Abstract

Health-care waste management requires technical, financial and human resources, and it is a challenge for low- and middle income countries, while it is often neglected in protracted crisis or emergency situations. Indeed, when health, safety, security or wellbeing of a community is threatened, solid waste management usually receives limited attention.

Using the Gaza Strip as the case study region, this manuscript reports on health-care waste management within the context of a humanitarian crisis. The study employed a range of methods including content analyses of policies and legislation, audits of waste arisings, field visits, stakeholder interviews and evaluation of treatment systems. The study estimated a production from clinics and hospitals of 683 kg/day of hazardous waste in the Gaza Strip, while the total health-care waste production was 3,357 kg/day. A number of challenges was identified including lack of clear definitions and regulations, limited accurate data on which to base decisions and strategies and poor coordination amongst key stakeholders. Hazardous and non-hazardous waste was partially segregated and treatment facilities hardly used, and 75% of the hazardous waste was left untreated. Recommendations for mitigating these challenges posed to patients, staff and the community in general are suggested. The outputs are particularly useful to support decision makers, and re-organize the system according to

reliable data and sound assumptions. The methodology can be replicated in other humanitarian settings, also to other waste flows, and other sectors of environmental sanitation.

Keywords

Palestine, Gaza Strip, Healthcare waste, Medical waste, Stakeholders engagement, Sustainability, Humanitarian context, Assessment methods.

Abbreviations

BOR: bed occupancy rate; EQA: Environmental Quality Authority; ER: emergency room; HCF: health-care facility; HCWM: health-care waste management; IPC: infection prevention and control; LMIC: low- and middle-income country; MoH: Ministry of Health; MSW: municipal solid waste; PMMS: Palestinian Military Medical Services; UNRWA: United Nations Relief and Works Agency for Palestine Refugees; WHO: World Health Organization; w/w: % weight per weight.

1. Introduction

Palestine is divided into two geographical entities, the West Bank and the Gaza Strip. Although theoretically managed by the same government and regulated by the same

legislative framework, they are de facto autonomous entities, and administered respectively by the Palestinian Authority (Fatah), and Hamas. In the Gaza Strip the situation is quite different from the West Bank. For example, the management of waste differs between the two regions (Caniato et al., 2015a).

A number of studies have been conducted across the Middle East on waste management (Abd El-Salam, 2010; Aghapour et al., 2013; Alhumoud and Alhumoud, 2007; Askarian et al., 2012; Bdour et al., 2007; Ciplak and Barton, 2012). More specifically, research has examined waste management in the West Bank (Al-Khatib, 2008; Al-Khatib et al., 2009; Al-Khatib and Sato, 2009), some of which are focused on social factors such as the opinions of staff from health-care facilities (HCF) (Massrouje, 2001; Sarsour et al., 2014). However, there are various limitations of these studies, including the fact that in some cases they refer to Palestine in general, some are based on quite old data, and there has been limited large scale study of the Gaza Strip specifically.

Since Hamas reinforced its power in Gaza in 2007, there have been three large-scale conflicts with Israel. However, the 2014 war was the most deadly and devastating, with more than 2,200 Palestinians (mostly civilians) killed, and 11,231 Palestinians injured. On the Israeli side, 67 soldiers and six civilians were killed, and 1,600 people wounded. About 170,000 homes and 360 factories in Gaza were damaged or lost, key

58 infrastructure hit, and thousands of acres of farmland were ruined (Schabas et al.,
59 2015). In a similar context access to and quality of health-care are a particularly critical
60 issue, as well as the management of by-products, like the waste generated.
61 Therefore, a study focused on the Gaza Strip is important and timely. Similar contexts
62 are usually characterized by shortage of accurate and coherent data, and information
63 is even conflicting or based on the personal opinion of different stakeholders. Using
64 health-care waste management (HCWM) as the key focus, this study aimed to
65 understand the management of waste during a humanitarian crisis and to develop
66 effective recommendations to address the issues identified. It aims to show that is
67 possible to overcome such challenges with a combination of different qualitative and
68 quantitative methods in order to draw evidenced-based conclusions.
69
70 **2. Methods**
71 The Gaza Strip is such a small area that the national and local administrative levels are
72 almost overlapping. The governorates and municipalities are very small and do not
73 play an important role concerning HCWM. Thus the study was focused on the entire
74 Gaza Strip.
75 The analysis included the following topics:
76 - Regulation, legislative framework and guidelines;

- Background information at the Gaza Strip level (e.g. identification of available treatment options, market opportunities);
- HCWM at the health-care facility level (rapid assessment);
- Quality of HCW segregation and estimation of waste production;
- Identification of stakeholders (role, importance, relationships, and communication networks);
- Identification of challenges and evaluation of stakeholder priorities.

Some methods were often applied together. For example, while assessing a HCF, staff were also interviewed, and questions about different topics submitted.

2.1. Regulation, legislative framework and guidelines

Some thirty officers from departments of the Ministry of Health (MoH), municipal solid waste (MSW) service providers, and staff from HCFs were interviewed to examine the regulations concerning HCWM. The research was extended to the guidelines and laws concerning public health and infection prevention and control (IPC), in order to have a picture of all the pieces of regulation potentially of interest. Some laws were officially available also in English, while the other documents were translated by COOPI – COOPERAZIONE INTERNAZIONALE (COOPI) staff. COOPI is an international NGO which acted as partners in the study.

96

97 *2.2. Background information at the Gaza Strip level*

98 One of the most complete databases about HCFs was developed by the World Health
99 Organization (WHO) in April 2009 (WHO and EMRO, 2010). It provides information
100 about each HCF, including utilization statistics, GPS coordinates, and health services.
101 This information was used as the main baseline (Table 1). The data were checked as
102 much as possible during meetings and visits, to confirm that they were still
103 representative of the Gaza Strip situation. However, in some facilities, utilization
104 statistics and other information were not easily available, and staff did not have the
105 data. Therefore, it is possible that they were either collected with different definitions,
106 or some facilities simply were not used to have a data recording system. It is important
107 to note that official documents report different numbers of beds and bed occupancy
108 rates (BOR) in MoH hospitals (Home Engineering Unltd et al., 2005a; Ministry of
109 Health, 2011a; WHO et al., 2011; WHO and EMRO, 2010). Other information was
110 collected from online documents, the MoH website, and interviews with MoH and
111 WHO officers, HCF staff and local experts in 2011 and 2012.
112 In the Gaza Strip, hazardous HCW were either incinerated or disposed of in a dedicated
113 landfill. Qualitative and quantitative data about incinerators were collected with a
114 simple form during field visits. All of the three incinerators in the Gaza Strip were

visited several times, in order to understand the practices discussed with operators and the responsible officers. The hazardous waste landfill was visited as well, and its manager interviewed.

2.3. HCWM at the health-care facility level

HCFs were assessed adapting the 1st version of the rapid assessment tool developed by WHO & UNEP/SBC (2011). The 2nd edition was published in November 2011 only, after the first field mission in the Gaza Strip. Waste segregation was surveyed in different departments/wards in each HCF visited. Some 16 HCFs were assessed, 10 public and 6 non-governmental respectively. Non-governmental HCFs were managed by private companies, NGOs or the United Nations Relief and Works Agency for Palestine Refugees (UNRWA). The 16 HCFs were a representative sample from different governorates, and represent the vast majority of both bed capacity and patients treated in the Gaza Strip.

2.4. Estimation of waste production and quality of HCW segregation

In January-February 2012, COOPI staff carried out a rapid weighing campaign in four HCFs (two hospitals and two clinics), for six consecutive days (from Saturday to Thursday). This analysis aimed to quantitatively estimate waste production and waste

segregation. Moreover, direct observation gave some qualitative indication of onsite collection and storage practices. Clinics had an internal collection shift (7.00–14:30) only, thus the analysis, carried out in the morning, covered the entire HCW production. Hospitals were operative 24/7 and had three waste internal collection shifts (6:00–14:00, 14:00–22:00, 22:00–6:00), and COOPI staff could only weigh the first shift. However, the majority of waste was collected during this shift, which meant that this was representative of the overall quantities of waste. COOPI staff assessed the volume occupied by the waste by evaluating the percentage of filling of containers in use. The day after, COOPI staff assessed the volume of the total HCW produced in the previous day before it was transported out of the hospital. This estimated volume was then used to determine the waste quantities, using sample weights of the waste for the conversion. Therefore, COOPI staff could estimate the total HCW daily production. Safety boxes were collected just once a day, thus this generation was the actual value, not an estimation.

Also UNRWA kindly agreed to participate, and their staff weighed the waste produced by the Rimal clinic for eight days (19 October – 27 October, 2011, excluding Friday 21 October), without the presence of COOPI staff.

The effectiveness of waste segregation was assessed directly in both producer (HCF) and treatment/disposal site (incinerator, hazardous waste landfill and MSW landfill).

153 Only two waste streams could be identified, namely: (1) waste managed by MSW
154 service providers, and (2) hazardous waste treated by MoH with incinerators. In all the
155 assessed HCFs, after interviews, some wards were visited, as well as the temporary
156 storage sites in use for non-hazardous (i.e. similar to MSW) and hazardous waste. In
157 the incinerator at Al Shifa hospital (the biggest HCF in Palestine), some bags and safety
158 boxes were opened in order to qualitatively observe the contents before incineration.
159 Mixture of hazardous and non-hazardous waste was observed in both the streams
160 during all the field activities, and was confirmed by all the interviews.

161 *2.5. Identification of stakeholders*

162 Stakeholders and social networks were analysed based on Caniato et al. (2014b).

163

164 *2.6. Identification of challenges and evaluation of stakeholder priorities*

165 During meetings and interviews, stakeholders were asked to give their opinions about
166 HCWM in the Gaza Strip, to state the challenges and the suggestions to improve the
167 situation. A set of challenges was identified, and a possible way forward for each one
168 was suggested, integrating requests from the field with indications from guidelines and
169 literature. Stakeholders stated their priorities about HCWM, as described in Caniato et
170 al. (2014b). A program of intervention was developed through the triangulation of
171 challenges, possible way forward, and priorities.

172

173 *2.7. Site surveys and data triangulation*

174 Some 39 stakeholders were engaged with, covering all the categories, and providing an
175 overview of the region, in particular general indications about organizational, logistical
176 and legislative factors. Visits, direct observation and field discussion with operators
177 contributed to investigation of practices. MSW management was previously assessed
178 with a specific methodology (Caniato and Vaccari, 2014), thus the presence of
179 hazardous HCW in street containers, transfer stations and disposal sites had already
180 been detected.

181 About hospitals, the main hazardous HCW sources, 12 out of 28 facilities (43%) were
182 assessed, covering 70% of the bed capacity (1,886 out of 2,697) and 81% of patients in
183 the Gaza Strip, according to WHO et al. (2011) (1,358,381 out of 1,685,265). This
184 number of patients refers to the sum of admissions, outpatients and emergency room
185 (ER) visits. Thus considering the number of beds, all the governorates, except Rafah,
186 were well represented in the sample.

187 Clinics produce a smaller quantity of waste per patient than hospitals (Pruss-Ustun et
188 al., 2013), and hazardous wastes are mainly composed by sharps and infectious. Only
189 four clinics, two owned by the MoH and two by UNRWA, were visited. Information
190 about other clinics was directly or indirectly collected by the stakeholders met.

Therefore, the sample was not completely representative of all the clinics, but information was consistent, and results were deemed reliable. Finally, the overview of HCWM was obtained through information triangulation from both meetings and stakeholder analysis.

3. Results

National level: analysis of regulation, legislative framework and guidelines

At the time of the study there was no clear regulation about HCWM in the Gaza Strip. Only a few definitions (e.g. “hazardous substance” and “hazardous waste”) were provided by the *Palestinian Environmental Law* (President of the Palestinian Authority, 1999), while specific terms like “medical waste” were left undefined. The Environmental Quality Authority (EQA) had the responsibility to define the activities and procedures for waste management in coordination with the specialized agencies, and to monitor law enforcement. In the *National Strategy for SWM in the Palestinian Territory 2010-2014* (Palestinian National Authority, 2010), Strategic Objective Five dealt with medical, hazardous, and special wastes. In particular, the Authority aimed at creating an inventory and tracking system, and establishing suitable treatment plants for medical waste, though “... there are no Palestinian standards for dealing with special, hazardous, and medical wastes...” (Palestinian National Authority 2010, p. 5).

Although not clearly defined, responsibility to manage hazardous HCW was generally attributed to MoH, while Municipalities and Solid Waste Management Councils were in charge of the non-hazardous waste, based on the *Public Health Law* (Palestinian Legislative Council, 2004).

The law prepared in 2009 *"Concerning the management and the handling of medical waste"* (Palestinian National Authority, 2009) was still under approval in 2013. It included definitions, including "medical waste", and "general waste", a list of main and secondary sources, and responsibilities. Medical waste categories were defined similarly to the first edition of the WHO's Blue Book (Pruss et al., 1999). Finally, the law gave general indications about segregation, collection and temporary storage, and onsite and offsite transport, while little was written about treatment and disposal.

Due to the internal Palestinian political conflict, officers from the same Ministry (e.g. Ministry of Health) in the Gaza Strip and West Bank had little interaction, and practically were independent structures, with specific regulations, recommendations and plans. At the Gaza Strip level, *Recommendations of the committee of the directorate of the medical wastes in the Ministry of Health, October 2010* (Ministry of Health, 2010) required the establishment of a committee to classify waste, to introduce an appropriate segregation system and to monitor its application. *Medical waste incinerator situation in Ministry Of Health of Gaza, 5 October 2011* (Ministry of

229 Health, 2011b) reported the existing situation concerning incineration in the Gaza
230 Strip, and certified the lack of a segregation system, the old and poor condition of
231 incinerators, and their risks to public health. *Incineration run protocol* (Ministry of
232 Health, 2011c) set some general incineration procedures. Finally, some documents
233 about IPC were officially present, like "*Infection Prevention and Control Protocols*"
234 (Ministry of Health, 2004), but they were not being implemented at the time of the
235 study.
236
237 *3.1. National level: collection and analysis of data and useful information at the Gaza*
238 *Strip level*
239 Health-care was provided by both public and nongovernmental actors. Public HCFs
240 were owned and managed by either MoH or military services in Palestine (MSP, also
241 called Palestinian Military Medical Services PMMS), while non-governmental HCFs
242 were managed by private companies and local or international NGOs. UNRWA ran its
243 own facilities, providing primary health-care to refugees. In 2010, some 1,002,329
244 people accessed UNRWA health services (UNRWA, 2011).
245 HCFs were divided into clinics, which provided mainly primary services and dealt with
246 outpatients only, and hospitals, which provided secondary and tertiary services. Public
247 clinics had four levels according to the health services provided. Non-governmental

248 facilities did not follow specific rules (Regional Health Systems Observatory and EMRO,
249 2006). Table 1 presents the number of HCFs and main available statistics for each. The
250 Ministry of Health (2011a) reported a different number of non-governmental hospitals,
251 clinics and beds available. The lack of an univocal recording system, in particular
252 regarding non-governmental HCFs is evident.
253 TABLE 1 HERE
254 The most recent data estimated a HCW production of 730 tonne/month in the Gaza
255 Strip, but it was actually based on 2004-2008 surveys (PCBS, 2009). In 2011, the MoH
256 estimated that incinerators burnt about 4.5 – 5 tonnes/month (Ministry of Health,
257 2011b), but no weighing or reliable estimations were available about general HCW
258 production and composition. The *Master Plan for Healthcare Waste Management*
259 *West Bank/Gaza Strip* was the most up to date study and was still considered valid by
260 all the stakeholders. It estimated a production of 2,003 kg/day (400 kg/day of
261 hazardous waste) in 2004, considering 1.306 kg/bed/day and a BOR of 80% (1,534
262 occupied beds out of 1,917) (Home Engineering Unltd et al., 2005a). The *Feasibility*
263 *Study for the Implementation of Healthcare Waste Master Plan in West Bank/Gaza*
264 *Strip* reported slight differences, but the estimation of hazardous waste production
265 was similar (Home Engineering Unltd et al., 2005b). HCW was composed mainly of
266 domestic waste (80%), while infectious waste was the main fraction of hazardous

267 waste. This estimation was based on a questionnaire, some visits to HCFs in the Gaza
268 Strip and a rapid sampling campaign. However, sampling probably was carried out for
269 only one day, analysing just one UNRWA clinic and one blood bank, and with an
270 unclear methodology (Home Engineering Unltd et al., 2005c). Therefore the data were
271 not completely reliable. Most of all, the final estimation considered only hospitals and
272 thus was based on waste production per occupied bed. Unfortunately, in the Gaza
273 Strip the number of clinics and visits cannot be accurately verified. In 2000, the *Quality*
274 *Improvement Project*, funded by the World Bank, estimated a waste production from
275 hospitals of 800 kg/day, out of a total HCW production in Gaza Strip of 3,800 kg/day
276 (DHV et al., 2012). Other studies, based on questionnaires or field activities, tried to
277 estimate HCW generation and composition (El-Hawi, 2004; Kamel, 2011; PCBS, 2000;
278 Qumboz, 2002; Zoarob, 1997), but did not provide a significant contribution to the
279 analysis.
280 Visits and meetings confirmed and integrated previous studies (DHV et al., 2012; El-
281 Hawi, 2004; Home Engineering Unltd et al., 2005b) about the poor HCWM standards.
282 Indeed, infectious waste and sharps management were not regulated by specific
283 procedures, while also those concerning pharmaceutical and anatomic waste were not
284 completely implemented (Table 2). Regarding pharmaceutical waste, for example, 200
285 m^3 were collected and disposed in the only hazardous waste landfill of the Gaza Strip in 2010,

286 though encapsulation procedure was not fully respected. In 2012, about 250 m^3 out of 6,500
287 m^3 capacity of this landfill was filled (Solid Waste Director - Gaza Municipality, personal
288 communication, 16/02/2012). Assuming a 0.9 density conversion factor valid in UK for both EWC
289 code 180108 and 180109 – "cytotoxic and cytostatic medicines" and "medicines other than
290 those mentioned in 18 01 08" respectively – (UK Environment Agency, 2014) around 180
291 tonnes were disposed in 2010, and further 45 tonnes in the following two years.
292 TABLE 2 HERE
293 The three incinerators in the Gaza Strip were located in Al-Shifa hospital, in Gaza City,
294 Nasser hospital, and European hospital, both in Khan Younis. Their performances did
295 not meet international standards (Pruss-Ustun et al., 2013; SBC and UNEP, 2011; SSC
296 and UNEP, 2009) in terms of operations (e.g. temperature, retention time, emission of
297 pollutants) and staff safety (e.g. use of personal protective equipment, presence and
298 application of an accident monitoring system). In addition, operation and maintenance
299 procedures were neither written nor clearly defined.
300
301 *3.2. National level: rapid assessment of HCFs*
302 HCW management inside HCFs was often poor and potentially risky for patients,
303 visitors and health workers. Table 3 presents a detailed picture of the situation in HCFs
304 according to the health service provider.
305 TABLE 3 HERE

306 During the field visits, it was documented that in HCFs every HCWM step commonly
307 met neither international minimum requirement (Pruss-Ustun et al., 2013) nor
308 indications provided by local regulation. These non-compliances are reported in Table
309 4, and it was the key starting point to improve the entire HCWM system in the Gaza
310 Strip.
311 TABLE 4 HERE
312
313 *3.3. National level: estimated HCW generation and quality of HCW segregation*
314 The two MoH clinics provided 135,035 and 161,962 visits (i.e. general practitioner +
315 specialist visits) per year (WHO and EMRO, 2010). Their specific waste generation was
316 similar, 0.022±0.012 and 0.027±0.010 kg/visit, respectively. The two clinics segregated
317 safety boxes only, but the level of segregation was probably different. In the first clinic,
318 a segregation of 8.2% weight per weight (w/w) on the total HCW produced was
319 estimated, while in the latter it was 2.1% w/w only.
320 Two MoH hospitals were assessed, Kamal Edwan hospital in the North governorate,
321 and Al Shifa hospital in Gaza City. The first was a medium size hospital with 117 beds
322 and an average production of 2.64±0.48 kg/occupied bed/day. The second was the
323 largest hospital in the Gaza Strip with 657 beds and a much smaller waste production,
324 0.91±0.10 kg/occupied bed/day. Infectious waste, segregated exclusively in safety

boxes, on average was 2 kg/day (i.e. 0.8% w/w) and 10 kg/day (i.e. 2.0% w/w), respectively. Therefore infectious waste segregation per occupied bed was very limited, that is 0.025 and 0.018 kg/occupied bed/day, respectively.

UNRWA staff weighed two waste categories, namely sharps and non-sharps. However, due to some confusion over the definition of “sharps”, all the infectious waste was considered as segregated. Based on this hypothesis, the average infectious waste production was 14.9±5.1 kg/day out of a total production of 67.6±11.3 kg/day, that is 22% w/w. Using a total of 415,356 visits/year (WHO and EMRO, 2010), the average specific waste generation was 0.06±0.01 kg/visit, which was much higher than in the MoH clinics.

During the weighing campaign it was evident that MoH HCFs segregated and collected only sharps, using almost exclusively carton safety boxes. Further field visits confirmed that at least some private and NGO HCFs were in the same situation. UNRWA had some infectious waste segregation procedures, but all the waste, both hazardous and non-hazardous, was collected and transported by the same truck and sent to the landfill together. However, official records at the Gaza Strip level were available neither about HCW generation nor segregation in 2012 (DHV et al., 2012). Ministry of Health (2011c) estimated that incinerators in Al Shifa, Nasser and European hospitals regularly dealt with 2-2.5, 1.5 and 1 tonne/month, respectively. Only data about

344 incineration in Al Shifa hospital were confirmed by a record of waste burnt, with an
345 average of 77 kg/day. Unfortunately, the incinerators in both Al Shifa and European
346 hospitals were sometimes out of order. Therefore the Nasser hospital sometimes had
347 to manage hazardous waste from all the HCFs in the Gaza Strip. 2011 data about Al
348 Shifa hospital incinerator demonstrated that few HCFs sent hazardous waste for
349 treatment. Indeed, only 15 HCFs regularly sent waste, totalling an average of 73±46
350 kg/day, while other 10 HCFs were considered periodic or irregular sources, with a total
351 supply of 4 kg/day (it was not possible to estimate the related standard deviation).
352 Thus in several HCFs waste segregation was either ineffective or even absent, and the
353 large majority of hazardous HCW was comingled with MSW. It resulted in more than
354 75% of hazardous waste generated in the Gaza Strip being left untreated. This share
355 was probably higher in reality because the overall production of hazardous waste was
356 probably underestimated.
357
358
359 *3.4. National level: stakeholders, their roles, and relationships*
360 There were a number of stakeholders involved in HCWM with a complex network of
361 relationships, as evaluated in Caniato et al. (2014b). Only MSW service providers had a
362 clear picture of HCWM, while other actors, like MoH HCFs, WHO, private contractors in

HCFs, EQA and health NGOs, had high interest but medium-low power. The MoH was both a regulator and manager of public HCFs, and in such a position was the only stakeholder with enough power to affect HCWM. However, it was also a very complex institution and lacked financial resources.

The analysis evidently showed that technical staff dealing with HCWM suffered from the lack of a discussion platform to share practices, and develop appropriate solutions. Only official institution's managers and representatives were usually allowed to communicate with other stakeholders, and it was particularly true especially for MoH HCFs. Finally stakeholders did not feel well trained about HCWM. Indeed, they had to rely on a few training opportunities, their initiative, and personal research using the internet. Only UNRWA staff reported having been trained specifically about this topic. However, guidance on HCWM, including training, experience sharing and pilot activities, were requested by almost all the stakeholders. Finally, it is remarkable that stakeholders gave little attention to the blockade imposed to the Gaza Strip since 2006 or to the difficult economic conditions due to it. However, a private hospital did report that sometimes buying safety boxes was more difficult and importing treatment technologies was difficult and limited.

382 *3.5. National level: identification of challenges and evaluation of priorities*

383 Stakeholders self-evaluated HCWM in their facility, and tried to identify challenges and
384 needs. Their indications were used to identify the global challenges of the HCWM
385 system, and develop a possible way forward, including both procedural and
386 infrastructural factors (Table 5).

387 The stated priorities reflected the stakeholders' knowledge and work. In particular,
388 waste segregation at the HCF level, appropriate material for first storage and cleaning,
389 and onsite storage were the most cited steps (Caniato et al., 2015b).

390

391 **4. Discussion**

392 *4.1. Evaluation of the key findings*

393 The results suggest that HCWM varied across the different HCFs in the Gaza Strip. A
394 number of challenges were identified including lack of clear definitions and
395 regulations, limited accurate data on which to base decisions and strategies, limited
396 coordination amongst key stakeholders, limited segregation of hazardous and non-
397 hazardous waste, limited training opportunities and treatment facilities that were not
398 fit for purpose (and hardly used). These challenges posed significant risks to patients,
399 staff and the community in general, as reported in several other low- and middle-

400 income countries (Caniato et al., 2015a; Liu et al., 2015; Ara et al., 2016; Thakur and
401 Ramesh, 2015).
402 Although regulation was lacking in several aspects, it was evident that existing laws
403 were not well-known by all the stakeholders, and they were confused about what
404 should be enforced and how. Regulations did not give clear indications about HCWM,
405 but practices did not apply even what was suggested. Indeed, standard procedures
406 applicable in the Gaza Strip for the management of each hazardous HCW, from the
407 segregation to final disposal, should be developed. There are already a number of
408 existing international guidelines which could be employed to provide definitions and
409 guidance (e.g. WHO, 2014; UNEP, 2012). Given that, there are already various policies
410 in place and, evidently, a key factor is also the effective implementation of any existing
411 and new guidelines. As the key agency, the MoH should probably take at least initial
412 responsibility for implementation and regulation.
413 Several studies tried to describe HCW generation and composition, but none was able
414 to give a reliable picture of the situation, and the gap of knowledge was still evident.
415 For this reason verification and triangulation of data and information were considered
416 so fundamental and received greatest attention. Nevertheless, all the hazardous waste
417 categories should be better analysed and tracked from production to final disposal.

418 Indeed, all the HCWM steps were not compliant with international standards and local
419 regulation (e.g. Pruss-Ustun et al. 2013; SBC & UNEP 2011; SSC & UNEP 2009).
420 Despite the limited data on HCW generation, a range of waste production of 0.9-2.7
421 kg/occ. bed/day looks acceptable for the Gaza Strip and similar with other countries in
422 similar economic conditions (Pruss-Ustun et al., 2013). However, there is a need for
423 more accurate data on which to develop evidence-based policies and strategies.
424 Moreover, data were largely estimated on the basis of data of other studies, like bed
425 capacity, BOR and number of patients (Ministry of Health, 2011a; WHO et al., 2011;
426 WHO and EMRO, 2010).
427 According to the findings, UNRWA segregated about 22% of the waste, but then it was
428 all transported and managed together. HCWM could be effective onsite with more
429 effective segregation, with good results in terms of IPC. However, it was ineffective
430 once the waste left the HCF, and was managed by the MSW service provider.
431 Moreover, any waste segregation was almost nullified by mixing as soon as the waste
432 was collected. In MoH clinics, waste segregation depended on the HCF size, and
433 health-care services provided. A more effective segregation could lead not only to a
434 reduction in public health incidences, but also to a reduced amount of waste to treat in
435 the incinerators. A key factor in effective waste segregation and management is the
436 provision of training, which was identified as a major concern by almost all staff. Given

its importance, the MoH should take lead responsibility for developing training programmes for all relevant stakeholders. This could be done in conjunction with the international agencies (e.g. NGOs), that operate in the Gaza Strip. Some of these programmes should be made compulsory in order to improve the standards and procedures across both the health-care and the treatment facilities.

It is particularly important to note that little attention was paid to the Gaza Strip blockade and the difficult economic conditions. Indeed, 30% of the population is below poverty line and unemployed rate is among the highest in the World (CIA, 2016). Probably such a situation was considered as given, and all the stakeholders were used to coping with it. Moreover the difficulty in the importation of items was only limitedly reported. Indeed, health-care items are only partially affected by the blockade, including those useful for HCWM. Access to suitable treatment technologies would evidently be limited and constrained. However, during recent years none has tried to import any systems to the best of the authors' knowledge. Finally the situation has an evident impact on HCWM, as all the aspects of people life in the Gaza Strip but with an indirect link, thus often neglected. For example, very few HCF staff can rarely attend training sessions out of the Gaza Strip, and the presence of trainers coming from abroad is strongly limited by the situation and depending on access permits. Therefore it is very difficult for HCFs to have clear references for inspiration. In general it is

456 already hard to provide minimum standards of the service – especially during violence
457 escalations – thus a complex issue as HCWM is rarely a priority for health-care service
458 providers.
459 Table 5 outlines some recommendations for overcoming the procedural and
460 infrastructural barriers identified. These recommendations include the development of
461 protocols and procedures, definition of roles and responsibilities, improved availability
462 and conditions of consumables and vehicles, and identification of appropriate
463 treatments and final disposal of waste. Given the particular complexity of working on
464 HCWM in a humanitarian crisis, it is reasonable that only a few recommendations can
465 be implemented in the short term. In particular the reason behind a crisis and the
466 consequences cannot be affected by a waste management intervention and must be
467 considered as part of the context. However, a picture of the main challenges and a
468 clear way forward can support both local institutions and humanitarian organizations
469 to identify priorities for intervention and planning, and facilitate coordination of their
470 work.
471 TABLE 5 HERE
472
473 *4.2. Developing a programme of interventions*

474 The production coefficients calculated for both clinics and hospitals were applied to
475 utilization statistics. Indeed a production of 683 kg/day of hazardous waste out of
476 3,357 kg/day total HCW was estimated for the Gaza Strip (Table 6). However, the study
477 providing the unit production for hospitals did not give any error estimation (Home
478 Engineering Unltd et al., 2005b). Indeed, these quantities appeared to underestimate
479 production levels, because the number of beds in private HCFs was probably higher
480 and BOR considered was smaller than other documents (Ministry of Health 2011a).
481 Finally, none of the scattered sources was considered. According to these hypothesis,
482 the production of 683 kg/day of hazardous waste should be mainly composed of
483 infectious (80%, that is 16% of total HCW), sharps (15%, that is 3% of total HCW), blood
484 and bodily fluids, and others.
485 TABLE 6 HERE
486 Considering the spatial distribution of HCFs, HCW production was concentrated in the
487 Gaza City governorate, due to the presence of Al Shifa hospital. Hazardous HCW
488 production from clinics was instead more regularly distributed (Table 7).
489 TABLE 7 HERE
490 Finally, the analysis allowed the development of a program of intervention, based on
491 the field work and the system's needs (Table 8).
492 TABLE 8 HERE

493

494 *4.3. About the methodology*

495 The triangulation process of information from interviews, field visits, reports and other
496 documents was effective. The large set of primary sources considered served not only
497 to enable data reliability and validity, but also to provide background information to
498 better inform further investigations.

499 The approach to understanding regulation and HCWM at the Gaza Strip level enabled
500 definition of the required detail for the HCF rapid assessment, as well as an analysis of
501 key stakeholders. The rapid assessment gave a clear picture of public HCFs, and
502 informed judgments of non-governmental and private facilities. Indeed, HCWM in
503 these HCFs could potentially be different. However, the approach enabled an overview
504 of HCWM without the need to survey all the producers. The stakeholder analysis not
505 only helped identify challenges and priorities, but also completed the picture of HCWM
506 practices.

507 The estimation of HCW generation was difficult, due to the lack of adequate resources.
508 Indeed Kamal Edwan hospital presented a large production per occupied bed, while in
509 Al Shifa it looked more realistic. However, effective bed occupancy during any
510 weighing campaign should have been considered, as well as other factors like hospital
511 size, health-care services provided and specific level of management. Similar

512 considerations should be applied to the data from the clinics. Utilization statistics and
513 the estimations calculated were not particularly reliable due to the shortage and poor
514 quality of data, as is typical for similar situations (e.g. Manga et al., 2011; Caniato et al.,
515 2015a). However, estimations of HCW coefficients gave a rough indication of total
516 HCW production and hazardous component, and in particular demonstrated that a
517 large quantity of hazardous HCW was mismanaged. Moreover it was possible to
518 predict where the largest production of hazardous waste was concentrated. The
519 triangulation of this data with the HCFs segregating at least part of the waste allowed
520 identification of the main points of concern, and the development of the program of
521 intervention. Although it was not stated directly by HCWM stakeholders, the program
522 was based on their opinions and priorities. Therefore the process was implicitly
523 participated and experience-based. It did not only identify some humanitarian
524 responses, but suggested a holistic program of intervention which can address the
525 HCWM system improvement for a certain period. Keeping the focus on both the global
526 (i.e. the Gaza Strip) and the local (i.e. the HCF) level is the most appropriate strategy to
527 achieve an effective and sustainable improvement of HCWM.
528 Finally, such an in-depth data collection and triangulation process was necessary to
529 draw a reasonably acceptable picture of the situation in the area of intervention,
530 including some quantitative benchmarks. The extensive use of locally available reports

and documents was mandatory, due to the lack of more reliable data sources. Even in the case of an intervention on a very limited area (e.g. a single hospital), such a process should be undertaken in order to provide the analysis with an adequate contextualization and set reasonable targets of improvements. In particular, the goal of conservation of resources requires knowledge of the context, including barriers, threats and opportunities.

5. Conclusions

At the time of the study, the Gaza Strip faced and continues to face significant social, political and humanitarian challenges. These challenges placed a strain on the availability of resources to provide effective services, including for HCWM. However, it is evident that there was a link between the management of HCW (and indeed waste in general), and the partial alleviation of some of these challenges. For example, more effective management of HCW could lead to reduction in the public health and environmental risks posed not only to staff employed in the provision of health-care and management of waste, but also the community at large. A more sound management of HCW could also lead to a better use of resources, with an impact on financial performances of HCFs. The methodology proposed proved to be applicable in a humanitarian crisis. It could collect a large quantity of information, evaluate its

quality and address specific analyses through integration of the data. In particular the need for additional analyses is reduced because they entail particularly relevant costs and risks for field staff in a humanitarian context. Recommendations were developed starting from the challenges identified, considering opinions and priorities of all the stakeholders involved and the resources actually available. While so many barriers have been identified, given the resource-strained nature of the situation, some of the recommendations suggested could be implemented at low or no costs (e.g. introduction of technical specifications and guidelines, and provision of training). In particular, in order for these benefits to be realised, it is important to improve the governance structures and coordination amongst key stakeholders within the Gaza Strip, including local and international organisations. Despite the major hurdles to be overcome, effective management of waste and resources during a prolonged and serious humanitarian crisis such as is the case in the Gaza Strip is possible, and can lead to significant environmental and public health outcomes. However, effective, holistic and coordinated strategies have to be put in place for these outcomes to be realised.

Acknowledgements

This study was conducted within the activities of the “Support to vulnerable households affected by limited livelihood opportunities in the West Bank and the Gaza

Strip, Occupied Palestinian Territories" project, funded by the EU's Humanitarian Aid and Civil Protection, implemented by COOPI. The authors wish to thank all the COOPI staff, both in Italy and in oPt, for their support in the research activities.

Marco Caniato was a PhD student in "Appropriate Methods and Technologies for International Development Co-operation" at the University of Brescia, supported by the Alberto Archetti Fund.

References

Abd El-Salam, M.M., 2010. Hospital waste management in El-Beheira Governorate, Egypt. J. Environ. Manage. 91, 618–29. doi:10.1016/j.jenvman.2009.08.012

Aghapour, P., Nabizadeh, R., Nouri, J., Monavari, M., Yaghmaeian, K., 2013. Analysis of the health and environmental status of sterilizers in hospital waste management: a case study of hospitals in Tehran. Waste Manag. Res. 31, 333–7. doi:10.1177/0734242X12472706

Alhumoud, J.M., Alhumoud, H.M., 2007. An analysis of trends related to hospital solid wastes management in Kuwait. Manag. Environ. Qual. An Int. J. 18, 502–13. doi:10.1108/14777830710778274

Al-Khatib, I.A., 2008. Management of solid medical waste in the private medical sector in the Occupied Palestinian Territory: Problems and remedial measures. East. Mediterr. Heal. J. 14, 1164–72.

Al-Khatib, I. a, Al-Qaroot, Y.S., Ali-Shtayeh, M.S., 2009. Management of healthcare waste in

588 circumstances of limited resources: a case study in the hospitals of Nablus city, Palestine. Waste
589 Manag. Res. 27, 305–12. doi:10.1177/0734242X08094124

590 Al-Khatib, I. a, Sato, C., 2009. Solid health care waste management status at health care centers in the
591 West Bank--Palestinian Territory. Waste Manag. 29, 2398–403.
592 doi:10.1016/j.wasman.2009.03.014

593 Askarian, M., Motazedian, N., Palenik, C.J., 2012. Clinical laboratory waste management in Shiraz, Iran.
594 Waste Manag. Res. 30, 631–4. doi:10.1177/0734242X11413330

595 Bdour, a, Altrabsheh, B., Hadadin, N., Al-Shareif, M., 2007. Assessment of medical wastes management
596 practice: a case study of the northern part of Jordan. Waste Manag. 27, 746–59.
597 doi:10.1016/j.wasman.2006.03.004

598 Caniato, M., Tudor, T., Vaccari, M., 2015a. International governance structures for health-care waste
599 management: A systematic review of scientific literature. J. Environ. Manage.
600 doi:10.1016/j.jenvman.2015.01.039

601 Caniato, M., Tudor, T., Vaccari, M., 2015b. Understanding the perceptions, roles and interactions of
602 stakeholder networks managing health-care waste: A case study of the Gaza Strip. Waste Manag.
603 35, 255–64. doi:10.1016/j.wasman.2014.09.018

604 Caniato, M., Vaccari, M., 2014. How to assess solid waste management in armed conflicts? A new
605 methodology applied to the Gaza Strip, Palestine. Waste Manag. Res. 32, 908–17.
606 doi:10.1177/0734242X14543553

607 CIA, 2016. The World Factbook - Gaza Strip [WWW Document]. URL
608 https://www.cia.gov/library/publications/the-world-factbook/geos/gz.html (accessed 9.11.16).

609 Ciplak, N., Barton, J.R., 2012. A system dynamics approach for healthcare waste management: a case
610 study in Istanbul Metropolitan City, Turkey. Waste Manag. Res. 30, 576–86.
611 doi:10.1177/0734242X12443405

612 DHV, ENFRA, TECC, 2012. Feasibility Study and Detailed Design for Solid Waste Management in the Gaza
613 Strip.

614 El-Hawi, M.K., 2004. Towards an environmentally sound sustainable solid waste disposal strategy: the
615 Gaza Strip case. University of Salford, UK.

616 Home Engineering Unltd, ECO Consult, Tebodin, 2005a. Master Plan for Healthcare Waste Management
617 West Bank/Gaza Strip - revised draft. Gaza City.

618 Home Engineering Unltd, ECO Consult, Tebodin, 2005b. Feasibility Study for the Implementation of
619 Healthcare Waste Master Plan in West Bank/Gaza Strip - Final Report. Gaza City.

620 Home Engineering Unltd, ECO Consult, Tebodin, 2005c. Analysis of Current Situation Regarding
621 Healthcare Waste Management in West Bank/Gaza - Report 1.

622 Kamel, S., 2011. Medical waste materials and methods of disposal in the Gaza Strip. Islamic University,
623 Gaza City, Palestine.

624 Massrouje, H.T., 2001. Medical waste and health workers in Gaza governorates. East. Mediterr. Health J.
625 7, 1017–24.

626 Ministry of Health, 2011a. Health Status in Palestine 2010. Nablus.

627 Ministry of Health, 2011b. Medical Waste incinerator situation in Ministry of Health of Gaza - Unofficial
628 translation from Arabic. Gaza City.

629 Ministry of Health, 2011c. Incinerator run protocol - unofficial translation from Arabic. Gaza City.

630 Ministry of Health, 2010. Recommendations of the committee of the Directorate of the medical wastes
631 in the Ministry of Health - unofficial translation from Arabic. Gaza City.

632 Ministry of Health, 2004. Infection Prevention and Control Protocols.

633 Palestinian Legislative Council, 2004. Public Health Law. Occupied Palestinian Territories.

634 Palestinian National Authority, 2010. National Strategy for Solid Waste Management in the Palestinian
635 Territory 2010-2014. Palestinian Territory.

636 Palestinian National Authority, 2009. Concerning the management and the handling of medical waste -
637 Draft and still to approve. Unofficially translated to English by COOPI staff. Occupied Palestinian
638 Territories.

639 PCBS, 2009. Environmental Survey for Health Care Centers. Ramallah, Palestine.

640 PCBS, 2000. Medical Environmental Survey 2000: Main Findings. Ramallah, Palestine.

641 President of the Palestinian Authority, 1999. Palestinian Environmental Law. Occupied Palestinian
642 Territories.

643 Pruss, A., Giroult, E., Rushbrook, P. (Eds.), 1999. Safe management of wastes from health-care activities,
644 1st ed, World Health. World Health Organization, Geneva.

645 Pruss-Ustun, A., Emmanuel, J., Rushbrook, P., Zghondi, R., Stringer, R., Pieper, U., Townend, W.K.,
646 Wilburn, S., Chartier, Y. (Eds.), 2013. Safe management of wastes from health care activities, 2nd
647 ed, Bulletin of the World Health Organization. World Health Organization, Geneva.

648 Qumboz, A., 2002. Hazardous Waste Management in Gaza Governorates. Al-Quds University, Gaza City,
649 Palestine.

650 Regional Health Systems Observatory, EMRO, 2006. Health Service Delivery, in: Health System Profile -

651 Palestine. Regional Health Systems Observatory - World Health Organization, pp. 29–39.

652 Sarsour, A., Ayoub, A., Lubbad, I., Omran, A., Shahrour, I., 2014. Assessment of Medical Waste
653 Management within Selected Hospitals in Gaza Strip Palestine: A Pilot Study. Int. J. Sci. Res.
654 Environ. Sci. 2, 164–173. doi:10.12983/ijsres-2014-p0164-0173

655 SBC, UNEP, 2011. Basel convention on the control of transboundary movements of hazardous wastes
656 and their disposal. Secretariat of the Basel Convention, Chatelaine, Switzerland.

657 Schabas, W., McGowan Davis, M., Diene, D., 2015. Report of the independent commission of inquiry
658 established pursuant to Human Rights Council resolution S-21/1. Geneva.

659 SSC, UNEP, 2009. Stockholm Convention on Persistent Organic Pollutants (POPs). Secretariat of the
660 Stockholm Convention, Geneva, Switzerland.

661 UK Environment Agency, 2014. UK Conversion Factors for waste.

662 UNRWA, 2011. The Annual Report of the Department of Health 2010.

663 WHO, EMRO, 2010. Health Facilities Maps in oPt [WWW Document]. URL
664 http://www.emro.who.int/palestine/index.asp?page=maps (accessed 9.15.11).

665 WHO, UNDP, UNSCO, MoH, 2011. Assessment of Public Health Estate in Gaza - Final version (still
666 unpublished).

667 WHO, UNEP/SBC, 2011. HCWM Rapid Assessment Tool (RAT) - 2nd edition [WWW Document]. URL
668 http://www.healthcarewaste.org/fileadmin/user_upload/resources/RAT-v2-en.xls (accessed
669 12.27.13).

670 Zoarob, Z.K., 1997. Hazardous Waste Management in Gaza Strip. IHE Delft, Netherlands.

671 Table 1 – Hospitals and clinics in the Gaza Strip

673

Reference / HCFs	WHO et al. 2011		WHO & EMRO 2010		
	# of facilities	# of beds	# of facilities	# of beds	# of patients*
Hospitals	**27**	**2,697**	**28**	**2,697**	1,685,265
MoH	13	2,009	13	2,040	1,325,658
PMMS	-	-	1	45	56,720
NGOs	14	688	11	549	302,887
Private			3	63	N.A.
	# of facilities	Facilities with buildings in bad conditions	# of facilities	# of visits**	
Clinics	**131**	**9**	**110**	6,493,704	
MoH	54	9	56	2,735,716	
UNRWA	20	N.A.	20	3,449,316+	
NGOs	57	N.A.	34	308,672++	

674 *N.A.: not available.*
675 **: # of patients includes admissions, outpatient and ER visits.*
676 ***: # of visits includes general practitioner and specialized visits.*
677 *+: data from 3 clinics are missing.*
678 *++: data from 8 clinics are missing.*

679

680 Table 2 – Management of hazardous health-care waste categories in the Gaza Strip

HCWM step	Pharmaceutical waste	Anatomic waste	Infectious and sharps waste
Definition and segregation	MoH HCFs segregated parts of expired medicines or leftover without any clear criterion or specific procedures.	Anatomic waste includes body parts and placenta and should be buried in accordance with Islamic practices. The waste was segregated, with different procedures according to the HCF.	Waste considered infectious by HCF were segregated. Only some nongovernmental HCFs used colour coding. Several HCFs did not segregate infectious waste, or did it for a very small quantity. Sharps should be segregated in a safety box.

Collection and onsite storage	Pharmaceutical waste was stored without specific attention.	Anatomic waste was collected and temporary stored in the HCF. Then, patient's family collected it and provided for an adequate burial. In several HCFs, placentas could not be stocked properly, thus they were directly disposed in plastic bags with general MSW, sometimes with chlorine. Animals regularly scavenged for it in MSW containers. Body parts uncollected by families should be buried by the MoH, but this practice did not follow a specific procedure.	Collection was usually carried out with the same trolleys for general waste and without specific routing. Safety boxes were temporary stored with infectious waste bags, frequently not in a dedicated room (e.g. generator house or entrance).
Haulage	General Directorate for Pharmacy within the MoH periodically collects from MoH HCFs and sends to Johr al Deek landfill.		Hospitals and nongovernmental clinics had their own haulage system. MoH provided a monthly collection service, but without a fixed schedule.
Treatment	A small part of the waste was disposed in the hazardous waste section (it should be encapsulated in cement boxes, but they are simply stocked without proper closure), and the remaining was crushed and landfilled in the non-hazardous section. Separation criterion were not well defined.		3 small-scale incinerators were available, but a limited number of HCFs sent their infectious waste and sharps there. Others simply mixed such a waste stream with MSW.
Residue disposal			Bottom ash was mixed with MSW. Incinerators were not provided with air pollution control devices, thus fly ash was not produced.
Quantity estimation	No official data were available.	No data were available.	No clear data were available.
Cost	Collection and transportation costs were not available. Disposal costs were 150 NIS/m^3 (about 39 USD/m^3).	No data were available.	No data were available.

681

682 Table 3 – HCWM in HCFs in 2012 according to the health service providers

Step	Aspect	MoH hospital	MoH clinic	UNRWA clinic	NGO clinic/hospital	Private hospital
Segregation	*Written procedure*	No	No	Yes	According to NGO	N.A.
	Procedure in place	Sharps segregation , theoretically infectious but rarely applied	Sharps segregation, theoretically infectious but not applied	3 categories: - Sharps - Infectious - General	According to NGO	N.A.
	Colour coding	No	No	Yes	According to NGO	N.A.
	Bins	Generally plastic	Generally plastic	Plastic	Generally plastic	N.A.
	Bags	Poor quality plastic, not always present	Poor quality plastic, not always present	Plastic, according to waste typology	According to NGO	N.A.
Collection	*Procedure*	3 times/day	1-2 times/day	1-2 times/day	According to NGO	N.A.
	Workers	Private company	Private company	Internal staff	Private company/internal staff	N.A.
	PPE	According to private company	According to private company	Good	N.A.	N.A.
Onsite transport	*Procedure*	No	No	No	N.A.	N.A.
	Method	Trolley, cart, hand	Trolley, cart, hand	Trolley	Trolley, cart, hand	Trolley, cart, hand
Temporary storage	*Hazardous (sharps)*	Various	Various	Various	Various	Various
	To landfill	Container	Container	Container	Container	Container

N.A. not available (information was not enough to determine a general practice)

NOTE: Liquid waste from all the HCFs was directly disposed into the sewage system. Only a fraction was partially treated.

683

684

685 Table 6 – Estimation of HCW coefficients and total production

SOURCE		ESTIMATION		TOTAL PRODUCTION	
CLINICS*	Total visits/year	HCW (kg/visit)	Hazardous HCW (%)	HCW (kg/day)	Hazardous HCW (kg/day)

MoH	2,735,716	0.025±0.011	20%	187±82	37±16
UNRWA	3,449,316	0.060±0.010	22%	567±95	125±21
NGO	308,672	0.060±0.010	22%	51±8	11±2
			SUB TOTAL	**805**±185	**173**±39
HOSPITALS**	**Total beds**	**HCW (kg/bed/d)**	**Hazardous HCW (%)**	**HCW (kg/day)**	**Hazardous HCW (kg/day)**
MoH/MSP	2,085	1.3	20%	1,973	395
Private	549	1.3	20%	520	104
NGO	63	1.3	20%	60	12
BOR (Bed Occupancy Rate) = 72.8%			**SUB TOTAL**	**2,552**	**510**
				HCW (kg/day)	**Hazardous HCW (kg/day)**
			TOTAL PRODUCTION	**3,357**	**683**

Scattered sources were not included.
Error estimation of total production not included due to the impossibility to estimate it for hospital production.
*: MoH unit production based on weighing campaign, and composition on Pruss-Ustun et al. (2013). UNRWA estimation was applied for both UNRWA and NGO clinics. Number of visits is based on WHO & EMRO (2010).
**: Unit production and composition based on Home Engineering Unltd et al. (2005b). Number of beds based on WHO & EMRO (2010). BOR adapted from WHO et al. (2011): total BOR was calculated as the total beds occupied on the total beds available in MoH hospitals. Error estimation for hospital production was not available.

686

687

688 Table 7 – Estimation of hazardous HCW production in kg/day and distribution per governorate

CLINICS	**North Gaza (kg/day)**	**Gaza City (kg/day)**	**Middle Zone (kg/day)**	**Khan Younis (kg/day)**	**Rafah (kg/day)**	**TOT (kg/day)**	**%**
MoH	7±3.1	15±6.6	5±2.2	7±3.1	4±1.8	37±16.7	22%
UNRWA	21±3.5	43±7.2	29±4.8	8±1.3	24±4.0	125±20.8	72%
NGO	2±0.3	4±0.7	1±0.2	4±0.7	1±0.2	11±2.0	6%
SUB TOTAL	**30**±6.9	**61**±14.4	**34**±7.2	**19**±5.1	**29**±5.9	**173**±39.6	100 %
	17%	35%	20%	11%	17%	100%	
HOSPITALS	**North Gaza (kg/day)**	**Gaza City (kg/day)**	**Middle Zone (kg/day)**	**Khan Younis (kg/day)**	**Rafah (kg/day)**	**TOT (kg/day)**	**%**
MoH	26	212	26	105	18	386	76%

MSP	9	0	0	0	0	9	2%
NGO	13	57	9	24	0	104	20%
Private	0	12	0	0	0	12	2%
SUB TOTAL	**48**	**280**	**35**	**129**	**18**	**510**	100 %
	9%	55%	7%	25%	3%	100%	
	North Gaza (kg/day)	**Gaza City (kg/day)**	**Middle Zone (kg/day)**	**Khan Younis (kg/day)**	**Rafah (kg/day)**	**TOT (kg/day)**	
TOTAL PRODUCTION	**78**	**341**	**69**	**148**	**47**	**683**	
%	11%	50%	10%	22%	7%	100%	

Error estimation of total production not included due to the impossibility to estimate it for hospital production