

Please cite the Published Version

Filho, Walter Leal, Voronova, Viktoria, Kloga, Marija, Paco, Arminda, Minhas, Aprajita, Salvia, Amanda Lange, Ferreira, Celia Dias and Sivapalan, Subarna (2021) COVID-19 and waste production in households: A trend analysis. *Science of the Total Environment*, 777. p. 145997. ISSN 0048-9697

DOI: <https://doi.org/10.1016/j.scitotenv.2021.145997>

Publisher: Elsevier

Version: Accepted Version

Downloaded from: <https://e-space.mmu.ac.uk/629982/>

Usage rights:  [Creative Commons: Attribution-Noncommercial-No Derivative Works 4.0](https://creativecommons.org/licenses/by-nc-nd/4.0/)

Additional Information: This is an Author Accepted Manuscript of an article published in *Science of the Total Environment*, by Elsevier.

Enquiries:

If you have questions about this document, contact openresearch@mmu.ac.uk. Please include the URL of the record in e-space. If you believe that your, or a third party's rights have been compromised through this document please see our Take Down policy (available from <https://www.mmu.ac.uk/library/using-the-library/policies-and-guidelines>)

1 **COVID-19 and Waste Production in households: a trend analysis**

2 **Science of The Total Environment**

3 **Volume 777, 10 July 2021, 145997**

4 **<https://www.sciencedirect.com/science/article/abs/pii/S0048969721010640?via%3Dihub>**

5 **b**

6
7 Walter Leal Filho ¹, Viktoria Voronova ², Marija Kloga ², Arminda Paço ³, Aprajita Minhas ⁴,
8 Amanda Lange Salvia ⁵, Celia Dias Ferreira ⁶, Subarna Sivapalan ⁷

9 1. European School of Sustainability Science and Research, Hamburg University of Applied
10 Sciences, Germany & Department of Natural Sciences, Manchester Metropolitan University,
11 Chester Street, Manchester M1 5GD, UK. E-mail: walter.leal2@haw-hamburg.de.

12 2. Tallinn University of Technology, Department of Civil Engineering and Architecture,
13 Ehitajate tee 5, 19086, Tallinn, Estonia, tel. +3726202506, e-mail:
14 viktoria.voronova@taltech.ee

15 3. Universidade da Beira Interior, Núcleo de Estudos em Ciências Empresariais (NECE
16 UBI), Rua Marquês d'Ávila e Bolama, 6201-001, Covilhã, Portugal Email: apaco@ubi.pt

17 4. European School of Sustainability Science and Research, Hamburg University of Applied
18 Sciences, Germany E-mail: Aprajita.minhas@haw-hamburg.de.

19 5. Graduate Program in Civil and Environmental Engineering, University of Passo Fundo,
20 Campus I-BR 285, São José, Passo Fundo, RS 99052-900, Brazil. Email:
21 amandasalvia@gmail.com

22 6. Universidade Aberta, Department of Sciences and Technology, Lisbon, Portugal CERNAS
23 - Research Center for Natural Resources, Environment and Society, Coimbra, Portugal. E-
24 mail: celia.ferreira@uab.pt

25 7. Centre for Social Innovation, Institute for Self- Sustainable Building, Universiti Teknologi
26 PETRONAS,32610 Bandar Seri Iskandar, Perak Darul Ridzuan, Malaysia. e-mail:
27 subarna_s@utp.edu.my

28 Corresponding author: Aprajita Minhas⁴ (Aprajita.minhas@haw-hamburg.de)

29

30 **Abstract**

31

32

33 Apart from the health aspects and the high death toll, the COVID-19 pandemic has, since its
34 official recognition in March 2020 caused many social and economic problems. It has also led
35 to many environmental ones. For instance, the lockdowns have led to higher levels of
36 consumption of packaged products, and of take-away food.

37 This paper reports on an international study on the increased consumption and subsequent
38 changes in the amounts of waste produced since the COVID-19 pandemic. The results show
39 that 45-48% of the respondents observed an increased consumption of packed food, fresh
40 food, and food delivery. One of the main reasons for the increased waste generation during
41 the lockdown was the fact that people have spent more time at home. In addition, increases
42 of 43% and 53% in food waste and plastic packaging. Drawing from comparisons on the
43 amount of domestic waste produced before and during the pandemic, the findings suggest
44 that some specific types of municipal waste have visibly increased, putting additional pressure
45 on waste management systems. This characterises one of non-intended effects of the COVID-
46 19 pandemic. The results from this study provide useful insights to city administrations and
47 municipal utilities on consumption patterns during emergency situations. This, in turn, may
48 support more systemic and strategic measures to be taken, so as to curtail the increase of
49 household waste during pandemic situations.

50

51 **Keywords:** COVID-19, Waste generation, Waste management, Households waste,
52 International wide.

53

54 **1. Introduction:**

55 The novel 2019 coronavirus first emerged in December 2019 in Wuhan, China. It was not until
56 January 2020 that researchers distinguished and classified the virus from ordinary pneumonia
57 (Chen et al., 2020). The virus is easily transmitted through droplets released from an infected
58 individual's mouth or nose (Chen et al., 2020). Due to the easy transmission of COVID-19, the
59 virus soon spread to other parts of the world, with international travel accounting for the largest
60 percentage of the spread (Gössling et al., 2021). In March 2020, the World Health
61 Organisation classified COVID-19 as a pandemic (WHO, 2020a). The virus's epicentre shifted
62 quickly from China to Europe and, after that, to the United States of America (WHO, 2020b).
63 The highest number of confirmed cases were recorded in South Africa within the African
64 continent, and this number rose rapidly as winter arrived (WHO, 2020c). The increase in cases
65 in the southern hemisphere and the drop in increases in some countries in the northern
66 hemisphere are attributed to seasonal patterns. COVID-19 has been shown to spread more
67 quickly in colder temperatures than warmer temperatures (Poole, 2020). Since the outset of
68 the pandemic in early 2020, the world has experienced a so-called "second wave" in early
69 2021, whereby the virus -and the mutant variations- have widely spread across the world.

70

71 The onset of the pandemic posed many global challenges, especially in the health sector. The
72 influx of patients requiring hospital facilities and ICU spaces placed a significant burden on
73 healthcare systems (Remuzzi & Remuzzi, 2020). Many countries were forced to intensify
74 procuring procedures for additional medical resources, PPE, equipment, and hospital beds
75 (Ranney et al., 2020), whereas other countries that had treaty agreements in place were
76 forced to break such agreements and ration their medical resources for themselves (Anderson
77 et al., 2020).

78 Apart from this, most countries put in place several lockdown regulations, causing many
79 businesses to reduce the scope of their activities, or to simply close. In many instances,
80 companies have had to retrench workers or place staff on short work hours (Parolin & Wimer,
81 2020). This has caused an increase in the unemployment rate in many countries (Bonaccorsi
82 et al., 2020). In other cases, lockdown regulations have included international travel bans,
83 which have caused substantial losses to the tourism industry and- since it contributes
84 significantly to the economy of many countries- to a GDP decrease in countries around the
85 world (African-Union, 2020; Ozili, 2020).

86 Apart from the health sector, the most severe effects of the pandemic were felt in households
87 and day-to-day life. The lockdowns and the social distancing associated with them, have
88 resulted in widespread job losses (Kawohl & Nordt, 2020). Aside from this trend, many
89 breadwinners in the families have been infected or have lost their lives due to the virus, further
90 diminishing income. The mental health of individuals who anticipated -or faced- financial
91 constraints during the pandemic has also deteriorated, causing an increase in suicide rates
92 (Bhuiyan et al., 2020). In all, the pandemic has caused numerous people and households to
93 be plunged into poverty, thus increasing the poverty rate in many countries, especially in
94 developing nations (Singh, 2020).

95 More specifically, the lack of -or substantially reduced- income has threatened the food
96 security of millions of households. The lack of food compromises human health and makes
97 people more susceptible to contracting the virus (Devereux et al., 2020). Studies have shown
98 that household spending has increased by at least 50% despite the dwindling income. This
99 has been attributed to people attempting to stockpile food at home. In contrast, a sharp decline
100 in spending related to luxuries and travel (including public transportation) was also observed
101 (Baker et al., 2020).

102 Aside from this, many schools have shut down due to lockdowns. Wealthier families have had
103 the privilege of home-schooling their kids or using online learning tools. In other cases, more
104 impoverished families are unable to provide the same benefit to their children, leading to
105 inequalities in education systems as a result of lack of infrastructure and connectivity (Owusu-

106 Fordjour et al., 2020; Sahu, 2020). A recent study has shown that the closure of schools and
107 day-care facilities as a result of the pandemic, has severely affected working mothers and has
108 contributed to gender inequalities (Alon et al., 2020). Most working mothers form part of the
109 workforce, and have had their work impaired by the pandemic. In some cases, unemployed
110 fathers are now taking responsibility for children's primary care, which is defying social norms
111 in certain countries. This is not always possible, as some fathers do not have flexible work
112 arrangements (Alon et al., 2020). Apart from the health aspects and the high death toll, the
113 COVID-19 pandemic has caused many social and economic problems since it was officially
114 classified as a world issue in March 2020. It has also led to some environmental ones. For
115 instance, the lockdowns have led to higher consumption levels of packaged products and
116 containers from take away food. In this context, the objective of this paper is to report on the
117 increased consumption and subsequent changes in the amount of several types of household
118 waste produced in an adverse context - the COVID-19 pandemic. Its novelty lies on the fact
119 that this is an international study which investigated several types of household waste
120 production across a number of different countries.

121 **2. COVID-19 and Consumption**

122 According to World Health Organisation (WHO), the Americas, Europe, and South-East Asia
123 have been reported as the most affected regions in absolute numbers of confirmed cases of
124 COVID-19 (WHO, 2020d), as of November 24, 2020. France, Russia, Spain, United Kingdom,
125 Italy, and Germany have been confirmed to be the most impacted countries by COVID-19 in
126 Europe. The measures are taken to prevent and control the spread of COVID-19 had
127 numerous effects on the food supply, eating behaviour , and dietary practices of millions of
128 people worldwide.

129 According to the European Field Marketing Partners report (EFMP, 2020), some key stages
130 in consumer behaviour linked to COVID-19 can be identified, as people moved from
131 awareness about COVID-19 to physical restrictions and final lockdown in March 2020.
132 Regarding food purchase and consumption, two main stages can be highlighted. The first
133 stage is buying food in bulk or panic buying. At the beginning of the pandemic, the

134 understanding of the virus and its consequences was limited, and people started to make
135 provision of food, sometimes in inadequate large amounts, to mitigate future risks of food
136 shortage. Such a situation was observed throughout different countries in the world. For
137 example, 84% of respondents in Norway reported that they purchased extra dry goods, 38%
138 reported buying additional canned goods, and 37% - extra frozen food due to the COVID-19
139 outbreak (Statista, 2020).

140 Similarly, in other countries in Europe and the USA, frozen and packaged food purchases
141 have increased since March 2020, as people preferred to buy long lasting food products.
142 According to market research data (Morrison, 2020), customer behaviour has rapidly changed
143 during the first wave of COVID-19. Packed food sales in Italy have peaked by March 15,
144 making 33,8% in comparison with a year ago. In France and the UK, the packed food demand
145 continued to grow and reached the highest values by March 22, 49,8% and 69,6 %. In the
146 USA, the rapid increase of packed food sales from 10 % to 76 - 77 % was observed within the
147 first two weeks in March 2020 (Morrison, 2020).

148 A similar tendency with growing customer demand was seen in the frozen food sector. The
149 highest demand was observed in the USA and the UK with 92,7% and 84,4 % respectively
150 versus a year ago. In Italy, frozen food demand started to stabilize after March 15 and reached
151 36,7% by March 22. In France, the steady growth of customer demand for frozen food was
152 observed from 8 to March 22 (Morrison, 2020). Buying food in bulk was observed in many
153 other countries. Thus, in Vietnam, 38% of respondents reported that they had been engaged
154 in panic buying, purchasing mainly dry food such as rice, noodles, pasta, and flour (Statista,
155 2020).

156 During the second wave of COVID-19 pandemic in autumn and winter 2020, panic buying
157 was not an issue for most people since the fear of merely running out of food has receded. The
158 second stage, when analyzing consumer behaviour linked to COVID-19, is living in
159 quarantine. During this period, people were getting used to living in their new reality and
160 making less impulsive and irrational purchases. Going to restaurants or quick-service
161 restaurants was restricted, and people started to cook more meals at home. Thus, according

162 to Bracale and Vaccaro (2020), people began to buy more pasta, flour, eggs, long-life milk,
163 frozen foods, and less fresh food during Italy's quarantine. The sales of snacks have dropped
164 in relation to homemade bread, pizza, and cakes.

165 During the quarantine period, online grocery shopping and food delivery increases while the
166 store visits decrease. According to market research made by McKinsey & Company (2020) in
167 October 2020, customers purchasing online in the "Food takeout and delivery" category has
168 grown by 15-29% in the USA, Italy, and Japan. As of May 31, 16% of respondents in Germany
169 and 19% in the UK stated that they had preferred restaurant delivery/takeaway online instead
170 of offline shopping. Besides, 10% of respondents in Germany and 30% in the UK reported that
171 they had chosen food and drink delivery (e.g., from the supermarket) instead of going to the
172 stores (Statista, 2020). In Vietnam, more than 58% of respondents reported that they
173 purchased more online during the COVID-19 outbreak (Statista, 2020).

174 The increase of online food purchase and restaurant delivery means the growth of packaging
175 since it has been hailed as a key to ensure health and safety for the customers during the
176 pandemic. According to some estimations, e-commerce and takeaway service are expected
177 to continue growing alongside packaging materials (Felton, 2020). In addition to physical
178 changes in lifestyle, many people have experienced negative emotions like depression, stress,
179 and fear about COVID-19. These negative emotions could lead to overeating, the so-called
180 "emotional eating," particularly junk food. Thus, more than a third of consumers reported that
181 they purchased more of alcohol and snack because they required it more during social
182 distancing measures in the United States in 2020 (Statista 2020). In Italy, more than 34% of
183 respondents have reported that they had increased appetite, and more than 48% of the
184 population had the perception of weight gain (Di Renzo et al., 2020).

185 It can be concluded that COVID-19 has a significant impact on people's consumption
186 behaviour around the world. Consumption patterns of the people changed to more practical
187 during lockdown; however, it could sometimes lead to overeating. People preferred to buy
188 products with long shelf life, such as packed or frozen food. Home delivery and takeaway
189 sales have also increased since the COVID-19 outbreak.

190

191 **3. Methodology**

192 The study employed a quantitative research methodology. The data collection was carried out
193 with the help of a survey, which was developed by the research team. The survey items were
194 developed based on an extensive review of the international literature, including reports and
195 public documents, around the subject matter of the production of waste within households
196 (e.g. Devereux et al., 2020; Ikiz et al., 2021; Jribi et al., 2020) during the onset of the COVID-
197 19 pandemic. The final version of the survey contained three sections, namely Section 1:
198 Demographic Information, Section 2: Level of Consumption, and Section 3: Waste Generation
199 and Management. Section 1 contained 11 items, while Sections 2 and 3 had 7 items and 11
200 items.

201 Before finalizing the survey for data collection, an expert validation exercise was conducted to
202 determine the suitability of the items developed. A total of five international experts in the area
203 of sustainable consumption and production, waste management and recycling, environment
204 and sustainability, and public health provided feedback to the items in the survey. Some of
205 highlights from the expert validation exercise are as listed below:

- 206 1. Adjustments in the number of sections and items within each section
- 207 2. Fine-tune of the suitability of some of items related to the research aims. The survey
208 was designed to identify the increases in consumption and changes in waste
209 production since the pandemic. A few questions were modified in section 2, so as to
210 cater for a better understanding of the extent of waste products such as packed food,
211 fresh food (e.g. fruits and vegetables), online or takeaway food others. The goal was
212 to identify whether they increased, decreased, or if no changes were observed.
213 Following a recommendation by the panel of experts, more options were added in the
214 questions related to increased waste production, and about waste segregation.

215

216 Upon addressing the feedback from the expert validation process, and in order to ensure the
217 validity of the data, a pilot study (i.e. a pre-test) was conducted with six respondents. The pilot

218 study's findings revealed that the survey instrument was adequate, with minor changes. Both
219 steps (i.e. the validation with experts in the area and pilot application with additional
220 respondents) ensured the validity and reliability of the data collection instrument The finalized
221 survey items were then transferred into a Google Form. Using a purposive sampling approach,
222 combined with techniques such as snowballing and chain referrals, the link to the on-line
223 survey instrument was then shared with a global audience via the research team, the networks
224 of the European School of Sustainability Science and Research, and via , the Inter-University
225 Sustainable Development Research Programme (IUSDRP). Data collection was carried out
226 from August 2020 to November 2020. In accordance with research ethics protocols,
227 respondents were informed that their participation in the study was voluntary. Participants
228 were informed that the answers they provided would be treated with the strictest confidence,
229 and the protection of their personal data will be upheld at all times.

230

231 **4. Results and Discussion**

232 4.1 Demographics

233 The survey resulted in a total of 204 responses. Participants of the study originated from 23
234 countries, namely Portugal, Italy, Germany, Brazil, Estonia, United States, Australia, Canada,
235 Singapore, United Kingdom, Denmark, Spain, Poland, Finland, Bangladesh, Argentina, Chile,
236 Ireland, New Zealand, Japan, Malaysia, Indonesia, and Vietnam. 61.6% of the respondents
237 were male, while 37.4% were female. The balance 1% of respondents preferred not to disclose
238 their gender.

239 In terms of the respondents' age distribution, those between the ages of 31 and 40 made up
240 the largest pool of respondents, with 36% of the total. This was followed by respondents
241 between the ages of 21-30 years of age at 30%. Respondents between the ages of 41 to 50
242 were the third largest group of respondents totalising 15.3%, followed by those within the 15-
243 20 age group, with 8.9%. 7.4% of the respondents were from the ages of 51-60, while those
244 from the age group of 61 and over were the least represented in the survey, accounting for
245 2.5% of the total number of respondents. In terms of the level of education, the majority of the

246 respondents have post-graduate qualifications. This group makes up 61.4% of the total
247 number of respondents. This is followed by graduates at 33.2%. The remaining respondents
248 were made up of those with qualification at high school or under.

249 Respondents of the survey are made up of many occupation levels, including upper
250 management, middle management, junior management, administrative staff, trained
251 professionals, skilled laborers, consultants, temporary employees, and the self-employed
252 partners in a business, students, retirees, and the unemployed. They thus represent a variety
253 of social sectors and income levels. Trained professionals and students made up two of the
254 largest respondent groups at 24.3% each, while the unemployed made up the least, with a
255 total respondent rate at 2.5%. The majority of respondents' net monthly household income
256 was €500 - €1000 at 20.9%, while the 19.9% of respondents who preferred not to disclose
257 their monthly household income made up the second-largest respondent group. Interestingly,
258 19.9% of respondents had also chosen not to reveal their monthly household income.

259 The majority of respondents, namely 81.9%, live in urban areas, with 40.8% of them living in
260 flats and 32.8% and 17.4% of them living in detached houses and semi-detached houses.
261 Most households have two adults and children less than 18 years of age. At the height of the
262 COVID19 pandemic, 55.7% of respondents were in partial lockdown, 37.4% in full lockdown,
263 and 6.9% not in lockdown. When responding to the survey, 71% of the respondents were not
264 experiencing lockdown, 25.3% were in partial lockdown, while the remaining respondents
265 were in full lockdown.

266

267 4.2. Level of Consumption and Waste Generation

268 The respondents were then asked about their consumption of packed food, fresh food such
269 as fruits and vegetables, online or takeaway food during the lockdown between March and
270 June 2020, and any changes in the amount of waste generated. Table 1 shows the summary
271 and extent of consumption and waste generation for the sample.

272

273 *Table1. Summary of Consumption and Waste generation*

<i>Consumption and Waste generation</i>		Responses (%)	Distribution of responses (%)				
			Blanks	Up to 10%	Between 10%- 20%	Between 20%- 30%	Over 30%
Packed Food (N=204)	No change	40%	100%	-	-	-	-
	Yes, it has increased	48%	0%	37%	33%	14%	15%
	Yes, it has decreased	12%	8%	12%	36%	32%	12%
Fresh food (N=203)	No change	36%	100%	-	-	-	-
	Yes, it has increased	45%	1%	22%	37%	23%	17%
	Yes, it has decreased	18%	0%	46%	41%	11%	3%
Food Delivery (N=204)	No change	39%	100%	-	-	-	-
	Yes, it has increased	46%	0%	33%	32%	16%	18%
	Yes, it has decreased	16%	0%	22%	19%	19%	41%
Waste generation (N=204)	No change	21%	100%	-	-	-	-
	Yes, it has increased	55%	3%	36%	35%	16%	10%
	Yes, it has decreased	11%	5%	27%	50%	14%	5%
	Don't know	13%	100%	-	-	-	-

274

275 Table 1 shows that 45%-48% of the respondents observed increased consumption of packed
276 food, fresh food, and food delivery during the pandemic. About 36-40% of respondents
277 experienced no change, and 12-18% experienced decreased consumption. In terms of waste
278 production, more than half of the sample (55%) indicated an increase in waste generation
279 during the lockdown period. Most of the increase or decrease in consumption or waste
280 generation is between 10% and 20%, as shown in Table 1. As stated by Morrison (2020),
281 according to market researchers, frozen and packed food purchases increased due to panic
282 buying, as consumers stocked their home with long-lasting food). Sharma et al. (2020) have
283 also reported an increased demand for food delivery options and a consequent increase in
284 waste generation, especially of plastic products.

285 Respondents were also asked about the reasons for the potential change in a waste
286 generation. Figure 1 summarises the results, pointing out a balanced distribution of responses
287 across the provided options. Other responses include less socialization, eating at home
288 instead of going out, using masks, and having children at home instead of nurseries, for
289 example, which leads to an increase in cooking activities and therefore in waste generation.
290 All these reasons relate to common causes explored by other authors: the stay-at-home

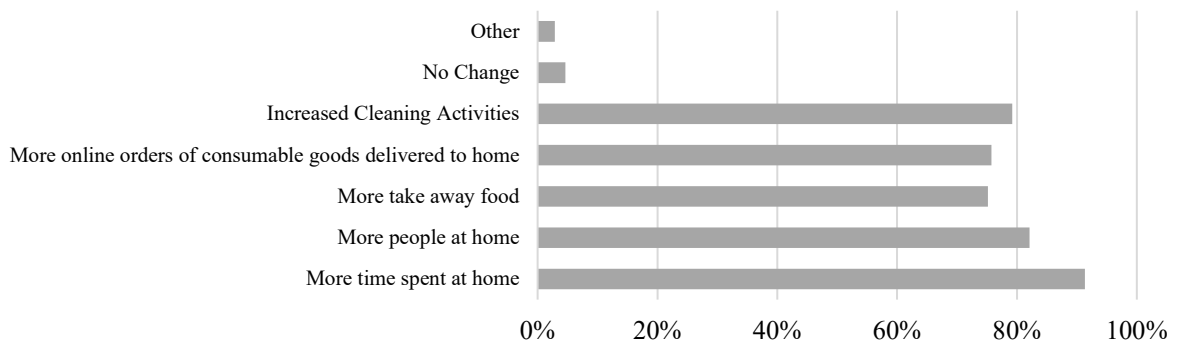
291 policies and preventives measures against COVID-19 (e.g., increased consumption of masks,
292 gloves, toilet papers, food delivery) (Ikiz et al. 2021; Sarkodie & Owusu, 2020)

293

294

295

296 *Figure 1. Reasons for change on waste generation during the lockdown (N=173)*

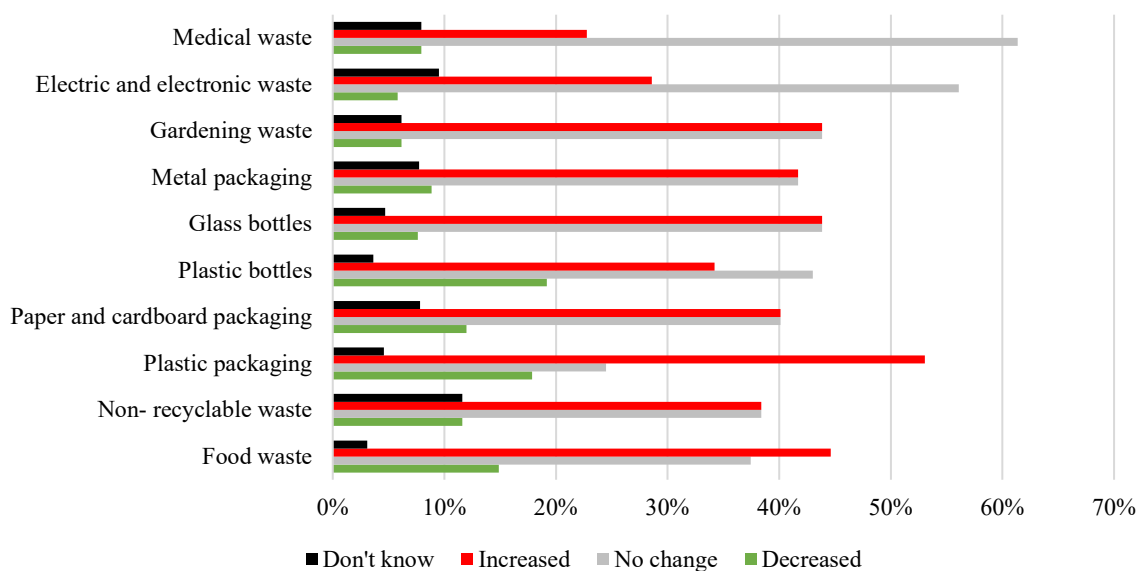


297

298

299 Figure 2 summarises the results of the change in types of waste generated during the
 300 lockdown. The highest increase was observed for plastic packaging and food waste (53% and
 301 45%, respectively). Other types of packaging (e.g., metal, paper) and glass bottles, and
 302 gardening waste, are also among the items with a higher percentage of increased generation.
 303 Most respondents also reported no change in waste generation, with higher medical and
 304 electronic waste rates, for example.

305 *Figure 2. Change in types of waste generation during the lockdown*



306

307 Explicitly focusing on food waste, the respondents were asked to rank the necessary
 308 household items discarded during the lockdown (from 1 the least to 5 the most discarded).
 309 Table 2 presents the average per item, with the most discarded items, including fruits and
 310 vegetables (2.63) and the least discarded potatoes (1.08). In March 2020, more consumption
 311 and purchase were reported in Italy for Bread (180.7%), yeast (189.6%), and cereals/grains
 312 (131.4%). Moreover, the UK reported an increased consumption of canned meat (143%).
 313 Similarly, the purchase of dried potato products increased in Germany by 202% (Morrison,
 314 2020). Ikiz et al. (2021) and Jribi et al. (2020) reflect that although the lockdown led to an
 315 overall increase in food waste, in some contexts decreases may be possible, in respect of
 316 eating less food or increasing the re-use of leftovers.

317 *Table 2: Ranking of items most discarded during the lockdown (1 - the least; 5 - the most)*

Item	Average	Standard Deviation
Fruits/ Vegetables	2.63	1.42
Meat	2.25	1.35
Dairy Products	2.18	1.29
Bread	2.16	1.24
Fish/Seafood	2.14	1.26
Ready-made meals	2.05	1.26
Canned Food	1.99	1.20
Milk	1.97	1.29
Cereal/grain products	1.96	1.19
Potatoes	1.8	1.08

318

320 Table 3 presents the responses to a set of questions related to regulations for waste
 321 separation by the local city council, existence of different litter bins to separate waste at home,
 322 and efforts to segregate waste. In case more changes in waste regulations have been applied,
 323 the sample might not have been aware or noticed any difference (49%), whereas 57% of the
 324 sample indicated changes in this aspect. Regarding household efforts, it was possible to
 325 observe that the separation of waste is still a topic that deserves further measures, as almost

326 half the sample indicated a negative response. Just a third of the sample (32%) indicated they
 327 have increased their efforts to segregate waste properly during the lockdown.

328

329 *Table 3. Questions and responses related to Waste Management*

Question	Response options (%)		
	Yes	No	Don't know
Have local council regulations been changed in your city/district/area in terms of household waste separation during the lockdown? (N=204)	19	57	49
Do you use different bins for the separation of household waste (e.g. black waste for general waste, green bin for fruits/vegetables, etc)? (N=202)	55	45	-
Have your efforts to segregate waste (organic and recyclables) changed in your household during the lockdowns? (N=204)	Yes, they decreased 4	No change 64	Yes, they increased 32

330

331 The respondents were also asked about sustainable packaging purchases (e.g., reusable
 332 packaging, biodegradable packaging), where 30.9% agreed that they always look for
 333 sustainable packaging options. About 47.5% of respondents practice that occasionally, and
 334 20.6% stated that they never look for sustainable packaging options while buying food online.

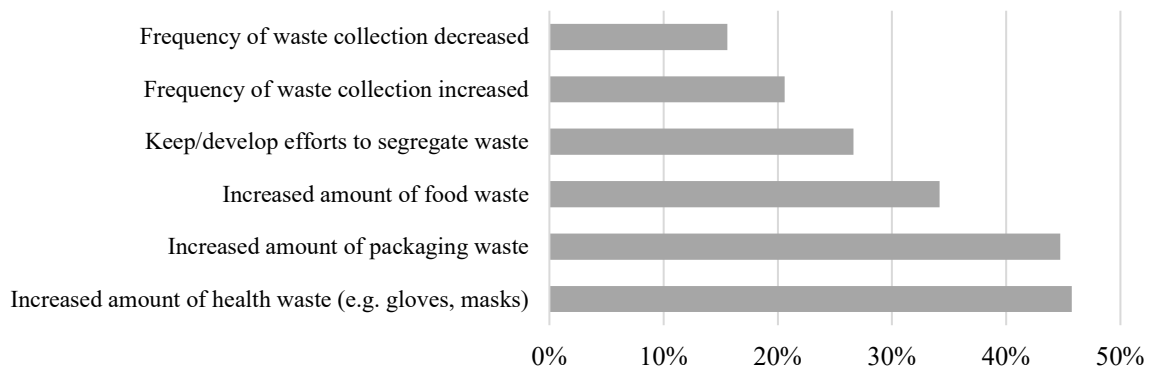
335

336 *4.3. Challenges, outcomes, and measures for waste management*

337 The COVID-19 pandemic resulted in challenges and impacted waste management in various
 338 ways. For instance, in connection with changes in the amount of waste produced, changes
 339 were seen in connection with disposal rates in households, changes in waste composition,
 340 and shifts in waste distribution (Fan et al., 2021). Figure 3 presents the main challenges
 341 regarding waste management at households during the lockdown. The highest percentages
 342 (45% of the respondents) were associated with an increased amount of health and packaging
 343 waste. A study by Fan et al. (2021) also reported increased plastic waste production, and that
 344 online meal delivery increased by 73% during the pandemic in Singapore.

345

346 *Figure 3. Main challenges regarding waste management at households during the lockdown*
 347 *(N=199)*

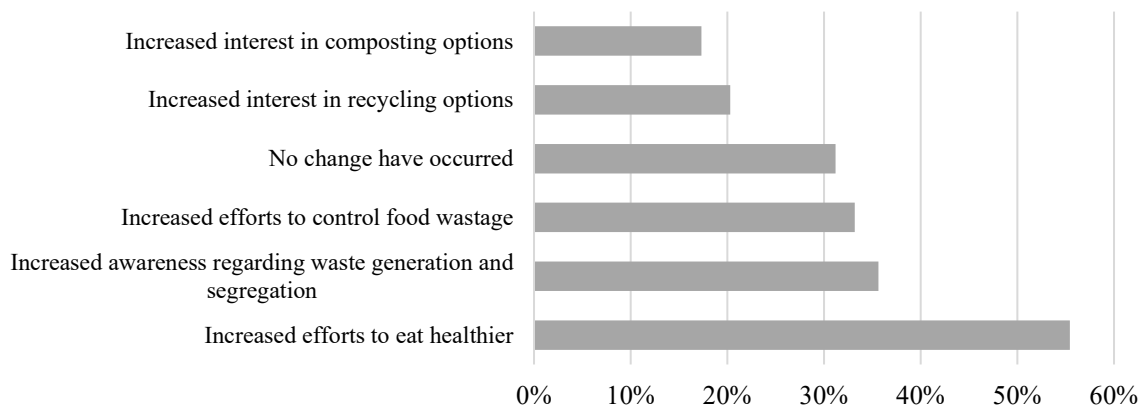


348

349

350 Respondents were also argued about possible positive implications of the lockdown to their
 351 households (Figure 4). 55% of the respondents indicated increased efforts to eat healthier,
 352 followed by efforts related to implement waste separation and prevent food wastage (36% and
 353 33%, respectively).

354 *Figure 4. Outcomes of the lockdown in the households (N=202)*

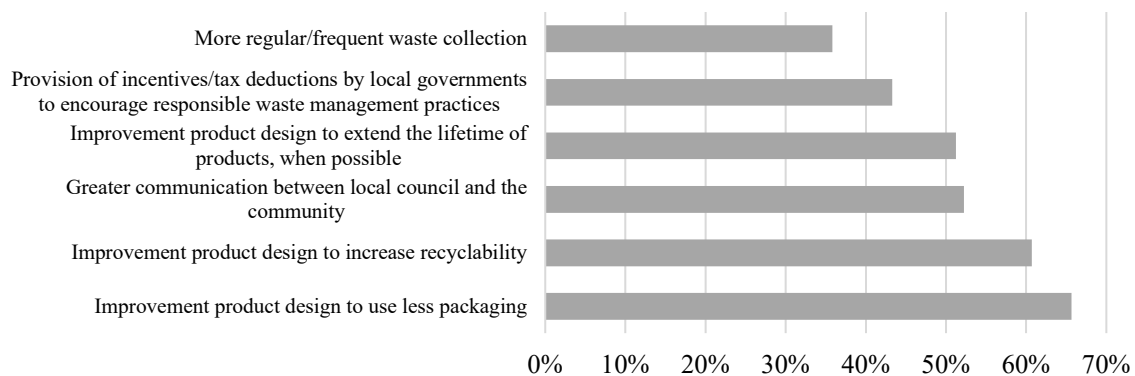


355

356 The lockdown experience seemed to have made some people reflect about measures that
 357 could be intensified for better waste management during disaster situations. Most responses
 358 (Figure 5) indicated the need for improving product design to use less packaging (66%) or to
 359 increase recyclability (61%). Moreover, about 51-52% of respondents indicated to extend the

360 lifetime of product design and better communication between the local council and the
 361 community. According to the United Nations Environment Programme, in order to better raise
 362 awareness and establish better communication between healthcare staff and the public,
 363 guidelines should be developed for the handling, treatment and disposal of waste generated
 364 during pandemic conditions. There should be clear responsibilities and roles assigned to
 365 collecting waste under such exceptional conditions (UNEP, 2020).

366 *Figure 5. Measures that should be intensified for better waste management during disaster*
 367 *situations (N=201)*



368

369

370 Implementing an appropriate waste management system assures the continuity and
 371 functionality of workers and waste services during the CODID-19 pandemic. It is also important
 372 to put measures in place to protect the safety of workers at waste collection and disposal
 373 facilities, and to foster the improvement in recycling services (Sarkodie & Owusu, 2020).

374

375 **5. Conclusions**

376 This study has presented evidences which show that the lockdowns triggered by the pandemic
 377 led to an increase in levels of consumption in households, and to changes in the amounts of
 378 waste and recycling. These items have, in turn, put an additional pressure on the waste
 379 management systems of many cities around the world. The increases in consumption were

380 initially due to purchasing food in bulk or panic buying. It could then be explained by the fact
381 that many citizens were forced to stay home. As a result, the purchase of frozen and packaged
382 food increased significantly since March 2020. Many consumers preferred to buy long-lasting
383 food products and changed their habits by shopping more online or taking away food.

384 The study presented here involved 204 consumers from several countries. About half of the
385 respondents noticed an increase in packed food, fresh food, and food delivery. Consequently,
386 more waste generation was reported, especially in respect of plastic packaging and food
387 waste. But not all trends were negative, since a significant number of individuals mentioned
388 their efforts to eat healthier food, and to separate the waste produced at home.

389 This situation also led to consumers being more critical with food producing companies,
390 pointing out that they should implement measures such as improve product design to use less
391 packaging, or increase the recyclability of the packaging they use. Nevertheless, this
392 responsibility should be also shared with public entities. These may, for instance provide better
393 infra-structure for selective waste collection, or for recycling. Complementarily, it could also
394 be useful to identify effective ways to reward citizens who actively participate in waste
395 prevention efforts. Although many people think it is challenging to reduce waste, small actions
396 can be taken (e.g., composting, replacing disposable products with durable ones, avoiding
397 over packaging, etc.).

398 Another issue is how the municipalities efficiently manage household waste during the
399 pandemic. In our study, if some changes in waste regulations have been applied, it was
400 observed that about half of the sample might not have been aware of these new regulations,
401 or noticed any change. Thus, it is important to identify best practices and analyze the key
402 success factors, so as to increase the capacity of waste management systems to respond to
403 pandemic crises, while keeping waste prevention and recycling high on the agenda. In many
404 places, the interruptions in some commercial activities, and diminishing tourist flows have also
405 influenced waste generation, which may free capacity to focus on household waste
406 management. Another matter of relevance is the communication with residents: changes to
407 collection services should be better communicated, preferably well in advance. The

408 population should also be "educated" to better collaborate with local management waste
409 authorities, by engaging on reductions on the amount of waste generated in households.

410 Regarding the limitations of our study, we recognize that using a convenience sample that is
411 country diversified reduces the possibility of picking specific local trends. On the other hand,
412 it caters for a greater degree of generalization. The limited number of responses can be also
413 considered a limitation of the study. Nonetheless, the study provides a welcome contribution
414 to the literature since it has enabled an overview of trends in 23 countries spread across the
415 various geographical regions. This serves the purpose of illustrating the wide-ranging impacts
416 of the COVID-19 pandemic on households' consumption habits, in face of the lockdowns it
417 triggered.

418 In respect of future research, and since the world is still facing a second wave, it could be
419 useful to analyze other stakeholders' perspectives regarding household waste (e.g.,
420 municipalities, producers, supermarkets) since these sectors have also been experiencing
421 changes due to the lockdowns. The search for other explanations about individuals' behaviour
422 could also be studied using other research perspectives such as green buying behaviour,
423 green consumption, lifestyle changes, or economic incentives to consumers, among others.

424

425 **Funding:** This research was performed by the European School of Sustainability Science
426 and Research (ESSSR), and the Inter-University Sustainable Development Research
427 Programme (IUSDRP). It did not receive any specific grant from funding agencies from the
428 public, commercial, or not-for-profit sectors

429 **Declaration of competing interest:** The author declares no competing interest.

430

431 **References**

432 African-Union. (2020). Impact of the coronavirus (COVID-19) on the African economy.
433 Available at: [https://www.tralac.org/documents/resources/covid-19/3218-impact-of-the-](https://www.tralac.org/documents/resources/covid-19/3218-impact-of-the-coronavirus-covid-19-on-the-african-economy-african-union-report-april-2020/file.html)
434 [coronavirus-covid-19-on-the-african-economy-african-union-report-april-2020/file.html](https://www.tralac.org/documents/resources/covid-19/3218-impact-of-the-coronavirus-covid-19-on-the-african-economy-african-union-report-april-2020/file.html)
435 [\(accessed 26 Jul 2020\)](https://www.tralac.org/documents/resources/covid-19/3218-impact-of-the-coronavirus-covid-19-on-the-african-economy-african-union-report-april-2020/file.html)

436 Alon, T. M., Doepke, M., Olmstead-Rumsey, J., & Tertilt, M. (2020). The impact of COVID-19
437 on gender equality. In N. B. o. E. Research (Ed.), NBER Working Paper Series (Vol. 26947).

438 Anderson, M., Mckee, M., & Mossialos, E. (2020). Covid-19 exposes weaknesses in
439 European response to outbreaks. *British Medical Journal*, 368, m1075.
440 <https://doi.org/10.1136/bmj.m1075>

441 Baker, S. R., Farrokhnia, R. A., Meyer, S., Pagel, M., & Yannelis, C. (2020). How does
442 household spending respond to an epidemic? consumption during the 2020 covid-19
443 pandemic. In N. B. o. E. Research (Ed.), NBER Working Paper Series (Vol. 26949).

444 Bhuiyan, A. I., Sakib, N., Pakpour, A. H., Griffiths, M. D., & Mamun, M. A. (2020). COVID-19-
445 related suicides in Bangladesh due to lockdown and economic factors: case study evidence
446 from media reports. *International Journal of Mental Health and Addiction*,
447 <https://doi.org/10.1007/s11469-020-00307-y>

448 Bonaccorsi, G., Pierri, F., Cinelli, M., Flori, A., Galeazzi, A., Porcelli, F., Quattrocioni, W.
449 (2020). Economic and social consequences of human mobility restrictions under COVID-19.
450 *Proceedings of the National Academy of Sciences*, 117(27), 15530-15535.
451 <https://doi.org/10.1073/pnas.2007658117>

452 Bracale, R. & Vaccaro, C.M. (2020). Changes in food choice following restrictive measures
453 due to Covid-19. *Nutrition, Metabolism and Cardiovascular Diseases*, 30(9), 1423-1426.
454 <https://doi.org/10.1016/j.numecd.2020.05.027>

455 Chen, N., Zhou, M., Dong, X., Qu, J., Gong, F., Han, Y., . . . Wei, Y. (2020). Epidemiological
456 and clinical characteristics of 99 cases of 2019 novel coronavirus pneumonia in Wuhan,
457 China: a descriptive study. *The Lancet*, 395(10223), 507-513. [https://doi.org/10.1016/S0140-
458 6736\(20\)30211-7](https://doi.org/10.1016/S0140-6736(20)30211-7)

459 Di Renzo, L., Gualtieri, P., Pivari, F., Soldati, L., Attinà, A., Cinelli, G., Leggeri, C., Caparello,
460 G., Barrea, L., Scerbo, F., Esposito, E., De Lorenzo, A. (2020). Eating habits and lifestyle
461 changes during COVID-19 lockdown: An Italian survey. *Journal of Transnational Medicine*,
462 18, 229. <https://doi.org/10.1186/s12967-020-02399-5>

463 Devereux, S., Béné, C., & Hoddinott, J. (2020). Conceptualising COVID-19's impacts on
464 household food security. *Food Security*, 12, 769-772. [https://doi.org/10.1007/s12571-020-](https://doi.org/10.1007/s12571-020-01085-0)
465 [01085-0](https://doi.org/10.1007/s12571-020-01085-0)

466 EFMP (2020). European Field Marketing Partners. The impact of COVID-19 on consumers
467 purchasing in Europe. Available at: <https://efmp.com/article.aspx?id=20> (accessed 30 Jun
468 2020)

469 Fan, Y. V., Jiang, P., Hemzal, M., & Klemeš, J. J. (2021). An update of COVID-19 influence
470 on waste management. *Science of the Total Environment*, 754, 142014.
471 <https://doi.org/10.1016/j.scitotenv.2020.142014>

472 Felton, D. (2020). 4 Inevitable packaging changes after COVID-19. *Packaging Digest*.
473 Available at: [https://www.packagingdigest.com/covid-19/4-inevitable-packaging-changes-](https://www.packagingdigest.com/covid-19/4-inevitable-packaging-changes-after-covid-19)
474 [after-covid-19](https://www.packagingdigest.com/covid-19/4-inevitable-packaging-changes-after-covid-19) (accessed 30 Jun 2020)

475 Gössling, S., Scott, D., & Hall, C. M. (2021). Pandemics, tourism and global change: a rapid
476 assessment of COVID-19. *Journal of Sustainable Tourism*, 29(1), 1-
477 20. <https://doi.org/10.1080/09669582.2020.1758708>

478 Ikiz, E., Maclaren, V. W., Alfred, E., & Sivanesan, S. (2021). Impact of COVID-19 on
479 household waste flows, diversion and reuse: The case of multi-residential buildings in
480 Toronto, Canada. *Resources, Conservation and Recycling*, 164,
481 105111. <https://doi.org/10.1016/j.resconrec.2020.105111>

482 Jribi, S., Ben Ismail, H., Doggui, D., & Debbabi, H. (2020). COVID-19 virus outbreak
483 lockdown: What impacts on household food wastage?. *Environment, Development and*
484 *Sustainability*, 22, 3939-3955. <https://doi.org/10.1007/s10668-020-00740-y>
485

486 Kawohl, W., & Nordt, C. (2020). COVID-19, unemployment, and suicide. *The Lancet*
487 *Psychiatry*, 7(5), 389-390. [https://doi.org/10.1016/S2215-0366\(20\)30141-3](https://doi.org/10.1016/S2215-0366(20)30141-3)

488 McKinsey & Company (2020). Consumer sentiment and behaviour continue to reflect the
489 uncertainty of the COVID-19 crisis. Available at: [https://www.mckinsey.com/business-
functions/marketing-and-sales/our-insights/a-global-view-of-how-consumer-behaviour-is-
changing-amid-covid-19](https://www.mckinsey.com/business-
490 functions/marketing-and-sales/our-insights/a-global-view-of-how-consumer-behaviour-is-
491 changing-amid-covid-19) (accessed 24 Nov 2020)

492 Morrison, O. 2020. Coronavirus: consumer demand for staple foods “high but stabilizing”.
493 William Reed Informing Business Growth. Available at:
494 [https://www.foodnavigator.com/Article/2020/04/08/Coronavirus-Consumer-demand-for-
staple-foods-high-but-stabilising#](https://www.foodnavigator.com/Article/2020/04/08/Coronavirus-Consumer-demand-for-
495 staple-foods-high-but-stabilising#) (accessed 29 Jun 2020)

496 Owusu-Fordjour, C., Koomson, C., & Hanson, D. (2020). The impact of Covid-19 on
497 learning-the perspective of the Ghanaian student. *European Journal of Education Studies*,
498 7(3). <http://dx.doi.org/10.5281/zenodo.3753586>

499 Ozili, P. K. (2020). COVID-19 in Africa: socioeconomic impact, policy response and
500 opportunities. *International Journal of Sociology and Social Policy*,
501 <http://dx.doi.org/10.2139/ssrn.3574767>

502 Parolin, Z., & Wimer, C. (2020). Forecasting estimates of poverty during the COVID-19
503 crisis. *Poverty and Social Policy Brief 2046*, Center on Poverty and Social Policy, Columbia
504 University. <https://ideas.repec.org/p/aji/briefs/2046.html>

505 Poole, L. (2020). Seasonal Influences on the Spread of SARS-CoV-2 (COVID19), Causality,
506 and Forecastability (3-15-2020)<http://dx.doi.org/10.2139/ssrn.3554746>

507 Ranney, M. L., Griffeth, V., & Jha, A. K. (2020). Critical supply shortages—the need for
508 ventilators and personal protective equipment during the Covid-19 pandemic. *New England
509 Journal of Medicine*, 382(18), e41. <http://dx.doi.org/10.1056/NEJMp2006141>

510 Remuzzi, A., & Remuzzi, G. (2020). COVID-19 and Italy: what next? *The Lancet*,
511 395(10231), 1225-1228.[https://doi.org/10.1016/S0140-6736\(20\)30627-9](https://doi.org/10.1016/S0140-6736(20)30627-9)

512 Sahu, P. (2020). Closure of universities due to Coronavirus Disease 2019 (COVID-19):

513 impact on education and mental health of students and academic staff. *Cureus*, 12(4),
514 e7541. <http://dx.doi.org/10.7759/cureus.7541>

515 Sharma, H. B., Vanapalli, K. R., Cheela, V. R. S., Ranjan, V. P., Jaglan, A. K., Dubey, B.,
516 Goel, S., & Bhattacharya, J. (2020). Challenges, opportunities, and innovations for effective
517 solid waste management during and post COVID-19 pandemic. *Resources, Conservation*
518 *and Recycling*, 162, 105052. <https://doi.org/https://doi.org/10.1016/j.resconrec.2020.105052>

519 Sarkodie, S. A., & Owusu, P. A. (2020). Impact of COVID-19 pandemic on waste
520 management. *Environment, Development and Sustainability*. [https://doi.org/10.1007/s10668-](https://doi.org/10.1007/s10668-020-00956-y)
521 [020-00956-y](https://doi.org/10.1007/s10668-020-00956-y)

522 Singh, O. (2020). Mental health of migrant laborers in COVID-19 pandemic and lockdown:
523 Challenges ahead. *Indian Journal of Psychiatry*, 62(3), 233.
524 <http://www.indianjpsychiatry.org/text.asp?2020/62/3/233/284460>

525 Statista (2020). The Statistics Portal for Market Data. Available at: <https://www.statista.com/>
526 (accessed 26 Nov 2020)

527 UNEP (2020). United Nations Environmental Programme. Waste Management during the
528 COVID-19 Pandemic, From Responses to Recovery. Available at:
529 <https://reliefweb.int/sites/reliefweb.int/files/resources/WMC-19.pdf> (accessed 11 Dec 2020)

530 WHO. (2020a). Coronavirus disease 2019 (COVID-19) Situation Report – 51. Available at:
531 [https://www.who.int/docs/default-source/coronaviruse/situation-reports/20200311-sitrep-51-](https://www.who.int/docs/default-source/coronaviruse/situation-reports/20200311-sitrep-51-covid-19.pdf?sfvrsn=1ba62e57_10)
532 [covid-19.pdf?sfvrsn=1ba62e57_10](https://www.who.int/docs/default-source/coronaviruse/situation-reports/20200311-sitrep-51-covid-19.pdf?sfvrsn=1ba62e57_10) (accessed 20 Mar 2020)

533 WHO. (2020b). Coronavirus disease 2019 (COVID-19) Situation Report – 54. Available at:
534 [https://www.who.int/docs/default-source/coronaviruse/situation-reports/20200314-sitrep-54-](https://www.who.int/docs/default-source/coronaviruse/situation-reports/20200314-sitrep-54-covid-19.pdf?sfvrsn=dcd46351_8)
535 [covid-19.pdf?sfvrsn=dcd46351_8](https://www.who.int/docs/default-source/coronaviruse/situation-reports/20200314-sitrep-54-covid-19.pdf?sfvrsn=dcd46351_8) (accessed 20 Mar 2020)

536 WHO. (2020c). Coronavirus disease (COVID-19) Situation Report – 193. Available at:
537 [https://www.who.int/docs/default-source/coronaviruse/situation-reports/20200731-covid-19-](https://www.who.int/docs/default-source/coronaviruse/situation-reports/20200731-covid-19-sitrep-193.pdf?sfvrsn=42a0221d_2)
538 [sitrep-193.pdf?sfvrsn=42a0221d_2](https://www.who.int/docs/default-source/coronaviruse/situation-reports/20200731-covid-19-sitrep-193.pdf?sfvrsn=42a0221d_2) (accessed 1 Aug 2020)

539 WHO (2020d). World Health Organisation. Available at: <https://www.who.int/> (accessed 24
540 [Nov 2020](#))

541