom u predpandemijskom i pandemijskom razdoblju za vrijeme COVID-19 pandemije u zdravstvenim ustanovama Splitsko-dalmatinske županije. Povećana upotreba dodatne zaštitne opreme za vrijeme rada zdravstvenih djelatnika u pandemiji COVID-19 uzrokovala je stvaranje trostruko više infektivnog otpada. U radu je istaknuta važnost pravilnog rukovanja, sakupljanja, obrade i odlaganja infektivnog medicinskog otpada kako bi se spriječilo izravno ili neizravno prenošenje zaraze te štetan utjecaj na zdravlje ljudi i/ili životinja.

Ključne riječi: MEDICINSKI OTPAD, PANDEMIJA COVID-19, GOSPODARENJE MEDICINSKIM OTPADOM

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