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SOLID MEDICAL HOSPITAL WASTE IN TIMES OF CORONA: INCREASED VOLUME BUT NO INCREASED BIOHAZARD RISK

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ABSTRACT
The effect of the COVID-19 pandemic on medical waste EWC/EURAL code 180103* (infectious medical waste) and 180104 (non-infectious medical waste) was investigated in 6 university hospitals and 6 general hospitals. Data on the number of in-hospital patients and on quantity and volume of waste were obtained during 2019 (control period) and in 2020 up to March 2021 (COVID-19 period) for the hospitals, from the waste managing company, and from the regional destruction facility. The presence of SARS-CoV-2 on the surface of waste recipients was analyzed using RT-PCR. We found that the effect of the pandemic on the total weight of waste is limited during the first wave (March 2020), while during the second wave, the quantity of waste type 180103* increased. The main effect is a nearly doubling of the volume of waste during both waves caused by the use of cardboard hospital boxes with a yellow inner plastic bag. We demonstrated that the average weight of these cardboard boxes generated for the treatment of COVID-19 patients is significantly lower compared to the weight of the waste from non-COVID-19 patients. COVID-19-related health care activities caused a weight increase of the 180103* waste from historical data (0.2-1.4 kg/day/bed) up to 5-8 kg/day/bed. RT-PCR analysis of swabs demonstrated the absence of viral RNA on personal protection materials and on the surface of recipients containing the waste. We conclude that COVID-19-related hospital waste is predominantly of the EWC 180104 type.

1. INTRODUCTION

It is beyond saying that the pandemic caused by severe acute respiratory syndrome coronavirus type 2 (SARS-CoV-2), the virus that leads to coronavirus disease 2019 (COVID-19), has startled society in all aspects since January 2020. Drastic measures such as social isolation, restriction on travel, and economic activity, up to the complete lockdown of cities and countries, were installed and legally secured. The WHO declared the SARS-CoV-2 epidemic officially a pandemic on March 11, 2020 (Cucinotta and Vanelli, 2020). At the time of writing this manuscript in January 2022, nearly 300 million infections are ascertained with nearly 5.5 million deaths throughout the world (Huraimel et al., 2020, WHO, 2021, John Hopkins University, 2022). As a consequence of the lockdown and adjacent measures, other aspects of societal life gained interest. Reports on the effect of climate change on COVID-19-incidence, a significant reduction in air pollution, both in particulate matter and nitrogen oxide, and a reduction of water pollution to name a few, have been published (Sarkodie and Owusu, 2020, Saadat et al., 2020, Hens and Fraeyman, 2021).

Within the health care sector, the focus was evidently on patient care and on the research on antiviral medication and vaccines, the latter being produced at an unprecedented speed (Hebbani et al., 2022, Dubey et al., 2022). Gradually, the management of solid medical waste gained attention because it was suggested that this waste might be a source of viral transmission (Mol & Caldas, 2020). The finding that the virus has extended viability on many inert surfaces indeed warranted a precautionary approach (Wiktorczyk et al., 2021; Van Doremalen et al., 2020). Hence all material used for the treatment or diagnosis of COVID-19 patients was considered dangerous, and the waste was attributed to the EWC/EURAL code 180103*, which is waste with a risk for infection, requiring specific UN3291 certified recipients for collection and transport (Hoseindzadeh et al., 2020; WHO 2020). As a consequence, a massive in-

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crease in waste volume and a shortage in recipients were seen (Lavagnolo, 2020). In Wuhan, China, the volume of waste considered high-risk was in March 2020 about 5 times higher compared to the pre-COVID-19 period, while the waste density (kg/m³) decreased from 120 to 67-85 because of the use of the light-weight single-use personal protection equipment such as aprons, gloves, and masks (Wei, 2021). During that period, rather confusing and conflicting messages were distributed by, among others, the CDC (US Centers for Disease Control and Prevention) and the ECDC (European Centre for Disease Control), who stated that the waste from COVID-19 patients was not different from other patients (CDC 2021, ECDC, 2020), while WHO advised people handling health care waste from COVID-19 patients to wear boots, aprons, long-sleeved gowns, thick gloves, masks and face shields (WHO, 2020). From the point of view of transport legislation (ADR), COVID-19 waste was not taken within list A but considered in list B requiring UN 3291 certified recipients for transport. Needless to say that this was a disturbing and troublesome period for the whole health care sector.

Now, more than 2 years after the start of the pandemic, we want to describe the evolution of the waste management during the first and second wave of infections, based on formally registered data from 6 university hospitals (Vienna, Jena, and 4 university hospitals in Flanders and Brussels in Belgium) and 6 general hospitals in Flanders. First, we addressed a number of questions about the weight and volume and the financial consequences of the COVID-19 waste compared to waste from non-COVID-19 patients. Secondly, we investigated whether the allocation of the waste from COVID-19 patients to the EWC/EURAL 180103* code was justified. We used data from waves 1 and 2 in the year 2020 up to March 2021 and we used similar data from 2019 as an internal control.

2. METHODS

The name and the capacity of the 12 participating hospitals are summarized in Table 1. The number of beds refers to the situation in 2019.

The following data related to bed occupation by in-patients were obtained from the hospital administrations: (1) total number of non-COVID-19 hospitalized patients occupying a bed for at least one day, and (2) number and bed occupancy of hospitalized COVID-19 patients. Data were available on a daily basis, both for 2019 which is considered the control year, and for 2020 up to March 31st, 2021 (approximately the end of the second wave) which is considered the COVID-19 period.

As far as solid medical waste is concerned, we distinguish on the one side, the medical waste that might cause diseases to waste handlers and identified within Europe as waste with code EWC/EURAL 180103* and within the US as regulated medical waste, and waste generated from health care activities but non-infective and comparable to household waste, identified in Europe as EWC/EURAL 180104. The acronyms EWC and EURAL, the latter being frequently used in Belgium, are used interchangeably.

The following data were obtained: (1) quantity in kilograms of waste according to the EWC/EURAL code 180103* and 180104, and (2) the type of recipient the waste was collected in. In this respect, the legal restraints were respected: the risk waste (EWC 180103*) was collected in plastic material bins of 30, 50, or 60 liters or in cardboard containers with a plastic inner bag all according to the UN code 3921. The records of the weight during 2019 and 2020 were as detailed as possible and in most cases, this included the record of the weight of every transport of waste from the hospital to the destruction facility: for EWC/EURAL 180104 on a daily basis; for EWC/EURAL 180103* every 2-3 days.

In one of the university hospitals, the weight of each waste recipient coming from a COVID-19 ward was recorded on a daily basis from December 1st, 2020, until January 31st, 2021, covering a large part of the second wave. As a control, a similar number of recipients from conventional hospital wards were weighted on the same day.

Two additional commercial organizations were contacted and delivered information: the SUEZ group for recovery and waste management and the INDAVER facility in

TABLE 1: Identification of the participating hospitals.

Name and type of hospital	Number of beds
VAMED-KMB University Hospital, Vienna, Austria	1728
University Hospital Jena, Germany	1369
Ghent University Hospital, Ghent, Belgium	1049
University Hospital Saint Luc, Brussels, Belgium	945
Antwerp University Hospital, Antwerp, Belgium	573
University Hospital Brussels, Brussels, Belgium	721
General hospital Sint-Lucas, Bruges, Belgium	422
General city hospital, Aalst, Belgium	344
General hospital Maria Middelares, Ghent, Belgium	542
General hospital Virga Jesse, Hasselt, Belgium	769
General hospital GZA, Antwerp, Belgium	346
General city hospital St Elisabeth, Herentals, Belgium	243

Antwerp for incineration of EWC 180103* type of medical waste in Flanders - Belgium.

Calculations include the comparison between data from COVID-19 and non-COVID-19 patients during the whole study period: (1) estimation of the evolution of the number of patients on a daily basis, (2) estimation of the total waste weight (kg), of the volume and of the weight per day per bed during the control period and during the COVID-19 wave, (3) estimation of the average weight of the recipients.

The presence of SARS-CoV-2 RNA on different surfaces was examined by taking swab samples in one university hospital from the surface of a range of materials. A total of 98 samples were analyzed. These include high-contact materials in the room of 2 patients with proven COVID-19 (mobile phone, food tray, washbasin, door handle of the room and window), surfaces outside the room (floors of corridor and service rooms in the COVID-19 ward, door handles), personal protection materials immediately after disposal (gloves, aprons, masks) and surfaces of all type of waste recipients at the recycling park within the hospital. Samples were obtained by gentle rubbing between 10 and 20 cm^2 of the surface with a swab moistened in RNA conserving fluid (DNA/RNA Shield, Zymo Research, Irvine, CA). RNA extraction was done with the MagMAX™ Viral/Pathogen II (MVP II) Nucleic Acid Isolation Kit from ThermoFisher (ref: A48383) on KingFisher instruments. The PCR detection was performed using the TaqPathTM COVID-19 CE-IVD RT-qPCR Kit (Thermo Fisher, ref: A28575, targets N-gene; S-gene and ORF1; control MS2) using QuantStudio™ 5 Real-Time PCR Instrument (348-Well Block), Thermo Fisher, Waltham, MA. The results are expressed in Cycle Threshold (CT) values. A CT value lower than 20 is considered a high viral load, between 20-30 intermediate viral load, and more than 30 is the absence of viral load.

The assay included controls, including samples taken in a room of a randomly chosen non-COVID-19 patient and samples taken on the surface of waste recipients originating from non-COVID-19 units.

All data were processed in MS excel. Calculations were done either in excel or in SPSS. Significance was estimated at $p<0.05$. The study was initiated at Ghent University Hospital, Belgium, and the formal approval of the ethical committee was obtained. Not all hospitals could deliver all data, figures are in most cases representative of the general picture.

3. RESULTS

3.1 Evolution of the number of patients, weight, volume, and cost of the medical waste.

Figure 1 shows a typical pattern of the number of COVID-19 patients and non-COVID-19 patients in one university hospital.

During the 2019 control period, a regular sequence of inpatient bed occupations is seen with a drop of about 25% during weekends, a slight reduction in the number of patients during holidays, and a sharp, short-lasting drop during the new year period. This pattern is identical in all hospitals that delivered data. During the first wave in 2020 and in this particular university hospital, the number of non-COVID-19 patients dropped from about 850 to about 500, while the number of COVID-19 patients increased to a maximum of 95. Subsequently, as the number of COVID-19 patients decreased, the number of non-COVID-19 patients gradually increased reaching approximately the same level as before the first wave and just before the second wave. During this second wave, the number of non-COVID-19 patients decreased from 800 to 700 with a parallel increase of COVID-19 patients up to 120. A similar result was found in the other hospitals that delivered the appropriate data (9 out of 14 participating hospitals). The increase in COVID-19 patients was accompanied by a decrease in non-COVID-19 patients and this compensation was more pronounced in the first wave compared to the second.

The effects of the pandemic on the waste volume and weight are shown in Figure 2.

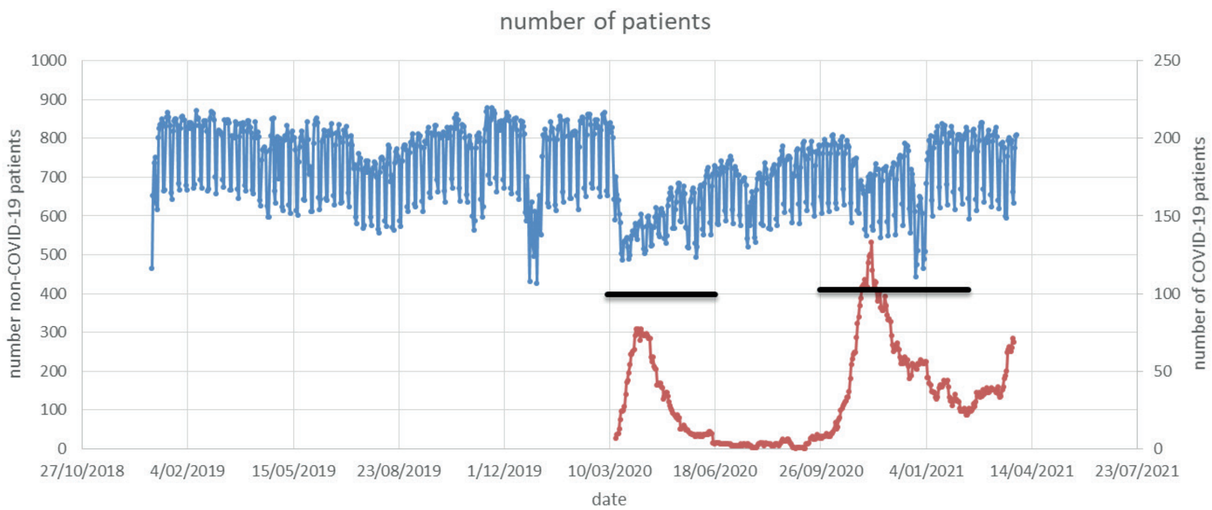

FIGURE 1: Evolution of the number of patients and weight of medical waste. Number of COVID-19 (orange, right y-axis) and non-COVID-19 (blue, left y-axis) patients from 1/1/2019 till 31/12/2020. The black lines refer to wave 1 (1/3/2020 – 20/6/2020) and wave 2 (1/10/2020 – 1/3/2021) of the corona epidemic.

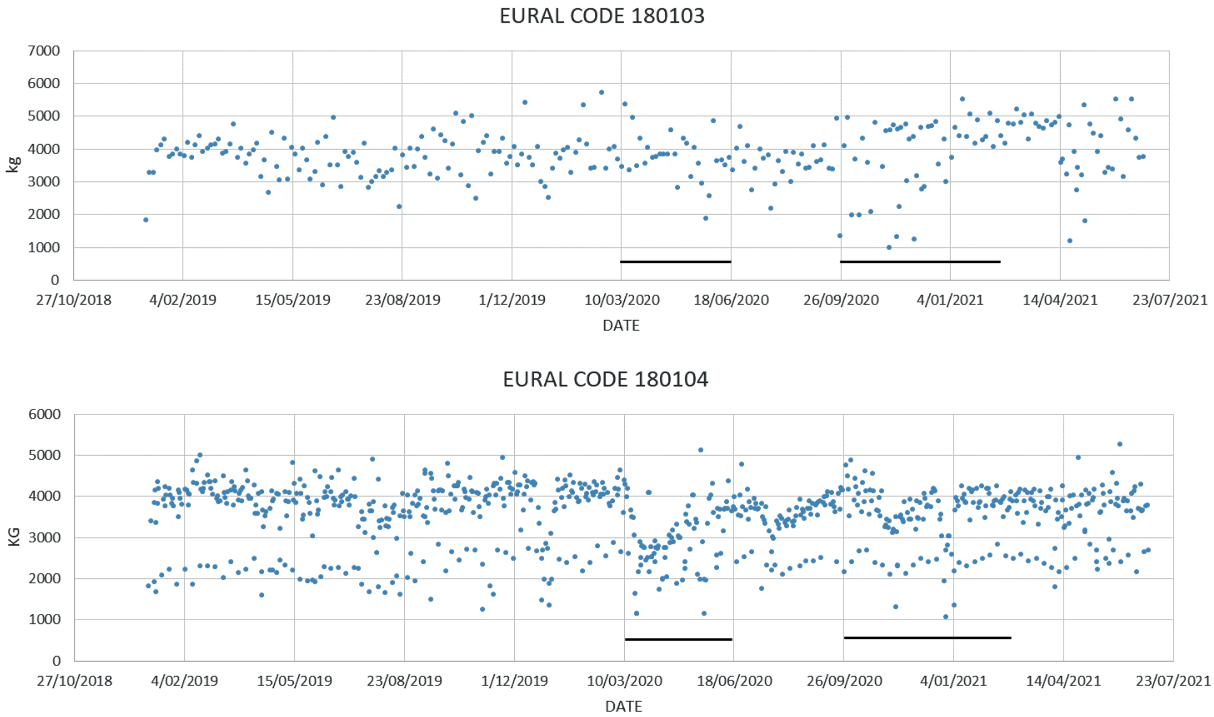

FIGURE 2: Evolution of the number of patients and weight of medical waste. Number of COVID-19 (orange, right y-axis) and non-COVID-19 (blue, left y-axis) patients from 1/1/2019 till 31/12/2020. The black lines refer to wave 1 (1/3/2020 – 20/6/2020) and wave 2 (1/10/2020 – 1/3/2021) of the corona epidemic.

During the first wave, the quantity of the 180104 type of waste shows a tendency to decrease (data from 3 participants) while the quantity of the 180103* waste remained nearly unchanged (data from 9 participants).

The quantitative data on the medical waste EWC 180103* type of waste was further analyzed in more detail in one university hospital; the results are shown in Figures 3 and 4.

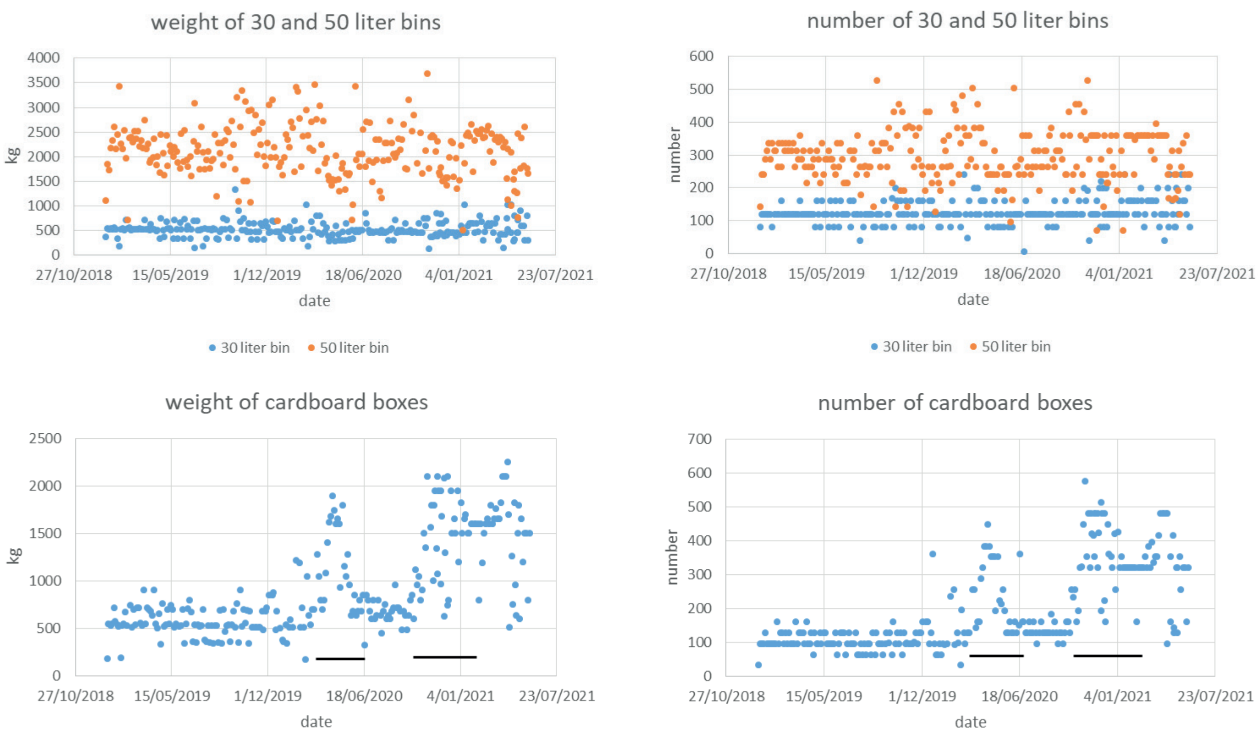

FIGURE 3: Weight (left panel) and number (right panel) of 30 and 50-litre bins (upper panel) and cardboard boxes (lower panel). Each dot represents one transport event from the hospital to the incineration plant. The black lines represent the two COVID-19 waves.

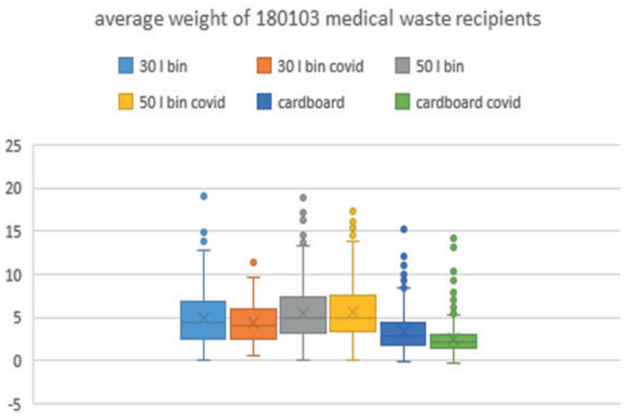

FIGURE 4: B&W plot of the weight of the waste recipients. Significance ($p<0.05$) was obtained for the cardboard containers. The average value of 600-1200 recipients of each type is shown.

The data clearly show that for the 30 and 50-litre bins, the effect of the presence of COVID-19 patients on weight and number of recipients is very limited except for a tendency of the increase in weight of the 50-litre bins during the second wave. The only significant change was a marked increase in the total weight of the cardboard recipient and this increase in weight is mirrored by the increase in the number of recipients leading to a significant increase in total volume. The weight and number of cardboard boxes remain higher in the aftermath of the second wave compared to pre-pandemic figures.

In one hospital, the individual recipients for the 180103* type of waste were weighed during the second wave. The result is shown in Figure 4. The comparison between COVID-19 and non-COVID-19 patients was maintained.

There is no difference in weight between COVID-19 and non-COVID-19 recipients for the solid bins of 30 and 50 litre. The average weight of the cardboard boxes was lower than the weight of the bins and the average weight of the COVID-19-waste containing recipients was significantly lower than the weight of other departments ($p<0.05$).

The observations in individual hospitals are further ascertained by averaging the data on a monthly basis, thereby avoiding the intrinsic variability seen in the first figure, and extrapolating to the total weight of this waste for the whole region of Flanders - Belgium covering about 100 hospitals was analyzed; this is shown in Figure 5.

In 3 university hospitals, the quantity of waste expressed as kg/day/bed was calculated. In 2019 and the years before that, the amount of waste type EWC 180103* was variable depending on the hospital and varied between 0.2 and 1.4. During the subsequent waves of the COVID-19 pandemic, this increased to 5.3, 6.2, and 6.4, respectively. In one hospital, the weight of waste kg/day/bed was monitored during the second wave for two periods of 2 weeks each. On average, 8.5 ± 1.9 and 6.1 ± 2.4 kg/bed/day were found.

The cost of destroying the waste was calculated for 2 partners who delivered sufficient details. The cost during the last 6 months of 2019 was set at 100 %; the results are presented in Figure 6.

This figure is compatible with the information on the quantity of waste. During the first wave, the amount of risk waste was unchanged and consequently, there is no effect on the cost. During the second wave, the quantity of risk waste increased by about 20 % of the control value, and the cost mirrors perfectly this increase to approximately 140 % of the control value.

Additional controls on weight and volume of waste include the registration of residual waste (o.a. packaging materials, plastic bottles, drink cartons….) or green waste. No influence of the pandemic was found (results not shown).

3.2 Is EWC 180103* the correct assignment of the COVID-19-waste?

The results of the PCR assay are shown in Table 2.

Positive samples were found in the room of COVID-19 patients and on materials handled by these patients, such as mobile phones and food trays. Considering the waste recipients, only one weakly positive needle disposal unit was found. Extensive sampling in the waste storage room and at the recycling park on campus yielded no positive results.

4. DISCUSSION

The influence of the SARS-CoV-2 pandemic on societal life is enormous, and long-term negative effects are to be expected (Sarkodie and Owusu, 2020). The initial focus of the biomedical scientific community was evidently on patient care and vaccine development, but it became soon clear that other aspects were affected, in particular environmental and sustainability aspects (Hens and Fraeyman, 2021). Within the broad range of sustainability, interest in medical waste became clear, and alarming messages on the overwhelming and excessive volumes of waste were published both in the scientific and lay press (You et al., 2020, Yang et al., 2021). Over time, this initial panic-like attitude was replaced by a more rational approach (Das et al., 2021) although the available information was still to a large extent contradictory.

The data as presented here are typically highly variable. Furthermore, not all participating hospitals were able to deliver all data for two reasons. The main reason is the overwhelming workload during the COVID-19 waves hindering appropriate engagement to transmit the data. Secondly, it is clear that smaller hospitals in contrast to larger and university hospitals have frequently less developed internal systems for extensive data registration.

The data on the number of both COVID-19 and non-COVID-19 patients are reproducible for all hospitals delivering the data: normal activities were reduced in order to cope with the presumed wave of COVID-19 patients and this reduction is nearly independent of the type of hospital and the number of beds. Consequently, the total number of patients (COVID-19 and non-COVID-19) even decreased during the first wave. During the second wave and in view of the experience gained in the hospitals on how to cope with

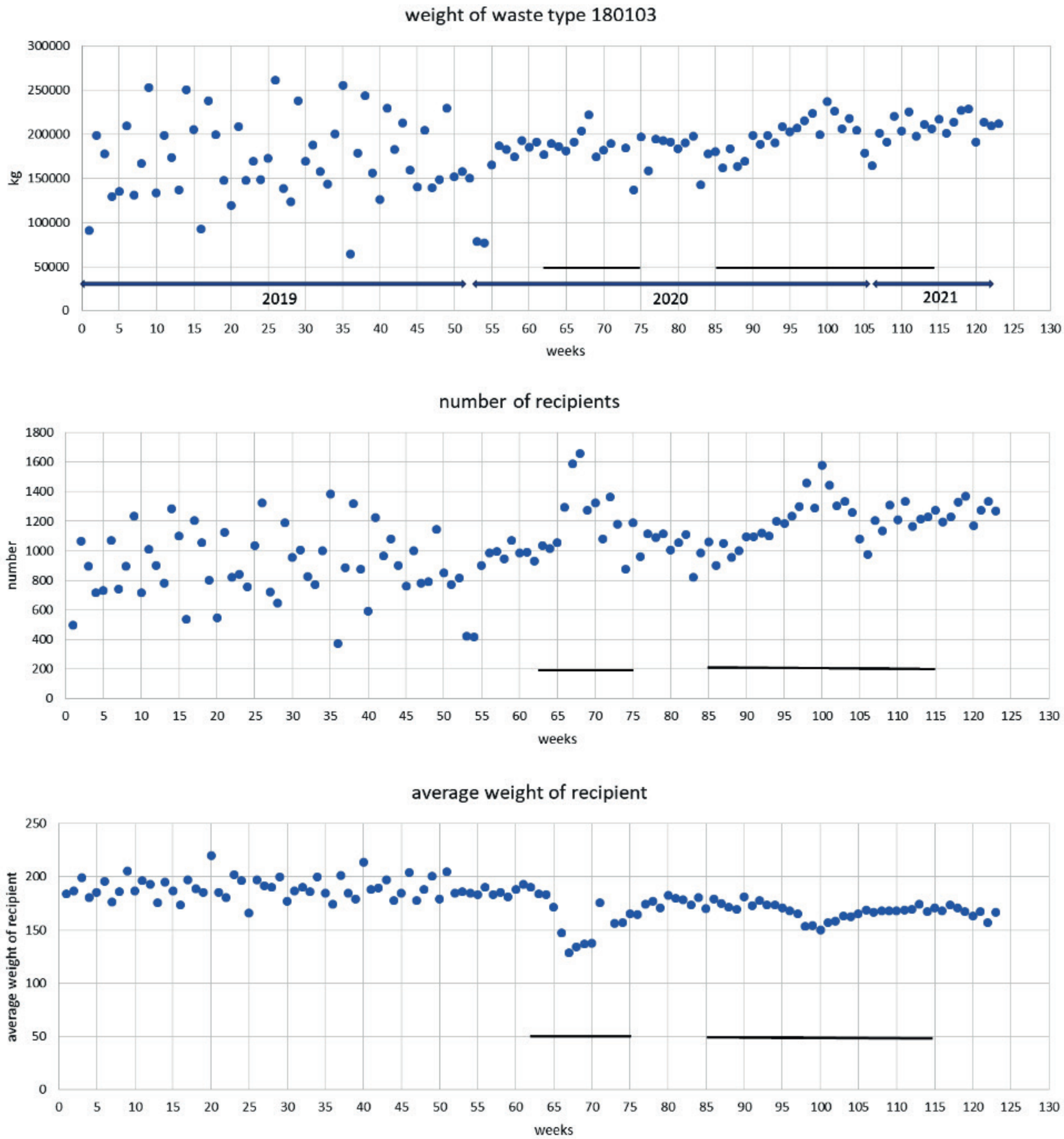

FIGURE 5: Risk waste type EWC 180103* processed at the incineration plant, upper panel: total weight, middle panel: number of recipients, lower panel: average weight of the recipients. X-axis (Time) is expressed in weeks: 2019 from week 1 to 53, 2021 from week 54 to 106, and 2021 from 107 to 123. The black lines represent COVID-19 waves 1 and 2.

the patient flow during the first wave, normal activity was less reduced, resulting in a slightly increased total number of patients. This is highly in contrast to the alarming messages in some countries on the overcrowded hospitals and the pressure on the whole health care system: there is no evidence of an overflow of the hospitals in this study when taking the total number of beds occupied into account. Of note is that at times and particularly during the second wave, the intensive care unit in some hospitals was almost entirely occupied by COVID-19 patients.

The effect of the COVID-19 pandemic on medical waste is more complex than a simple increase in volume and/or weight.

There is a clear difference between the two waves of the COVID-19 pandemic. During the first wave, we found that the total quantity of the EWC 180103* type of waste expressed in kg was virtually unchanged in all hospitals and not different from the situation in 2019. We conclude that the quantity of waste from COVID-19 and non-COVID-19 patients at the level of the individual hospital is in a commu-

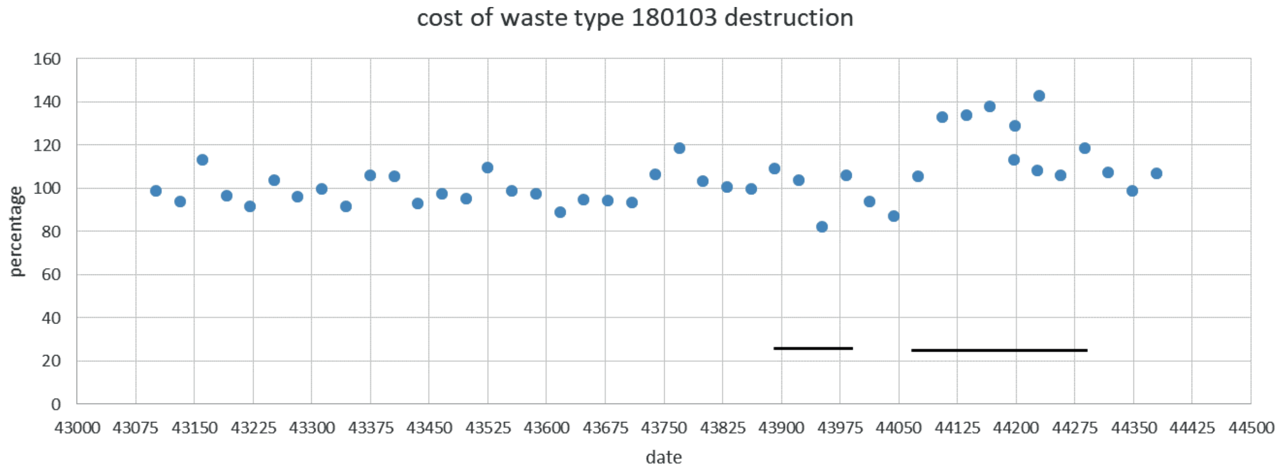

FIGURE 6: Total costs for the destruction of the risk medical waste type EWC 180103*. The average cost for the last 6 months of 2019 was set at 100 %; all other values were calculated as the percentage of the average value. The black lines represent the first and second COVID-19 waves.

nicating vessel system: the reduction of waste because of the reduction of non-COVID-19 patients is compensated by the increase of waste generated by the care for COVID-19 patients. This conclusion is supported by the decrease in weight of non-risk waste (EWC/EURAL 180104) due to the decrease in the number of non-COVID-19 patients which typically produce more non-risk waste, while all the waste from COVID-19 patients was considered as risk-waste.

Although the total quantity of waste within the hospitals remained fairly stable, there is a clear-cut shift in the type of recipient used for transporting the waste showing increased use of cardboard recipients due to the extensive use of personal protection equipment such as gloves, aprons, goggles, and face masks, for treating COVID-19 patients. All of these are lightweight and – mostly not contaminated with blood or bodily excretion products – could be confined to the cardboard recipients. The predominantly lightweight character of COVID-19 waste is convincingly illustrated by the fact that the average weight of the COVID-19 cardboard recipients is significantly lower than that of non-COVID-19 patients. As a consequence, the number of used cardboard recipients increased significantly while the number of 30 and 50-litre bins remained nearly unaltered.

During the second wave, the increase in EWC 180103* type of waste is clear at the level of the region but less obvious for the individual hospitals. The main reason is that many hospitals in the region changed the protocol during or immediately after the first wave because of the growing shortness of the plastic material bins; hence, the waste was no longer considered as category 180103* but as category 180104 eventually including a limited time (72 hours) for quarantine of the waste before destruction. It is clear that this change was less motivated by knowledge of the risks of infection caused by the waste but for logistic reasons. While during the first wave, the numbers of COVID-19 patients and non-COVID-19 patients were in balance as far as the production of waste is concerned, in the second wave, both types of patients were no longer balanced and an in-

TABLE 2: Results of the analysis of SARS-CoV-2 RNA on different inanimate objects. The results are expressed as positive (P) with CT < 20, or negative (N) with CT > 30. CT values between 20 and 30 were considered weakly positive. The number of samples for the control patients and for the COVID-19 patients is 1 for each of the objects mentioned in the table. Otherwise, the number of samples is indicated.

Room, location	samples	Positive (P) or negative (N) PCR test
Room of a non-COVID-19 patient	Mobile phone, food tray, door handle, patient handset, washbasin	N
Room of COVID-19 patient 1	Food tray, washbasin, door handle, table, patient handset, waste recipient, window	N
	Mobile phone, floor	Weakly Positive
Room of COVID-19 patient 2	Patient handset, floor, waste recipients	P
	Mobile phone, food tray, washbasin, door handle, table trapeze bar	Weakly positive
Personal protection material after use	Aprons (n=11), masks (n=6), gloves (n=11)	N
Waste storage room in COVID-19 ward	All filled recipients: plastic bins (n=7), cardboard boxes (n=7), plastic bags (n=14)	N
Hallway and service rooms in COVID-19 ward	Door handle, sharps container (n=1)	N
	Floors (n=5)	P
Waste recycling park in the hospital	All waste recipients from the COVID-19 ward (n=15)	N
	All waste recipients from non-COVID-19 wards (n=9)	N

crease in waste was observed. The cost for waste destruction is compatible with this evolution although most of the increase is due to costs of logistics, sub-optimal transport due to increased volume, costs of extra bins, etc. The cost for incineration in EUR/kg is unchanged.

All data indicate that more waste is generated through the care of COVID-19 patients compared to other patients. This is obvious from the figures obtained from 3 university hospitals and amounts to between 5 and 8 kg/day/bed. This is significantly higher than the normal historical value obtained in control conditions (between 0.2 and 1.4 kg/bed/day). Literature data indicate similar figures : (all in kg/day/bed) 3.4 (Haque et al., 2021), 3.64 and 2.7 (Yang et al., 2021) and 3.95 (Abu-Qdais et al., 2020). The abundant use of personal protection equipment when taking care of COVID-19 patients is obviously the main reason for this difference.

Numerous alarming messages on the possibility that medical waste from COVID-19 patients should be considered as a transmission route for the virus were spread through scientific literature and the lay press. Reports on the survival of the virus on different surfaces gave additional way to concern (Bedrosian et al. 2021, Cheng et al., 2020, Hoseinzadeth et al., 2020, Huraimel et al., 2020, Kampf et al., 2020, Pastorino et al., 2020, Peng et al., 2020, Ren et al., 2020, Van Doremaelen et al., 2020; Wang et al., 2020). Mobile phones were identified as a possible pathway for microbial transmission (Olsen et al., 2020). The dependency on environmental conditions of the infectivity of SARS-CoV-2 and of other coronaviruses present on surfaces was demonstrated (Bueckert et al., 2020). However, most of these studies are done under experimental laboratory conditions with high virus loads and optimal environmental conditions of humidity and temperature. It is to be expected that the real, in-hospital conditions are far from the optimal experimental conditions; hence the reliability of the above-mentioned results is questionable as shown by others (Ben-Shmuel et al., 2020, Cheng et al., 2020, Goldman, 2020, Huang et al., 2020, Hororo et al., 2020, Ong et al., 2021, Meyerowitz al., 2020, Shah et al., 2021, Wei et al., 2020). Our results confirm the latter observations: nearly all surfaces touched by the patients are positive – as expected – but except for one tray in the room of a patient which was slightly positive, all surfaces of waste recipients were negative. During sampling, care was taken to mimic worst-case scenarios i.e. circumstances in which most chance for infection would occur: the patients in the room were diagnosed with COVID-19, the CT-value was low (below 20) suggesting the presence of active virus, samples were taken in different locations in the COVID-19 ward including the waste collection room where waste is stored after providing medical care to the patient. Samples at the recycling park were taken upon arrival at the park of the waste from the COVID-19 ward. We clearly demonstrated that no contamination with SARS-CoV-2 RNA was found on the surface of any of the waste recipients manipulated at the recycling park of the hospital. This indicates that the viral RNA does not survive very long on these surfaces and even the one slightly positive sample found in the room of the patient has apparently no consequences. Even more important, none of the personal protection material, used in close contact with the patients, was positive. A similar finding has been published before (Ong et al., 2020, Huang et al., 2020). We believe that in real-life conditions, these materials are not able to retain any RNA on their surfaces. Two important restrictions are to be made. The RT-PCR test only provides evidence for the presence of SARS-CoV-2 RNA (Ben-Shmuel et al., 2020). Hence, a negative PCR test is meaningful, a positive PCR test reveals the presence of RNA but does not distinguish between viable and non-viable viruses. However, Mondelli et al. (2021) demonstrated that SARS-CoV-2 RNA recovered from a positive swab was unable to grow on Vero E6 cells, demonstrating that these fomites are unable to infect people. Until now and to the best of our knowledge, no case of transmission of SARS-CoV-2 through waste has been documented, which is compatible with our findings. Secondly, our conclusions are valid for the virus-RNA species that were the dominant infectious variants at that time, In theory, extrapolation of our conclusions to other variants e.g. the actual dominant infectious omicron variant should be done cautiously. However, no data are available on the variants which might suspect a difference in virus-surface interactions, As discussed in extenso by Castano et al. (2021), the most important physicochemical characteristic of the viruses in relation to virus-surface interaction is the presence of the viral envelop which is likely to be comparable for all coronaviruses. Hence, it can be expected that the properties of the virus particles from different variants of the SARS-CoV-2 related to survival outside the patients on the surface of innate subjects are less affected compared to e.g. capacity to infect people.

5. CONCLUSIONS

In conclusion, the dependency of the quantity and volume of medical waste on the COVID-19 pandemic is complex and dominated by the balance between the number of COVID-19 and non-COVID-19 patients. The shift from EWC type 180103* to 180104 waste is plausible because we provided additional evidence that SARS-CoV-2 RNA is absent at the surface of all waste recipients investigated, and that waste originating from the care for COVID-19 patients, in particular the personal protection equipment, is likely to be of the EWC/EURAL type 180104.

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