How COVID-19 pandemic affected medical waste management in Türkiye

Fusun Akcam,[1] Yunus Pamukoglu[2] and Ersin Uskun[3]

[1]Department of Infectious Diseases and Clinical Microbiology, Faculty of Medicine; [2]Department of Environmental Engineering Faculty of Engineering; [3]Department of Public Health, Faculty of Medicine, Suleyman Demirel University, Isparta, Türkiye (Correspondence to Fusun Z. Akcam: fusunakcam@sdu.edu.tr).

Abstract

Background: The COVID-19 pandemic has caused an increase in medical waste in hospitals.

Aims: To evaluate how the COVID-19 pandemic is affecting medical waste management in hospitals in Isparta Province, south-western Türkiye.

Methods: We examined medical waste production in 3 different types of hospital (1 private, 1 public and 1 university) in Isparta Province, south-western Türkiye. We compared the number of patients, amount of medical waste and occupancy rates of the 3 hospitals during the pre-pandemic (2019–2020) and pandemic (2020–2021) periods. The data were analysed using *SPSS*, version 22.0, and statistical significance was set at $P < 0.05$.

Results: During the pandemic, the number of inpatients in the public and university hospitals decreased, while the number in the private hospital increased. The amount of medical waste during the pre-pandemic period was 8.4 kg per person in the public hospital, 7.7 kg per person in the university hospital and 6.3 kg per person in the private hospital. During the pandemic, these amounts were 14.2 kg, 10.1 kg and 7.6 kg per person, respectively.

Conclusion: There was a significant increase in medical waste during the COVID-19 pandemic. Health institutions in Isparta Province, Türkiye, need to review their medical waste management strategies to better manage the increased waste.

Keywords: medical waste, hospital waste management, personal protective equipment, COVID-19

Citation: Akcam F, Pamukoglu Y, Uskun E. How COVID-19 pandemic affected medical waste management in Türkiye. East Mediterr Health J. 2023;29(6):474–481. https://doi.org/10.26719/emhj.23.068

Received: 05/06/22; Accepted: 22/12/2022

Introduction

Certain types of waste are produced as a consequence of manufacture and services in every service-generating institution. Some of these wastes are harmful to humans and may disrupt the ecological balance by remaining in and contaminating the air, water and land for a long time. Special measures need to be taken regarding the transportation, storage and disposal of these waste materials.

Waste materials containing infective disease-causing pathogens are defined as infectious healthcare-related wastes, and include blood and other bodily fluids, laboratory cultures and materials contaminated with infectious matter (*1,2*). Safe and environmentally conscious management of these wastes will prevent their negative impact on health and the environment, and thus protect public health.

In the fight against COVID-19, the management of medical, domestic and other hazardous wastes is an urgent and fundamental public service to minimize possible effects on health and the environment. Contaminated wastes such as masks, gloves and other protective equipment and numerous noncontaminated medical and hazardous wastes emerged during the pandemic (*3*).

A number of studies have been conducted to investigate medical and solid wastes, particularly during the pre- and post-pandemic eras (*4,5*), and hospital-based studies are frequently carried out (*6–9*). The aim of this study was to evaluate how COVID-19 pandemic affected medical waste production in 3 types of hospital.

Methods

Data collection

Three hospitals in Isparta Province, south-western Türkiye, were selected for this study: a university hospital, a state hospital and a private hospital. Isparta is close to Antalya, one of the most important tourism centres in Europe and Türkiye. We reviewed data on medical waste production and management from the 3 hospitals during the first year of the COVID-19 pandemic and the previous year. On receiving approval from the Provincial Directorate of Health, data on the number of patients and rates of medical waste and occupancy were retrieved from the hospital records. The state hospital is the largest hospital in the province with an 830-bed capacity. The research and training hospital at the university has a

595-bed capacity. Among the private hospitals, the largest one, having a 260-bed capacity, was selected.

For this study, the pre-pandemic period was considered to be between 1 April 2019 and 31 March 2020 and the pandemic period between 1 April 2020 (the date when the first COVID-19 patient was hospitalized in our hospitals) and 31 March 2021. The number of patients, amount of medical waste and occupancy rates in both periods were compared.

Statistical analysis

We used the Kolmogorov–Smirnov test to test for the conformity of the variables to the normal distribution, taking into account skewness and kurtosis indices. Conformity to the normal distribution was set at $P > 0.05$ for comparisons of the Kolmogorov–Smirnov test and where skewness and kurtosis index values were less than 2 times the standard error. Data were presented as descriptive statistics (mean, standard deviation) and by analysing using hypothesis testing; parametric tests were used in all hypothesis tests. The Pearson test was used to assess all correlations between number of patients, occupancy rate and amount of medical waste. We used 1-way analysis of variance (ANOVA) to compare the hospitals in terms of patient numbers, occupancy rate and amount of medical waste and to determine any differences in these parameters over 3-month periods in each of the hospitals. The post hoc Bonferoni test was used to detect the groups that showed a difference after ANOVA. For each hospital, the paired *t*-test was used to identify any difference between the pre-pandemic and the pandemic periods in terms of patient numbers, occupancy rate and amount of medical waste. Statistical significance was set at $P < 0.05$.

Results

In the pre-pandemic period (April 2019–March 2020), the state hospital had the highest number of occupants with 48 187 inpatients, followed by the university hospital with 31 121 and the private hospital with 7 249. Correspondingly, the state hospital produced the greatest amount of waste (406 603 kg), with the university and private hospitals following. Table 1 shows changes in the amount of waste and number of patients seen in the 3 hospitals during the pre-pandemic and pandemic periods.

Table 2 presents the mean values for number of patients, amount of waste and occupancy rate for each hospital during the pre-pandemic and pandemic periods. Figure 1 reflects the amount of medical waste and the number of inpatients for the university, state and private hospitals during the same periods and shows the effect of the pandemic on these statistics. The number of patients was statistically significantly lower during the pandemic in the university ($P = 0.004$) and state ($P = 0.001$) hospitals but significantly increased in the private hospital ($P = 0.002$). Although the university and state hospitals also demonstrated a decrease in their occupancy rates ($P = 0.001$ and $P < 0.001$; respectively), the changes were not statistically significant in the private hospital during the pandemic ($P = 0.201$). When the hospitals were cyclically compared in themselves, there was no statistically significant difference over the 3-month periods in the state hospital ($P = 0.051$). However, during the pandemic, the university and private hospitals generated the highest amount of medical wastes in the 3-month period October–December ($P = 0.020$ and $P = 0.028$; respectively) (Table 2).

The mean values for patient numbers and amount of medical wastes during the pre-pandemic period were highest in the state hospital and lowest in the private hospital ($P < 0.001$ for both); in fact, all 3 hospitals were significantly different from each other ($P < 0.001$ for all comparisons). During the pre-pandemic period, the occupancy rate of the university hospital was lower than and significantly different from those of the state and university hospitals ($P < 0.001$ for both) (Table 2).

During the pandemic, mean values for patient numbers at the private hospital were lower than and significantly different from those of the university and state hospitals ($P < 0.001$ for both). During the same period, mean values for occupancy rate at the private hospital were higher than and significantly different from those of the university and state hospitals ($P < 0.001$ for both). The mean values for amount of medical waste were also different, highest in the private hospital and lowest in the university hospital ($P < 0.001$ for all comparisons) (Table 2).

In the university hospital, during the pre-pandemic and pandemic periods, as the patient numbers ($P = 0.019$ and $P = 0.008$ respectively) and occupancy rates ($P = 0.024$ and $P = 0.002$ respectively) increased, so did the amount of medical waste (Table 3). No significant relationship

Table 1 Changes in the amount of medical waste and number of inpatients during the pre-pandemic and pandemic period at 3 different hospitals in Isparta Province, south-west Türkiye

Hospital	Pre-pandemic 1 April 2019 to 31 March 2020		Pandemic 1 April 2020 to 31 March 2021	
	Patients No.	Medical waste (kg)	Patients No.	Medical waste (kg)
State	48 187	406 603	31 173	442 608
University	31 121	238 258	25 411	257 500
Private	7 249	45 629	8 494	65 097

Table 2 Distribution of patient numbers, amount of medical waste and occupancy rates for 3 hospitals in Isparta Province, south-west Türkiye during the pre-pandemic and pandemic periods

Period	University hospital			State hospital			Private hospital			P^2		
	No. patients	Amount of medical waste (kg)	Occupancy rate (%)	No. patients	Amount of medical waste (kg)	Occupancy rate (%)	No. patients	Amount of medical waste (kg)	Occupancy rate (%)	No. patients	Amount of medical waste (kg)	Occupancy rate (%)
Pre-pandemic period, 1 April 2019 to 31 March 2020												
April–June 2019	2 853 (254)	19 850 (996)	69 (7)	3 842 (314)	34 090 (2 964)	82 (9)	596 (15)	3 685 (275)	89 (2)	< 0.001[d]	< 0.001[e]	< 0.001[f]
July–September 2019	2 999 (301)	19 233 (2 525)	70 (8)	4 055 (326)	35 007 (2 692)	80 (7)	652 (42)	3 478 (405)	95 (1)			
October–December 2019	3 097 (82)	20 586 (229)	75 (2)	4 271 (42)	33 977 (2 514)	89 (3)	555 (53)	3 748 (514)	89 (2)			
January–March 2020	2 759 (546)	19 750 (1 819)	68 (14)	3 894 (804)	32 460 (1 827)	84 (15)	613 (8)	4 298 (795)	90 (7)			
Overall mean	2 927 (320)	19 855 (1 485)	71 (8)	4 016 (431)	33 883 (2 363)	84 (9)	604 (47)	3 802 (554)	91 (4)			
P^1	0.639	0.792	0.798	0.679	0.680	0.761	0.051	0.342	0.161			
Pandemic period, 1 April 2020 to 31 March 2021												
April–June 2020	1 484 (811)	16 350 (4 338)	36 (16)	1 753 (1 075)	33 218 (53 23)	37 (15)	680 (88)	4 834 (706)	94 (9)	< 0.001[g]	< 0.001[h]	< 0.001
July–September 2020	2 412 (138)	22 667 (874)	53 (4)	3 064 (181)	34 129 (3 103)	55 (2)	755 (15)	59 151 (189)	91 (3)			
October December 2020	2 124 (117)	25 833 (1 845)	52 (2)	2 481 (308)	45 067 (6 390)	59 (4)	764 (44)	6 778 (662)	91 (3)			
January–March 2021	2 451 (520)	20 983 (3 009)	55 (8)	3 093 (777)	35 123 (3 443)	61 (11)	632 (55)	4 171 (847)	68 (2)			
Overall mean	2 118 (582)	21 458 (4 315)	49 (11)	2 598 (817)	36 884 (6 429)	53 (13)	708 (75)	54 251 (283)	86 (12)			
P^1	0.134	0.020[a]	0.134	0.131	0.051	0.049	0.062	0.028[b]	0.001[c]			
P^3	0.004	0.240	0.001	0.001	0.147	< 0.001	0.002	0.003	0.201			

All values are mean (standard deviation).

P^1 Periodic differences within each hospital itself (one-way variance analysis [ANOVA]).

P^2 Differences between hospitals (one-way variance analysis [ANOVA]).

P^3 Differences between the pre-pandemic and pandemic period within each hospital (t-test in dependent groups).

[a]During the pandemic period, the amount of medical waste in the university hospital was the highest in April/May/June and this difference was found to be significant (PostHoc Bonferroni, P = 0.021).

[b]In the private hospital, during the pandemic period, the amount of medical waste was the lowest in October/November/December and this difference was found to be significant (post-hoc Bonferroni, P = 0.039).

[c]During the pandemic period, the highest occupancy rate occurred in January/February/March and the highest amount was statistically significant (post-hoc Bonferroni, P = 0.001).

[d]The average number of patients in all 3 hospitals was different in the pre-pandemic period (post-hoc Bonferroni, P < 0.001 for all comparisons).

[e]In the pre-pandemic period, the medical waste averages of all 3 hospitals were different (post-hoc Bonferroni, P < 0.001 for all comparisons).

[f]In the pre-pandemic period, the occupancy rates of the university hospital were found to be different from the state hospital and the private hospital (post-hoc Bonferroni, P < 0.001 for both).

[g]During the pandemic period, the number of patients of the private hospital was different from that of the university and the state hospital (post-hoc Bonferroni, P < 0.001 for both).

[h]During the pandemic period, the medical waste averages of all 3 hospitals were different (post-hoc Bonferroni, P < 0.001 for all comparisons).

[i]During the pandemic period, the average occupancy rates of the private hospital were different from those of the university and the state hospitals (post-hoc Bonferroni, P < 0.001 for both).

Figure 1 **Distribution of the amount of medical waste and the number of inpatients at a (a) university hospital, (b) state hospital and (c) private hospital in Isparta Province, south-western Türkiye during the pre-pandemic and pandemic periods**

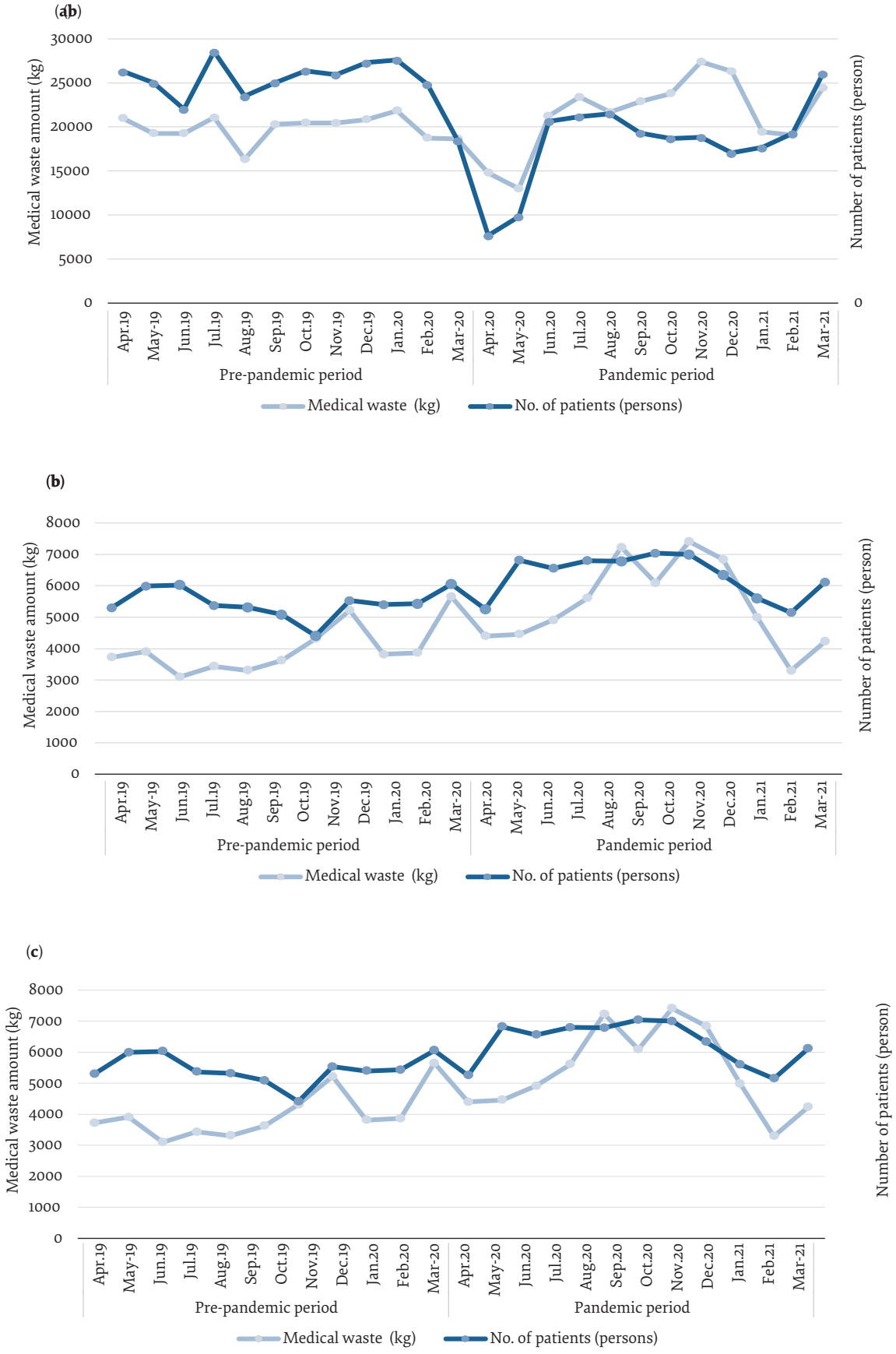

Table 3 Correlation between the amount of medical waste and number of patients and occupancy rates for 3 hospitals in Isparta Province, south-west Türkiye during the pre-pandemic and pandemic periods

Variable	Amount of medical waste		
	University hospital	State hospital	Private hospital
Pre-pandemic period, 1 April 2019 to 31 March 2020			
No. patients	$r = 0.662$; $P = 0.019$	$r = 0.481$; $P = 0.113$	$r = -0.192$; $P = 0.550$
Occupancy rate	$r = 0.643$; $P = 0.024$	$r = 0.882$; $P < 0.001$	$r = -0.255$; $P = 0.424$
Pandemic period, 1 April 2020 to 31 March 2021			
No. patients	$r = 0.719$; $P = 0.008$	$r = -0.072$; $P = 0.823$	$r = 0.666$; $P = 0.018$
Occupancy rate	$r = 0.785$; $P = 0.002$	$r = 0.887$; $P < 0.001$	$r = 0.614$; $P = 0.034$

was found between number of patients and the amount of medical waste during the pre-pandemic and pandemic periods in the state hospital ($P = 0.113$ and $P = 0.823$ respectively). A significant relationship was found between occupancy rate and the amount of medical waste during the pre-pandemic and pandemic periods in the state hospital ($P < 0.001$ and $P < 0.001$ respectively). No significant correlation was found between number of patients and occupancy rate and the amount of medical waste in the private hospital during the pre-pandemic period ($P = 0.550$ and $P = 0.424$ respectively). We found that, in the private hospital during the pandemic, as the number of patients and occupancy rate increased so did the amount of medical waste ($P = 0.018$ and $P = 0.034$ respectively) (Table 3).

Discussion and conclusion

In many countries, a national emergency was declared, and the restrictions on mobility and economic activities imposed due to the COVID-19 pandemic significantly affected waste production (*10,11*). Many companies and businesses switched to remote working. It has been reported that the infection rate decreased and mortality risk was reduced as a result of the physical distancing measures taken (*12–15*). A significant reduction in hospital admissions was also observed during the lockdown (*12,16*). In comparison with the pre-pandemic period, we found that routine hospital admissions were restricted and prioritized for the care of critically-ill patients; the number of patients attending state and university hospitals for mere self-concern was noticeably lower, but the number attending the private hospital increased during this period. This may be because patients preferred to attend less-crowded private hospitals during the pandemic. Patients preferring private hospitals tended to be older and opted for private hospitals because of the shorter waiting periods for test results, and there was a well-established population relying on private hospitals (*17*).

Although 75–90% of waste generated in hospitals does not have any potential risk, the remaining 10–25% can be hazardous (*2*). It is known that better training of healthcare workers and standardization of waste management are key aspects of efficient waste management in healthcare facilities (*18*). Our study demonstrated a significant increase in medical waste during the COVID-19 pandemic. It is normal for university hospitals to produce higher amounts of waste because they are research and training hospitals. The excessive waste in the state hospital could be partly attributed to their greater use of high technological infrastructure. On reviewing the amount of medical waste in Türkiye it was found that the amount of medical waste was 0.91 kg/per person in 2016 and 1.10 kg/per person in 2019 (*19,20*). Compared with these figures, we observed that the amount of medical waste per person in the 3 hospitals we studied was high. Hence, these establishments need to review their waste management protocols especially at inpatient wards where medical waste is predominantly higher.

The available disposal strategies comprise the separation of wastes at the disposal site within the healthcare facilities and their transportation to a safe disposal site where the infectious medical waste is incenerated or autoclaved. There are disadvantages to both incineration and autoclaving. While incineration creates unwanted atmospheric emissions that cause negative health and environmental effects, autoclaving cannot be used to treat all kinds of waste, nor can it produce a universally accepted processed product for waste yards (*18,21,22*). Medical wastes collected in our setting are often autoclaved and disposed of afterwards by being buried at the disposal site.

The best way to control the effect of medical waste is to produce less, i.e. reduction at source, and one of the most effective ways to do this is to ensure that only infectious medical wastes are sent for special processing and treatment. Other hospital wastes such as packaging and domestic wastes should be processed in a similar manner to that of municipality wastes (*18*).

The COVID-19 virus is spread through sneezing, coughing, physical contact and contact with infected surfaces (*23–26*). The survival period for SARS-CoV-2 on objects/surfaces depends on the type of substrate and environmental conditions and ranges from a few hours to a couple of days. The long survival period of SARS-CoV-2 raises the infection risk within a society (*27,28*). Because of this, all wastes from all wards where COVID-19 patients were treated were classed as medical wastes, consequently the amount of medical wastes increased. All wastes emanating from clinics dedicated to the care of

COVID-19 patients, including those from sterile dressing areas, were processed as medical wastes. Yet, the bags and packages for the personal protective equipment and masks used in the wards could have been disposed of as domestic wastes like the masks and gloves used in the community for protective purposes. A similar approach was observed in the state hospital, where medical waste production increased despite the reduced occupancy rates during the pandemic.

Several years ago, a report on "Hospital Waste Composition Research" from the Turkish Statistical Institute was presented by the General Directorate of Environmental Management. The total amount of solid wastes emanating from state and private hospitals and the distribution of the physical composition were investigated: the wastes were classified as medical wastes, domestic wastes and recyclable material. When the results of the survey were reviewed, it was seen that 0.09 kg per bed of recyclable waste was being produced daily in state hospitals, while in private hospitals this was 0.98 kg per bed per day (*29*). These data suggest that medical waste management is carried out more effectively in private hospitals. Our findings showed that, despite the decrease in patient numbers in the state and university hospitals, medical waste production increased. When changes in the amount of medical waste and the number of inpatients during the pre-pandemic and pandemic periods in the 3 hospitals were examined, we observed that even though patient numbers were much reduced in April 2020, the amount of medical waste slightly increased. This situation was associated with the fact that the state hospital cared for more COVID-19 patients than the university hospital did. The proportion of COVID-19 patients to the total number of patients in the hospitals during the pandemic had not been taken into consideration, therefore, this negative change in the state hospital can be attributed to the fact that more personal protective equipment was used during this time.

During the pandemic, the university and private hospitals generated the greatest amount of medical wastes during the period October–December. This was the time Türkiye experienced the second COVID-19 peak and information on mutations was shared around the world for the first time. However, there was no significant observation of how the amount of medical waste increased when patient numbers did not increase and occupancy rates did not change. In the private hospital in April–June, the occupancy rate was statistically significantly higher, suggesting that patients who specifically preferred a private hospital considered the fact that this hospital had fewer patients and thus there was less risk of contact. Comparing the 3 hospitals, it was expected that the private hospital would have the highest amount of medical waste since its occupancy rate was the highest. The low number of patients and the high occupancy rate of the private hospital are 2 outcomes in support of our argument that patients preferred the private hospital with fewer patients and a lower risk from contact (and for inpatient treatment).

Many developing countries still lack the infrastructure to process their medical as well as other infectious or hazardous wastes (*30*). As in the example of the COVID-19 pandemic, in the absence of an efficient waste management plan, wastes emanating from a healthcare facility may pose great problems. Despite the use of heat treatment, businesses may generate more medical wastes than their capacities can process and treat. In such a situation, wastes need to be directed to disposal sites. It is recommended to create an area isolated from non-hazardous wastes for these wastes and to cover them up every day (*23*). The daily capacity of the medical waste disposal site in the geographical region covered by our study is 350 tons. Since medical wastes were not brought from other sites to this region for disposal, overuse was not encountered during the pandemic.

To conclude, appropriate medical waste management is not only associated with the quality of services provided by the healthcare facilities but also reflects the welfare and level of consciousness of the institution and the country.

Funding: None.

Competing interests: None declared.

Impact de la pandémie de COVID-19 sur la gestion des déchets médicaux en Türkiye

Résumé

Contexte : La pandémie de COVID-19 a entraîné une augmentation des déchets médicaux dans les hôpitaux.

Objectifs : Évaluer l'impact de la pandémie de COVID-19 sur la gestion des déchets médicaux dans les hôpitaux de la province d'Isparta, au sud-ouest de la Türkiye.

Méthodes : Nous avons examiné la production de déchets médicaux dans trois types d'hôpitaux différents (un hôpital privé, un hôpital public et un centre hospitalier universitaire) situés dans la province d'Isparta. Nous avons comparé le nombre de patients, la quantité de déchets médicaux et les taux d'occupation des trois hôpitaux pendant la période pré-pandémique (2019-2020) et pendant la pandémie (2020-2021). Les données ont été analysées à l'aide du logiciel *SPSS*, version 22.0, et la signification statistique a été fixée à $p < 0,05$.

Résultats : Pendant la pandémie, le nombre de patients hospitalisés dans l'hôpital public et au CHU a diminué, tandis que le nombre de patients hospitalisés dans l'hôpital privé a augmenté. La quantité de déchets médicaux produits pendant la période pré-pandémique était de 8,4 kg par personne à l'hôpital public, de 7,7 kg par personne au CHU et de 6,3 kg par personne à l'hôpital privé. Pendant la pandémie, ces quantités étaient respectivement de 14,2 kg, 10,1 kg et 7,6 kg par personne.

Conclusion : La quantité de déchets médicaux a fortement augmenté pendant la pandémie de COVID-19. Les établissements de santé de la province d'Isparta doivent revoir leurs stratégies de gestion des déchets médicaux pour avoir un meilleur contrôle de l'augmentation des déchets.

كيف أثرت جائحة كوفيد-19 على إدارة النفايات الطبية في تركيا

فزون أكشم، يونس أوغلو، إرسين أوزكان

الخلاصة

الخلفية: تسببت جائحة كوفيد-19 في زيادة حجم النفايات الطبية في المستشفيات.

الأهداف: هدفت هذه الدراسة الى تقييم تأثير جائحة كوفيد-19 على إدارة النفايات الطبية في المستشفيات في محافظة إسبرطة، جنوب غرب تركيا.

طرق البحث: فحصنا إنتاج النفايات الطبية في ثلاثة مستشفيات مختلفة (مستشفى خاص، ومستشفى عام، ومستشفى جامعي) في محافظة إسبرطة، جنوب غرب تركيا. وقارنّا عدد المرضى، وحجم النفايات الطبية، ومعدلات الإشغال في المستشفيات الثلاثة خلال فترتَيْ ما قبل الجائحة (2019–2020) وأثناء الجائحة (2020–2021). وحُللت البيانات بالإصدار 22.0 من برنامج SPSS، وتحددت الدلالة الإحصائية عند قيمة احتمالية < 0.05.

النتائج: خلال الجائحة، انخفض عدد المرضى الداخليين في المستشفيات العامة والجامعية، بينما ازداد عددهم في المستشفيات الخاصة. وخلال فترة ما قبل الجائحة، كانت كمية النفايات الطبية 8.4 كجم للشخص الواحد في المستشفى العام، و7.7 كجم للشخص الواحد في المستشفى الجامعي، و6.3 كجم للشخص الواحد في المستشفى الخاص. وأثناء الجائحة، بلغت هذه الكميات 14.2 كجم، و10.1 كجم، و7.6 كجم للشخص الواحد، على التوالي.

الاستنتاجات: حدثت زيادة كبيرة في النفايات الطبية أثناء جائحة كوفيد-19. وعلى المؤسسات الصحية في محافظة إسبرطة بتركيا أن تراجع استراتيجياتها المعنية بإدارة النفايات الطبية.

References

1. Chartier Y, Emmanuel J, Pieper U, Prüss A, Rushbrook P, Stringer R, et al. eds. Safe management of wastes from health-care activities, 2nd ed. Geneva: World Health Organization; 2014:p329 (http://apps.who.int/iris/bitstream/10665/85349/1/9789241548564_eng.pdf, accessed 20 March 2023).
2. Askarian M, Heidarpoor P, Assadian O. A total quality management approach to healthcare waste management in Namazi Hospital, Iran. Waste Manag. 2010 Nov;30(11):2321-6. doi:10.1016/j.wasman.2010.06.020
3. Kalina M, Ali F, Tilley E. "Everything continued as normal": What happened to Africa's wave of Covid-19 waste? Waste Manag. 2021 Feb 1;120:277–9. doi:10.1016/j.wasman.2020.11.051
4. Tirkolaee EB, Abbasian P, Weber GW. Sustainable fuzzy multi-trip location-routing problem for medical waste management during the COVID-19 outbreak. Sci Total Environ. 2021 Feb 20;756:143607. doi:10.1016/j.scitotenv.2020.143607
5. Singh E, Kumar A, Mishra R, Kumar S. Solid waste management during COVID-19 pandemic: recovery techniques and responses. Chemosphere. 2022 Feb;288(Pt 1):132451. doi:10.1016/j.chemosphere.2021.132451
6. Dehal A, Vaidya AN, Kumar AR. Biomedical waste generation and management during COVID-19 pandemic in India: challenges and possible management strategies. Environ Sci Pollut Res Int. 2022 Feb;29(10):14830–45. doi:10.1007/s11356-021-16736-8
7. Mekonnen B, Solomon N, Wondimu W. Healthcare waste status and handling practices during COVID-19 pandemic in Tepi General Hospital, Ethiopia. J Environ Public Health. 2021 Jan 30;2021:6614565. doi:10.1155/2021/6614565
8. Rathnayake D, Clarke M, Jayasinghe VI. Health system performance and health system preparedness for the post-pandemic impact of COVID-19: a review. Int J Healthc Manag. 2021 Jan 2;14(1):250–4. doi:10.1080/20479700.2020.1836732
9. Kalantary RR, Jamshidi A, Mofrad MMG, Jafari AJ, Heidari N, Fallahizadeh S, et al. 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
10. Sarmento P, Motta M, Scott IJ, Pinheiro FL, de Castro Neto M. Impact of COVID-19 lockdown measures on waste production behavior in Lisbon. Waste Manag. 2022 Feb 1;138:189–98. doi:10.1016/j.wasman.2021.12.002

11. Ali MA, Al-Khani AM, Sidahmed LA. Migrant health in Saudi Arabia during the COVID-19 pandemic. East Mediterr Health J. 2020 Aug 25;26(8):879–80. doi:10.26719/emhj.20.094
12. Chowell G, Mizumoto K. The COVID-19 pandemic in the USA: what might we expect? Lancet. 2020 Apr 4;395(10230):1093–4. doi:10.1016/S0140-6736(20)30743-1
13. Ali MY, Bhatti R. COVID-19 (Coronavirus) Pandemic: information sources channels for the public health awareness. Asia Pac J Public Health. 2020 May;32(4):168–9. doi:10.1177/1010539520927261
14. Binns C, Low WY, Kyung LM. The COVID-19 pandemic: public health and epidemiology. Asia Pac J Public Health. 2020 May;32(4):140–4. doi:10.1177/1010539520929223
15. Sayad B, Rahimi Z. Blood coagulation parameters in patients with severe COVID-19 from Kermanshah Province, Islamic Republic of Iran. East Mediterr Health J. 2020 Sep 24;26(9):999–1004. doi:10.26719/emhj.20.105
16. Akıllı H, Bolankake N, Kuşçu ÜE, Haberal A, Ayhan A. Covid-19 pandemisi öncesi ve sonrasi uygulanan jinekolojik onkolojik cerrahilerin kisa dönem sonuçlarinin karşilaştirilmasi. [Comparison of the short-term results of gynecological oncological surgeries applied before and after the Covid-19 pandemic]. Sağlık ve Toplum [Health and Society]. 2021;31(1):54–9.
17. He J, Hou XY, Toloo GS, FitzGerald G. Patients' choice between public and private hospital emergency departments: a cross-sectional survey. Emerg Med Australas. 2017 Dec;29(6):635–42. doi:10.1111/1742-6723.12841
18. Windfeld ES, Brooks MSL. Medical waste management – a review. J Environ Manage. 2015 Nov 1;163:98–108. doi:10.1016/j.jenvman.2015.08.013
19. Sağlık kuruluşlari atik istatistikleri açıklandı [Health institutions waste statistics announced]. Ankara: Turkish Statistical Institute; 2016 (https://ohsad.org/tuik-2016-saglik-kuruluslari-atik-istatistikleri-aciklandi, accessed 20 March 2023).
20. Eryılmaz H Demirarslan KO. 2012–2018 Yillari tibbi atiklarinin nüfus ileilişkilendirilmesi ve mevcut bertaraf yöntemlerininincelenmesi [Evaluation of 2012–2018 medical wastes with the population and current disposal methods]. ADYU Mühendislik Bilimleri Dergisi [ADYU J Engineering Sci]. 2020;13:89–103 (https://dergipark.org.tr/tr/download/article-file/1221371, accessedÐ 23March2023).
21. Kudli LP, Jaishankar SS, Iyer RD. Biomedical waste management during the COVID-19 pandemic–Indian scenario. J Indian Assoc Environ Manage. 2021;41(1):41–53 (http://op.niscair.res.in/index.php/JIAEM/article/view/45615/465479117, accessed 20 March 2023).
22. Ghasemi MK, Yusuff RM. Advantages and disadvantages of healthcare waste treatment and disposal alternatives: Malaysian scenario. Pol J Environ Stud. 2016;25(1):17–25. doi:10.15244/pjoes/59322
23. Waste management during the COVID-19 pandemic, ISWA's recommendations. Rotterdam: International Solid Waste Association; 2020 (https://www.humanitarianlibrary.org/sites/default/files/2020/07/ISWA_Waste_Management_During_COVID-19.pdf, accessed 20 March 2023).
24. Duong DM, Le VT, Ha BTT. Controlling the COVID-19 pandemic in Vietnam: lessons from a limited resource country. Asia Pac J Public Health. 2020 May;32(4):161–2. doi:10.1177/1010539520927290
25. Abid K, Bari YA, Younas M, Tahir Javaid S, Imran A. Progress of COVID-19 epidemic in Pakistan. Asia Pac J Public Health. 2020 May;32(4):154–6. doi:10.1177/1010539520927259
26. Seyedin H, Moslehi S, Sakhaei F, Dowlati M. Developing a hospital preparedness checklist to assess the ability to respond to the COVID-19 pandemic. East Mediterr Health J. 2021 Feb 25;27(2):131–41. doi:10.26719/2021.27.2.131
27. van Doremalen N, Bushmaker T, Morris DH, Holbrook MG, Gamble A, Williamson BN, et al. Aerosol and Surface Stability of SARS-CoV-2 as Compared with SARS-CoV-1. N Engl J Med. 2020 Apr 16;382(16):1564–7. doi:10.1056/NEJMc2004973
28. Basij-Rasikh S, Khalil M, Safi N. Early responses to COVID-19 in Afgankara:hanistan. East Mediterr Health J. 2020 Dec 9;26(12):1442–5. doi:10.26719/emhj.20.137
29. Güvenli tibbi atik yönetimi [Safe Medical Waste Management]. Ankara: Ministry of Environment and Urbanization General Directorate of Environmental Management; 2013 (https://webdosya.csb.gov.tr/db/cygm/editordosya/guvenliatikkilavuz.pdf, accessed 20 March 2023).
30. Sawalem M, Selic E, Herbell JD. Hospital waste management in Libya: a case study. Waste Manag. 2009 Apr;29(4):1370–5. doi:10.1016/j.wasman.2008.08.028