

1 **Recovering value from used medical instruments: a case study of**
2 **laryngoscopes in England and Italy**

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9

10 **Abstract**

11

12 The healthcare sector has a relevant environmental footprint because of the
13 significant materials throughput, the hazardousness of certain wastes it generates
14 and the energy intensive treatment necessary to manage them. Using semi-
15 structured interviews carried out with stakeholders from hospitals in England and
16 Italy, this study sought to understand how best to recover value from used
17 laryngoscopes. The findings suggest that despite differences in the use of single use
18 instruments and the presence of a dedicated waste management department, sites
19 in both countries face similar challenges, including limited communication
20 between procurement and waste management staff, staff engagement, and end
21 markets. The implications of these challenges and strategies for overcoming them
22 are discussed.

23

24 **Key words:**

25

26 Circular economy, Healthcare waste, Medical waste, Laryngoscopes, Medical
27 devices

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28 **1. Introduction**

29

30 Within recent years, the concepts of the circular economy, including recovery of
31 the intrinsic value of materials, have gained progressively more attention
32 (Moscato, 2009; Pinjing *et al.*, 2013; UNEP and ISWA, 2015). Effective waste
33 segregation and treatment can enable the reintroduction of materials in the
34 economic chain, as reusable or recycled goods or in place of raw materials (UNEP,
35 2015). The EU Waste Framework Directive represents a step towards a circular
36 economy through the incorporation of a waste hierarchy in the decision-making
37 process, aiming at the promotion of value recovery from waste, through
38 minimisation, reuse and recycle and the reduction of disposal (EC, 2008; 2014).
39 Similarly, also national governments are trying to incorporate the concept into
40 their national policies, by promoting green purchases and sustainable waste
41 management practices. For example, the United Kingdom (UK) has sought to foster
42 the transition to a 'green economy' at national and local levels (DEFRA, 2011). The
43 Italian Government has also published the official guidelines for the national green
44 public procurement policy (Italian Ministry of the Environment, 2008). While the
45 Public Service Act in England requires commissioners to hold into consideration
46 the environmental value, together with the economic and social ones, when buying
47 goods for public services (Public Services Act, 2012). The decision-making process
48 at the stages of purchase, use and disposal have inevitable repercussions for the
49 type and amount of wastes produced, the risks to individuals and the environment,
50 and the potential for value recovery (Haas *et al.*, 2015; Castellani *et al.*, 2015;
51 Caniato *et al.*, 2015; Ghisellini *et al.*, 2015).

52

53 Although statistics concerning healthcare waste production and disposal at
54 national level are available (e.g. on the websites of the Italian Ministry of Health
55 and the English Health & Care Information Centre), there is limited information on
56 how best to ensure value recovery in the management of used medical
57 instruments. Therefore, using a case study approach, this study aimed to examine
58 strategies for enhancing the recovery of value from laryngoscopes in Italy and
59 England.

60

61 **2. Managing healthcare waste and used laryngoscopes**

62

63 Healthcare facilities produce a very wide range of waste streams, some of which
64 are hazardous, but most are non-hazardous. Indeed, more than 80% of the waste
65 generated in hospitals worldwide can on average be defined as 'general waste'
66 (WHO, 2014). Good segregation is a key factor in limiting contamination, and
67 containing risks (including the spread of infections), and reducing the quantity of
68 waste treated as hazardous (Chaerul *et al.*, 2008; Windfeld, 2015; De Feo and
69 Malvano, 2009; Di Maria *et al.*, 2014; Eriksson *et al.*, 2005).

70

71 Greater sustainability within healthcare can be facilitated through green
72 purchasing (Kaiser *et al.*, 2001; Bergsma and Sevenster, 2013), having a dedicated
73 waste manager (Tudor *et al.*, 2010) and effective segregation and management of
74 the waste (Windfeld and Brooks, 2015; Lee *et al.*, 2004).

75

76 The legislative background on which the English and Italian health care waste laws
77 have been developed is the European Waste Framework Directive (WFD) (EC,
78 2008). The WFD suggests the need to manage all types of wastes without
79 endangering people and the environment and according to a hierarchy, aiming at
80 recovering as much value as possible from it. In England, the Waste (England and
81 Wales) Regulations mandates separate collection and that the segregated streams
82 should undergo recovery operations (Defra, 2012). In addition, the Hazardous
83 Waste Regulations outline stringent guidelines that must be followed when
84 managing, transporting or treating hazardous waste (Defra, 2015). Lastly, the
85 Medical Devices Regulations prescribes that consignment notes must be duly filled
86 in including not only the components of a device but also the eventual presence of
87 a battery (DH, 2013).

88

89 In the Italian legislation, the legislative decree DLgs. 152/2006, as amended by the
90 DLgs. 205/2010, states that the first objective of a sound waste management
91 (including healthcare waste), is precaution, namely the protection of the health of
92 patients, operators and all people involved (Italian Government, 2010). It also
93 explicitly includes the safeguard of the environment and the reduction of

94 wastefulness as essential recommendations that operators should follow. The
95 D.P.R. 254/03 on clinical waste, called “special waste”, is another key regulation in
96 the field (President of the Italian Republic, 2003). The decree outlines seven
97 different waste streams that fall under the definition of clinical waste, and how
98 they should be stored and transported (Cottone and Cottone, 2008). In addition to
99 this classification, it establishes that the recovery of value from certain streams,
100 such as non-hazardous metals, should be incentivised (APAT, 2008).

101

102 A further fundamental aspect of hazardous healthcare waste management
103 concerns the sterilisation of potentially infectious and contagious devices. The
104 overarching piece of legislation is the European Directive 93/42 on Medical
105 Devices, introduced in the Italian legal system through the Legislative Decree
106 46/97 (Scaini, 2010). The decree sets out the minimum acceptable requirements
107 that sterilisation must satisfy, including the safeguard of patients’ and other
108 people’s health, and the efficacy and reliability of sterilised instruments. Another
109 important aspect that comes into play is the purchase of medical devices. This
110 subject is covered by the “*Piano d’azione per la Sostenibilità Ambientale dei*
111 *Consumi nel Settore della Pubblica Amministrazione*” (the action plan for the
112 environmental sustainability of consumption practices within the public
113 administration sector), a non-compulsory strategy issued by the Italian Ministry of
114 the Environment together with the Ministry of Economy supporting green
115 procurement in public administrations. The input to these guidelines comes from
116 the European Union, which in 2001 issued the European Communication n.
117 274/2001, the most important document on green public procurement (Testa *et*
118 *al.*, 2012).

119

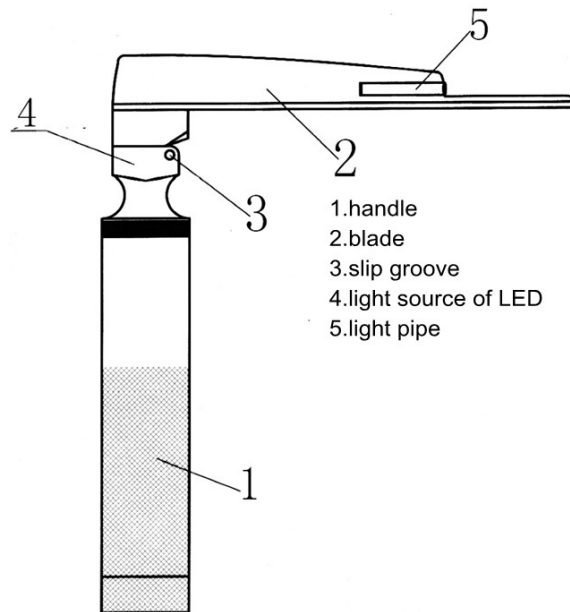
120 *2.1 Laryngoscopes*

121

122 The present work focused on laryngoscopes, which are medical devices inserted
123 into the mouth during a procedure to obtain a view of the patient’s vocal folds or
124 glottis (Fig. 1).

125

126



127

128 Fig. 1: A basic laryngoscope

129 Source: <http://about-surgical-instruments.blogspot.co.uk/>

130

131 Several reasons lay behind this choice. First, the high quality of the metal present
 132 in surgical instruments represents a valuable material to recover, as they are
 133 typically made from stainless steel (Ibbotson *et al.*, 2013). Second, the presence of
 134 a battery inside the laryngoscope. Batteries, if incinerated, could explode (DH,
 135 2013) and contribute negatively to the noxious emissions of the treatment plant
 136 (Xarà *et al.*, 2015). This means that laryngoscopes, no matter if single use or
 137 reusable, should ideally be disassembled and the components effectively
 138 segregated (Dahlén and Lagerkvist, 2010).

139

140 Before being utilised – unless new – non-disposable laryngoscopes must be
 141 sterilised. Given the inevitable contact with mucosae, used laryngoscopes have to
 142 undergo either high temperature sterilisation or disinfection (Scaini, 2010). This
 143 process is very energy intensive and can create a significant environmental
 144 footprint, depending on the energy source of the hospital (McGain *et al.*, 2012).
 145 There is widespread support for the use of reusable over disposable from an
 146 economic point of view (Deprez *et al.*, 2000; Adler *et al.*, 2005; Morrison *et al.*,
 147 2004; McGain *et al.*, 2012; Champion *et al.*, 2012). However, the economic efficiency
 148 depends on the number of times a device is used (Yang *et al.*, 2000).

149

150 During use, as the instrument gets into contact with sensitive and receptive body
151 parts such as the mucosae of the mouth, they can potentially become infectious
152 both for staff and patients (Williams *et al.*, 2010; Simmons *et al.*, 2000). Even when
153 using disposable scope blades, reusable handles can still represent a possible
154 source of contamination (Call *et al.*, 2009; Williams *et al.*, 2010). However, some
155 medical products (e.g. single use versus reusable), are often preferred to others
156 more based on anecdotal information and opinions, rather than on actual evidence
157 (McGain *et al.*, 2012).

158 **3. Methods**

159

160 Several potential interviewees in both England and Italy, with key roles in the
161 waste management or in the purchase department of a hospital, were initially
162 contacted through known acquaintances of the research team. In the end, three
163 sites for each of the two countries were selected, based primarily on access and the
164 availability of data. Therefore, as it is often the case with interviews, the sample
165 size was relatively small and was repeatedly adjusted (Denscombe, 2010). Face-to-
166 face semi-structured interviews conducted in the respondents' offices were
167 chosen, based in part on previous studies (Tudor *et al.*, 2010). The interviews in
168 England were conducted during May 2015, while in Italy they were conducted
169 from July to the beginning of September 2015. The questions were sent to the
170 interviewees beforehand, along with a consent form and participant information
171 sheet, as well as potential dates for the interview. Three interviews each were
172 undertaken in Italy and England, giving a total of six interviews. Ethical approval
173 for the study was granted by the School of Science and Technology at the
174 University of Northampton.

175

176 The use of semi-structured interviews enabled an in-depth understanding of the
177 site's policies and procedures, as well of the opinions and perceptions of the
178 interviewee. The questions aimed to understand how used medical instruments,
179 particularly laryngoscopes were disposed of and if there are potential options
180 available for recovery, as well as potential future trends in the field of medical

181 devices, possible obstacles to value recovery and influencing factors in the decision
182 making processes. Examples of questions asked included: How many inhalers and
183 laryngoscopes does the hospital purchase every year? How much do these
184 instruments cost? How many inhalers and laryngoscopes has the hospital
185 discarded yearly in the past three years (2012 – 2013 – 2014) and what is the cost
186 of their disposal? Which are the main obstacles to potentially recover more value,
187 (e.g. Logistic, financial viability, public health issues, etc.)?
188

189 All interviews were audio recorded and later transcribed (Seidman, 2013).
190 Analysis involved coding of the transcripts, a process composed of several steps:
191 reading and interpreting the qualitative data obtained and analysing and marking
192 all passages relevant to the aim of the research (Denscombe, 2010; Seidman,
193 2013). The data were categorised according to the phase they pertained to in the
194 life cycle of the medical device analysed (i.e. procurement of the instrument, use
195 and management (i.e. reuse or final disposal)).
196

197 The information from the interviews was contextualised with secondary data
198 gathered using government and industry publications, that were publically
199 available and had been published within the past five years.. More specifically,
200 websites of healthcare sites of the Italian Ministry of Health and the English Health
201 & Care Information Centre, provided quantitative data on the organisational
202 structures, such as number of beds and wards, and the amounts and types of waste
203 produced by the units. In addition, the Sanitary Medical Disposal Association
204 (SMDSA), the Environment Agency and the Italian Institute for Environmental
205 Protection and Research (ISPRA) supplied additional indications regarding the
206 environmental cost of hazardous healthcare waste treatments.

207 **4. Results**

208 *4.1 The English health care sector*

209

210 Table 1 outlines the characteristics of three sites visited in England and the job
 211 roles of the interviewees.

212

213 **Table 1: Overview of the health care sites visited in England and the job roles**
 214 **of the different respondents**

215

SITE	N° of beds	N° of employee	N° of Interviewees		Job role
Hospital 1	1,100	13,000 < x < 14,000	2	Interviewee 1.1	Sustainability Manager
				Interviewee 1.2	Waste Manager
Hospital 2	1,300	8,000 < x < 9,000	1	Interviewee 2.1	Waste Manager
Hospital 3	1,000	8,000 < x < 9,000	2	Interviewee 3.1	Sustainability Manager
				Interviewee 3.2	Waste Manager

216

217 4.1.1 Phase one: procurement of the instruments

218

219 In each of the three sites visited, reusable laryngoscopes were progressively being
 220 replaced by single use stainless steel or mixed material devices (i.e. with a plastic
 221 body and metallic blades). Most interviewees agreed that single use for
 222 laryngoscopes, as well as for other medical instruments would increase. In
 223 Hospital 3, use of single use instruments was as a result of a combination of
 224 factors, mainly infection control and the market of purchased products, which was
 225 pushing for use of single use instruments.

226

227 Interviewee 1.1: “we are seeing a real trend – in the NHS generally –
 228 towards disposable medical instruments, for one-time use
 229 instruments.”

230

231 Interviewee 2.1: “I think it might be part of a bigger trend to go
 232 towards single use as well. There’s a lot more...not even devices, a lot
 233 more things that are becoming single use.”

234

235 Interviewee 3.2: "I wouldn't say it's a trend. I would say it is the
236 market that brings them forward. And the regulation kind of supports
237 it because it kind of fits in with the regulation."
238

239 Together with the concern for infection prevention, another factor heavily
240 influenced the type of devices purchased, namely the price. According to
241 Interviewee 3.2, this element contributed "at least 40%" to the choice, but it
242 usually did not include the whole life cost of the instrument. The only element
243 considered during procurement was the amount each single piece costs, with
244 neither maintenance nor disposal taken into account. According to Interviewee 3.1,
245 not only are disposal costs neglected, but also all operational costs are excluded
246 when evaluating the cost of a product:
247

248 "we might end up buying something that is 50 quid (£s) cheaper,
249 because we always buy the cheaper, because that cheaper is clearly
250 without the cost of electricity, the cost of water, the cost of waste
251 disposal. So it's linking the capital budget with the operational budget.
252 That is probably one of the biggest challenges for organisations like
253 us."
254

255 In most cases, there was no interaction between the waste management team and
256 the procurement department. Interviewee 2.1 noted that the waste management
257 team did not come into play until the very last stage. Only then did the team find
258 out if new instruments had been purchased, what they were and had to figure out
259 how best to deal with them.
260

261 An additional concern that interviewee 2.1 raised on purchase regards the design
262 of the single use laryngoscopes bought by the hospital. In order to properly
263 dispose of an instrument with a fitted battery, it would be preferable to be able to
264 disassemble the object and effectively dispose of the different components
265 according to the legal provisions.
266

267 The general impression was that the market was contributing to the shift to
268 disposable instrument, by promoting cheaper single use solutions instead of more
269 'expensive' traditional instruments. This impression was reinforced by interviewee
270 3.2 concerning the use of disposable instruments, who noted that the market
271 "brings them [the single use instruments] forward". Furthermore, it was the
272 market that influenced the potential recycling of the instrument, by designing
273 "sealed units" that are not supposed to be disassembled or recovered.

274

275 Hospital 2 bought 150 packets containing 10 single use instruments each, between
276 February 2014 and March 2015. This suggests that a hospital with 1,300 beds
277 usually needs 1,500 laryngoscopes for 14 months, a rough average of 107
278 disposable scopes a month. During 2014/5, Hospital 3 ordered 17,700 packs,
279 containing 10 disposable blades for laryngoscopes. Over the same period, 30 packs
280 of 10 handles were purchased. The cost of disposable blades varied between £2.5 –
281 22.67.

282

283 4.1.2 Phase 2: Use of the instruments

284

285 The focus on single use as a way to avoid contamination was noted by Interviewee
286 1.1, who suggested that disposable instruments not only reduced pathways of
287 infections but also "remove doubts" on potential contamination. Thus the
288 perceived infection prevention played a key role in the use of the instruments.
289 However, not all instruments used in the three sites were disposable. The use of
290 reusable instruments was still widespread in Hospital 1, where the sterilisation
291 unit was still actively used and has been expanded in order to respond to the needs
292 of the site. Indeed, the presence of a sterilisation unit was inevitably a determining
293 factor in the sites choosing which type of instrument to purchase.

294

295 Segregation of the instruments from other waste was done with the help of colour-
296 coded packaging. However, the presence of so many different collection bins
297 generated difficulties, mostly connected to the lack of space to locate the
298 containers and the difficulty in training staff on how to properly segregate waste.

299

300 4.1.3 Phase 3: management of used instruments

301

302 Healthcare sites in the UK generated about 374,151 tons of waste during 2013 –
303 2014 (HSCIC, 2015). Table 2 illustrates that during 2013/4, nearly a quarter of the
304 waste was recycled, with most of the rest landfilled, or sent for high temperature
305 treatment.

306 **Table 2: Treatment processes for waste produced by the health care sector**
307 **during 2013/4**

308

High temperature disposal waste weight (Tonnes)	Non burn treatment disposal waste weight (Tonnes)	Landfill disposal waste weight (Tonnes)	Waste electrical and electronic equipment weight (Tonnes)	Preparing for re-use volume (Tonnes)	Other recovery volume (Tonnes)	Waste recycling volume (Tonnes)
69,524	62,709	82,408	2,046	6,382	62,441	88,639
19%	17%	22%	1%	2%	17%	24%

309

Adapted from HSCIC (2015)

310

311 The cost of waste disposal for the year 2013-2014 was over £86 million, of which
312 approximately £15.5 million was the cost of recovery, recycling and re-use (HSCIC,
313 2015). The difference of £70.5 million was spent for high temperature treatments,
314 other treatments and landfill disposal. Although being only a rough calculation,
315 from these amounts it is possible to say that the average cost of reuse, recovery
316 and recycling was about £98.3/tonne, while landfilling, thermal and other
317 treatments cost on average £326.5/tonne.

318

319 Single use instruments such as laryngoscopes were collected in bins and sent to
320 high temperature treatment facilities. An attempt to recover value from these
321 types of instruments was undertaken in Hospital 2, where metal devices were
322 collected in specific boxes that were then picked up free of charge by the waste
323 collector, although the hospital did not make any money. In exchange, the waste
324 collector got well-segregated, high quality metal instruments that could be sold to
325 companies recovering valuable materials. However, the continuous fluctuation in
326 the prices of certain recyclables threatened to interrupt the service or to introduce

327 charges. The presence of plastic components in some models and a battery
328 inserted in the sealed unit also presented a challenge to the hospital. In addition to
329 design, logistics represent a significant obstacle to value recovery. For example, the
330 site did not have enough staff to engage in a dismantling operation. A further
331 challenge faced was the lack of space for storage. Waste contractors generally
332 prefer to collect bigger bulks of materials, so the producer must be able to store its
333 waste until the desired amount is gathered.

334

335 Hospital 2 was charged on average £513/tonne for incineration and £190/tonne to
336 dispose of waste in hazardous landfills. The situation in Hospital 1 was slightly
337 different. Reusable tools were still widespread, with disposable instruments a
338 minority – even though they were increasing. Therefore, an attempt to limit the
339 loss of value came from the reutilisation of sterilised instruments.

340

341 Hospital 3 had different options as it was equipped with an on-site Energy from
342 Waste (EfW) facility. Thus the waste produced was not transferred to another site
343 to be treated. However, the presence of an EfW on-site provided an incentive to the
344 staff to dispose of more materials than necessary, the consequence being that
345 recycling was difficult to implement. According to Interviewee 3.2:

346

347 “We are our worst enemy in one way, because a lot of stuff goes
348 through that probably because we can...legally it’s fine, sustainably
349 mmm...it’s a bit of a bone of contention. The attitude is ‘We have an
350 on-site incinerator, we don’t have to worry quite as much because we
351 are not paying commercial prices for our waste’.”

352

353 Thus a significant role was played by the waste management behaviours of staff.
354 Further to this, according to Interviewee 3.2, lack of time and staff engagement
355 were also important challenges to effective waste segregation:

356

357 “We are getting less value back for scrap metal because our scrap
358 metal contractor is having to get the plastic part off it. So we are going
359 to lose some money out, we are not going to get as much, whereas if

360 we had somebody here to get that bit off, we could probably use a
361 different contractor or they'd give us a higher value.”

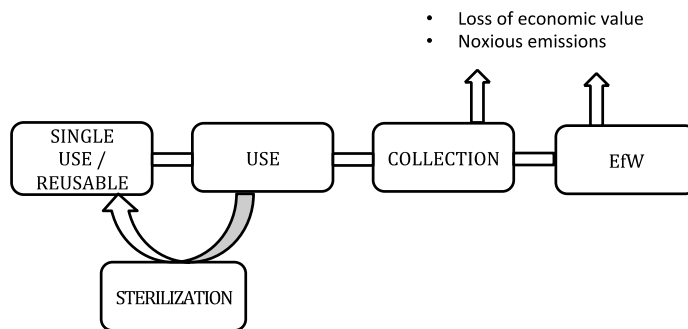
362

363 4.1.4 Practices of value recovery from used metallic devices in England

364

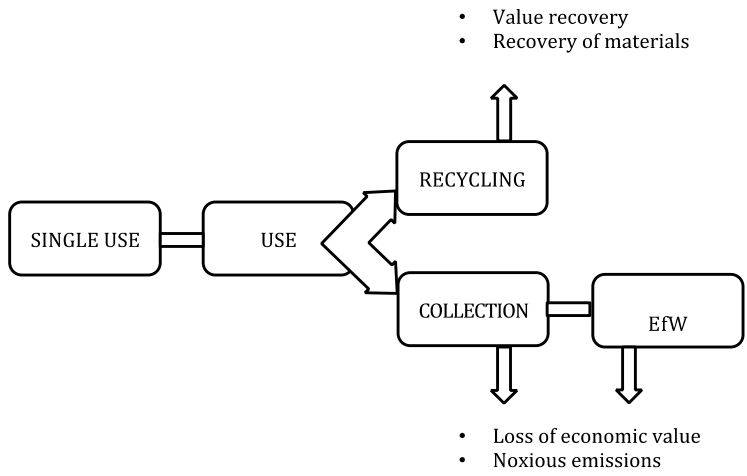
365 Figures 2 – 4 outline the overall management systems for the instruments, by the
366 three hospitals.

367



368

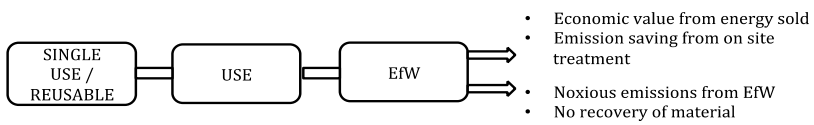
369 **Figure 2: Life cycle of metallic medical instruments in Hospital 1**



370

371 **Figure 3: Life cycle of metallic medical instruments in Hospital 2**

372



373

374 **Figure 4: Life cycle of metallic medical instruments in Hospital 3**

375 **4.2. The Italian health care sector**

376 Table 3 lists the characteristics of the sites and the job roles of interviewees at the
377 Italian hospitals.

378 **Table 3: Overview of the health care sites visited in Italy and the job role of**
379 **the different respondents**

380

SITE	N° of beds	N° of employee	N° of Interviewees		Job role
Hospital 4	1,600	$8,000 < x < 9,000$	1	Interviewee 4.1	Sustainability Manager
Hospital 5	600	$2,000 < x < 3,000$	1	Interviewee 5.1	Chief Medical Officer
				Interviewee 5.2	Health Engineer
				Interviewee 5.3	Nursing Staff
Hospital 6	1,400	$5,000 < x < 6,000$	2	Interviewee 6.1	Purchase Dept. officer
				Interviewee 6.2	Eco Manager

381

382 4.2.1 Phase one: procurement of the instruments

383

384 In Italy, in order to purchase any kind of good or service, hospitals – like any other
385 public structures – have to participate in tender notices. Tenders take place at
386 Regional level and are managed by an external organisation (e.g. for the Tuscan
387 region it is ESTAV (Ente per i Servizi Tecnico-Amministrativi di Area Vasta, i.e.
388 Public Body for technical and administrative services of large areas), which runs
389 them in response to the needs of all health care sites in the Region. Tender
390 processes are particularly long and bureaucratic processes: according to
391 Interviewee 6.1, they can easily last 2 years. The procedure is divided into several
392 steps, which involves different departments and stakeholders of the health care
393 sector. A key step concerns the cost evaluation of the new equipment that they are
394 purchasing. For the three sites, at the time of purchase, neither the environmental
395 impacts nor the final cost of disposal was taken into account. Ministerial guidelines
396 for green public procurement were totally disregarded at the hospitals visited, in
397 favour of other factors such as the efficiency of the instrument/device bought and
398 its cost. This aspect was confirmed by Interviewee 5.3, who noted:

399

400 “give guidelines to ESTAV, not only on waste management, waste
401 disposal, but also on other passages, on reconditioning, [...]. There are
402 like separate containers in the company government. I do a thing and
403 you do another one that will certainly increase the final cost of the
404 process but since it is divided between you and me, I do not care! I
405 saved money! Then if costs increase, it is an issue that concerns
406 someone else, someone dealing with waste.”

407

408 Thus the final cost of disposal was not taken into account at any stage during
409 procurement. Lack of communication, appeared to be one of the reasons
410 responsible for the situation. A significant exception to this lack of collaboration
411 between departments was represented by Hospital 4, where the purchase of larger
412 devices, furniture and machinery employed a different approach. This policy was
413 the result of collaboration and of the combination of the interests represented by
414 different departments. It meant that the site did not purchase or own any of these
415 instruments but rather it solely rented them. A monthly rental charge was paid to
416 the producer, who in exchange took care of maintenance, substitution and disposal
417 of the product. Although being slightly more expensive as a whole, this mode of
418 operation was preferable according to Interviewee 4.1 because it guaranteed a
419 steady, known cash outflow and did not require a huge start-up capital investment.
420 Smaller devices such as laryngoscopes, were excluded from this type of
421 management (with the exception of highly specialised instruments, such as
422 fiberscopes), although Interviewee 4.1 did not seem adverse to the idea of
423 extending the approach to all instruments. A key reason behind the more circular
424 approach adopted lay in the presence of a board meeting, held regularly at regional
425 level between staff of hospitals, representative of the industry and of the regional
426 government. During these meetings, guidelines for the purchase department and
427 for the different wards were issued to encourage efficiency.

428

429 All three sites used reusable laryngoscopes. All sites were equipped with a
430 sterilisation unit, and did not see any economic benefits in shifting to disposable
431 tools. Broad support for reusable laryngoscopes was shown in Hospital 5, where

432 all interviewees agreed that the pros of reusable outweighed the disadvantages of
433 disposable instruments.

434

435 Interviewee 5.3: Disposable is not reliable

436 Interviewee 5.1: Then it has a significant cost!

437 Interviewee 5.3: It is a tool that can be sterilised very well, the
438 blade at the end.

439

440 Interviewees in Hospital 5 stated that there was a tendency towards increased use
441 of single use instruments, unless a different response to multi resistant organisms
442 was found. In contrast with the other two sites, Hospital 6 was already starting to
443 use disposable instruments, although they still represented only a small
444 percentage. According to the interviewees, three main factors were responsible for
445 this choice: First, single use instruments met the necessity for precaution -
446 especially from the perspectives of legislative compliance and infection prevention.
447 Second, it followed a growing trend across the sector. For example, Interviewee 6.1
448 argued that:

449

450 "Unfortunately there isn't the same policy even in the same hospital!
451 Someone wakes up, wants single-use, explains why and maybe even
452 gets it. All the rest of the hospital keeps on using reusable. Random!
453 [...] We didn't have it before, it was all reusable. They do it for medico
454 legal reasons essentially, or for a fashion. Of course it costs more, but
455 is also more comfortable."

456

457 Third, the limited capacity of the internal sterilisation unit in Hospital 6, where
458 waste management was subcontracted to a private company.

459

460 According to Interviewee 5.1, in 2014, the hospital purchased 48 reusable
461 laryngoscopes for a total of €2,928. The average cost per instrument was therefore
462 about €61. This was clearly a higher price than that of a single use laryngoscope,
463 but it was balanced out by the extensive use over the years.

464 4.2.2 Use of the instruments

465

466 At the three sites, no concrete preference towards the types of devices was
467 expressed. Furthermore, no explicit guidelines had been issued, neither from
468 infection control departments nor from the hospital management, therefore none
469 of the sites was facing overt pressure to switch to disposable instruments.
470 However, it was becoming evident that possible contamination could take place
471 and so disposable instruments were starting to be purchased. At the same time, it
472 was also recognised that adequate staff training played a fundamental role in any
473 shift in practice.

474

475 The lifespan of reusable instruments was extended as much as possible, by
476 transferring the instruments – when possible – from one ward to another. In
477 Hospital 4, certain surgical instruments were transferred from the operation room
478 to different departments, before eventually ending up in the veterinary
479 department. According to Interviewee 4.1, a surgical instrument, when properly
480 managed, could easily last more than 20 years.

481 4.2.3 Management of the used instruments

482

483 The amount of single use disposable instruments as a percentage of the total waste
484 generated in Italian health care sites was very low. According to Interviewee 5.2
485 "*the incidence of these products on the total waste tends to zero*". However, there
486 was limited value recovery from metal waste at the three sites.

487

488 A key difficulty arose from the lack of functioning markets, to which recovered
489 materials could be sold. According to Interviewee 6.2, the crucial “mistake” was the
490 creation of consortia for the management of raw materials (e.g. paper, plastic,
491 glass, but also batteries and electronic devices). In Interviewee 6.2's opinion,
492 consortia disincentivised small scale collection, which was no longer cost-effective,
493 reducing the possibility to recover raw materials. Interviewee 5.2 also shared this
494 opinion, stating that:

495

496 "recovery can be done cost-effectively by huge providers, who have
 497 large quantities and also heavy bargaining power. [Company X] does
 498 have a remarkable turnover. For us that we could dispose of... What?
 499 Maybe 30, 40 kg of stainless steel a year, it is complicated. In fact
 500 logistics costs would counterweight..."

501

502 Company X was in charge of collecting and sterilising metal instruments and
 503 devices from over 50 hospitals.

504

505 In Hospital 4, laryngoscopes were collected and the batteries segregated from the
 506 metal part, which was collected by the waste contractor. The site was charged for
 507 the collection, however, according to Interviewee 4.1, they did not benefit from
 508 price fluctuations in the market. Thus even if the price of recycled materials rose,
 509 they would not benefit from a reduction of the charges. The cost of waste
 510 incineration for Hospital 4 was on average €1,270/tonne (about £923/tonne -
 511 while other types of disposal could cost up to €2,630/tonne (£1,913/tonne) in
 512 case of hazardous chemicals. However, the cost charged by the waste contractor
 513 was inversely proportional to the amounts produced. Thus the more the facility
 514 generated, the lower the charges per tonne. These prices were considerably higher
 515 than those provided by Hospital 2.

516

517 Table 4 suggests that quantities of hazardous healthcare waste produced in Italy
 518 between 2011 and 2012, were relatively constant. Depending on the definition
 519 used, the amounts vary considerably (ISPRA, 2014). Between the years 2011 and
 520 2012, the national coding used to distinguish different economic activities - the so-
 521 called ATECO codes - changed. In addition to this, data diverge substantially if
 522 calculated according to the European Waste Catalogue (EWC), which is yet again
 523 different.

524 **Table 4: Healthcare waste generation in Italy according to the ATECO code**
 525 **and the EWC, during 2011/12**

526

Year	Waste according to ATECO coding		Waste according to EWC	
	Non Hazardous	Hazardous	Non Hazardous	Hazardous
2011	57,964	146,330		

2012	55,215	156,759	4,778	141,340
------	--------	---------	-------	---------

Source: ISPRA (2014)

527

528

529 The most widespread treatment for hazardous healthcare waste in Italy is
 530 incineration without energy recovery, while only a small fraction was treated in
 531 EfW facilities (Table 5).

532 **Table 5: High temperature treatment for healthcare waste in Italy, during**
 533 **2011/12**

534

	Incineration		Incineration with Energy Recovery	
	Non Hazardous	Hazardous	Non Hazardous	Hazardous
2011	6,883	128,186	N.A.	N.A.
2012	6,414	108,194	451	13,198

Source: ISPRA (2014)

535

536

537 Laryngoscopes can be disposed of with hazardous or non-hazardous metallic
 538 waste, depending on whether the instrument has come into contact with a
 539 potentially contagious patient, if it has been sterilised or if it has not been used.

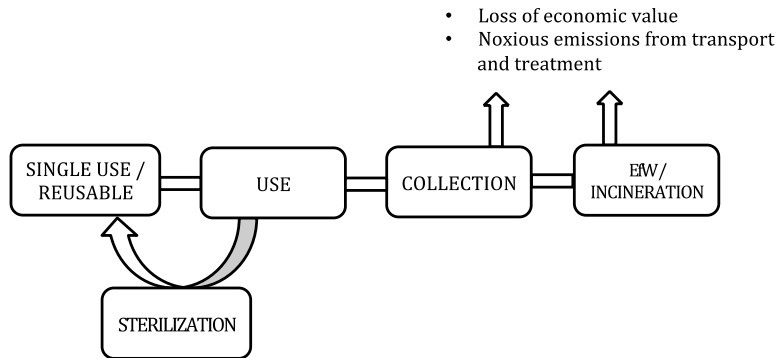
540

541 4.2.4 Practices of value recovery from used metallic devices in Italy

542

543 All three hospitals managed their instruments and metallic waste in the same way
 544 as represented in Figure 5.

545



546

547 **Figure 5: Life cycle of metallic medical instruments in Italian Hospitals**

548

549 The loop displayed on the left side of the Figure (reusable instruments – use –
 550 sterilisation) can last for a relatively long time span, while the amount of devices
 551 that undertake the right path of the process (collection – EfW/incineration) is
 552 marginal.

553 **5. Discussion**

554

555 There were two key differences in the approaches taken between the sites in the
 556 two countries. First, there was a difference in the usage of single use instruments.
 557 The generation of waste from the use of medical instruments was relatively limited
 558 in Italy due to the widespread use of reusable devices. Single use instruments were
 559 considered more expensive by all the interviewees, and were used in limited
 560 quantities. Despite some single use instruments being in use, neither infection
 561 control nor the market had yet led to a substantial change in the traditional
 562 approach to utilising reusable medical equipment. Despite the positive circular

563 process displayed at the sites in Italy, little value recovery from the metal
564 instruments was being intentionally carried out.

565

566 Unlike in Italy, the use of single use instruments was wide spread at the sites in
567 England. The rationale for this approach lay in two main factors: First, infection
568 control and prevention departments played a significant role in the decision
569 making processes at the sites. Similarly to previous studies, use of these
570 instruments was seen as a means of enabling greater infection control and
571 prevention (Campion *et al.*, 2012; Ibbotson *et al.*, 2013; McGain *et al.*,
572 2012;Ibbotson *et al.*, 2013). Disposable stainless steel or plastic instruments
573 reduce the number of people getting in contact with a potentially infected object,
574 decrease the movement of the same object between the place of use and its final
575 disposal and lastly, does not depend on the efficiency of a sterilisation process
576 (McGain *et al.*, 2012). Second, another key factor driving the use of the instruments
577 was costs. For most of the participants in England, the perception was that costs
578 were lower for single use items. However, these costs often did not take into
579 account waste disposal at the time of purchase (Ibbotson *et al.*, 2013; Adler *et al.*,
580 2005; Morrison *et al.*, 2004).

581

582

583

584

585 Another key difference between the two countries was with regards to the
586 presence of dedicated waste management departments. The structure of the
587 departments in Italy rarely included the presence of a waste manager. However, in
588 all of the sites in England, either a single person or a whole team (up to 37 people
589 in the case of Hospital 1) was employed. Hospital 4 in Italy was an exception,
590 however, this resulted solely from a particular synergy in the structures at the
591 regional level. While the eco manager in Hospital 6 cannot be compared, as their
592 responsibilities and tasks were not specifically those of a waste manager. A
593 consequence of the difference in department sizes was therefore differences in the
594 provision of resources and focus on management of wastes. Interesting, though,
595 despite this difference, the sites in both countries were practicing value recovery

596 from the instruments. Despite the high usage of single use instruments, the English
597 sites were practicing reutilisation. Hospital 2 was also specifically separating out
598 its medical instruments (even though fluctuations in prices and limitations in
599 space did make this challenging). At the same time, if value recovery is looked at in
600 a wider sense (e.g. extending product life), the Italian sites, while it was not a focus,
601 were also indirectly practicing recovery of value from the instruments.

602

603 The main reason for the difference between the two countries was due to the
604 availability of monies. The sites in England, generally had greater access to
605 finances and thus to resources.

606

607 Despite these key differences, there were similar issues in both countries, namely:
608 limitations in communication and end markets, , the presence of a sterilisation
609 unit and staff engagement, which ultimately impacted upon value recovery.

610 **5.1 Communication**

611

612 Limitation in communication between different departments was a fundamental
613 issue in most cases. Almost all the sites noted that there was a lack of collaboration
614 between the procurement and waste management teams (or equivalent), which
615 had important consequences on whole life cost considerations. Communication is
616 generally recognised as a fundamental aspect of sustainable purchase (Millett,
617 2000; Kaiser *et al.*, 2001). Given the lack of communication, managing the waste
618 was not factored in when evaluating the price of instruments, even though the
619 disposal costs and environmental risks were potentially high (Finnveden *et al.*,
620 2005; Ibbotson *et al.*, 2012; Tekin *et al.*, 2015). The exchange of information
621 between staff in the two departments would be essential in order to include
622 aspects such as the dismantling of an instrument, the cost of a waste treatment, etc.
623 into the evaluation process at the time of purchase. Furthermore, this could
624 indirectly influence the producers of metallic medical instruments, which could
625 eventually lead to adaptation to the necessities and requests of health care sites.

626

627

628 The one exception to this general lack of communication between departments
629 was Hospital 4, where regular board meetings were held between the waste
630 manager and other key stakeholders. The result was a set of interesting initiatives,
631 such as the use of leased equipment to avoid disposal costs, the introduction of
632 guidelines that the procurement department had to follow, and an evaluation and
633 reward system to engage staff with more sustainable practices.

634

635

636

637 **5.2 End markets**

638

639 In both countries, but particularly in Italy, limitations in end markets existed. Most
640 of the interviewees in both countries were of the opinion that the market was
641 progressively pushing to incentivise the use of single use instruments. However,
642 the development of end markets is largely dependent on the manufacturers of
643 medical devices to design instruments in a way to enable easy and quick
644 disassembly (Maris *et al.*, 2014; Bergsma and Sevenster, 2013). With limitations in
645 disassembly, segregation was consequently very difficult and this impacted upon
646 the potential value that any hospital could recover from an instrument. According
647 to Interviewee 3.2, if instruments composed of different materials were completely
648 dismantled at source, they would guarantee a higher income to the hospital.
649 However, an issue at all of the sites was limitation in storage space. Adequate on-
650 site storage space is crucial to enable effective segregation of materials (and
651 therefore a cleaner feedstock for waste contractors and reprocessors) (UNEP and
652 ISWA, 2015). Storage is also a fundamental prerequisite in order to accumulate
653 enough materials to make collection and transportation cost effective (Williams,
654 2007). Indeed, the level of segregation of the feedstock materials determines the
655 quality and thus the price that can be commanded.

656

657 A further barrier was the inadequate structure of the recycled materials' trade.
658 Although an end market for these products is present in both countries, many
659 interviewees suggested that the absence of potential buyers of recycled materials

660 was one of the key obstacles to value recovery. The market appeared to be
661 structured in a way to favour only big producers or suppliers of material, while if
662 only small amount of metal are recovered, it was not cost effective to collect and
663 sell it. Only in Hospital 2 was metal recovery taking place. However, Interviewee
664 2.1 appeared sceptical about the prospects of the collection, given the steady drop
665 of metal prices.

666

667 **5.3 The presence of an on-site sterilisation unit**

668

669 Sites equipped with an adequately sized unit perceived the use of disposable
670 instruments as more costly. For example, Hospital 3 paid about £57,000 to
671 purchase single use blades, laryngoscopes and reusable handles over one year,
672 while Hospital 5 spent €2,928 (approximately £2,131). This equates to an average
673 of £57 per bed for Hospital 3, while Hospital 5 -(an Italian site) spent less than £4
674 per bed.

675

676 There is wide acceptance of single use instruments from an economic point of view
677 (Deprez *et al.*, 2000; Adler *et al.*, 2005; Morrison *et al.*, 2004; McGain *et al.*, 2012;
678 Campion *et al.*, 2012). However given the lack of specific data, and the case
679 specificity of the elements that must be taken into account, it cannot be concluded
680 that sterilisation is more cost effective than the use of disposable instruments in
681 the analysed cases. However, what can be stated is that the presence of a well-
682 functioning and large sterilisation unit changes the approach towards the type of
683 instruments to be purchased and is a fundamental prerequisite in order for reuse
684 to be a cost effective option in lieu of disposable instruments (Ibbotson *et al.*,
685 2013). Indeed, the only Italian site where the presence of disposable instruments
686 was increasing was the same one that had a smaller, privately managed unit.

687

688 Disposable instruments were initially meant only for exceptional contexts where
689 effective decontamination of medical instruments could not be assured (Ibbotson
690 *et al.*, 2013). Economic and political considerations, together with the evolution of
691 the market and of infection control practices, have since contributed to pushing

692 either for the implementation of sterilisation or for a shift to disposable
693 instruments. For what concerns infection control, little evidence is found to
694 support disposable instruments over reusable ones. First, various writers assert
695 that even single use blades do not fully avoid spreading of contamination (Williams
696 *et al.*, 2010; Call *et al.*, 2009; Millett, 2000; Simmons, 2000). While others have
697 found that reusable handles do not pose a concrete risk of contagion to patients or
698 staff (Quareshi *et al.*, 2008). Second, sterilisation alone cannot guarantee the
699 complete decontamination of an instrument. Indeed, incorrect procedures,
700 insufficient training and lack of personnel play a role, even if sterilisation units are
701 functioning and well equipped (Scaini, 2010).

702

703 A further important feature that can influence value recovery is the presence of an
704 on-site treatment facility. The EfW facility at Hospital 3 guarantees an economic
705 return to the site for the infectious and sharps waste generated by the site. Even
706 though it can be argued that energy is being recovered, the plant, however,
707 “disincentivises” – in the words of Interviewee 3.2 – further material recovery and
708 recycling.

709

710 **5.4 Staff engagement**

711

712 The last, though fundamental, aspect that influenced the recovery of value from
713 metal surgical instruments in the two countries was staff engagement. Staff
714 training and engagement are fundamental for good resource segregation
715 (Windfeld and Brooks, 2015; Tsakona *et al.*, 2007; Hengevoss *et al.*, 2012). Beliefs
716 can also deeply influence the purchasing decisions, in particular the uptake of
717 green procurement practices (Testa *et al.*, 2012). The lack of a strategic focus and
718 interest in incorporating the concepts of green procurement was a key factor in the
719 purchase of the types of laryngoscopes. Personal interest or knowledge can also
720 contribute to the efficiency of a department or to the introduction of new practices
721 (Tudor *et al.*, 2008). Evidently, the opposite is also true, with a lack of interest in a
722 certain topic, resulting in it being ignored. For example, only Hospital 4 among the
723 three visited sites in Italy had a dedicated waste manager, who contributed to the

724 effective functioning of waste management practices at the site. Conversely, the
725 observed level of commitment and expertise was relatively high at all visited sites
726 in England. Implementing the concepts of the circular economy requires the direct
727 involvement of people as active participant to the process, instead of being a
728 passive representative of the throwaway culture as pointed out by Interviewee 6.1
729 (Ghisellini *et al.*, 2015).

730 **6. Conclusions**

731

732 While there were differences in the approaches between the sites in the two
733 countries, particularly related to the use of single use instruments and resource
734 provision, practices and challenges were largely similar. For example, both
735 countries faced difficulties in the development of end markets, as well as
736 limitations in communication between related departments, and staff engagement.

737

738 While there were elements of value recovery, particularly in the case of the English
739 sites, where there was a greater focus on sustainable waste management, there
740 was significant room for improvement in both countries. This improvement,
741 however, would require a more stream lined approach both at the site level (i.e.
742 more joined up thinking between procurement and waste management
743 departments and opportunities for effective waste segregation), as well as at the
744 wider level (i.e. the development of sustainable end markets). However, the key
745 factor in ensuring greater circularity in managing used laryngoscopes, is upstream,
746 at the procurement of the devices. Indeed, even before, at their manufacturer to
747 enable ease of disassembly. All of the respondents (except Interviewee 4.1)
748 indicated that no consideration was paid to waste at the time of purchase either in
749 England or in Italy. In addition, the choice concerning which type of device to buy
750 was linked more to other considerations, such as efficiency, price and the facilities
751 of the hospital, rather than to the whole life costs.

752

753 Rising quantities of single use medical instruments, including laryngoscopes, in
754 England and increasingly in Italy suggests the need for more circularity in the
755 manner in which they are managed. This more circular approach would not only

756 ensure cost savings, but also ensure legislative compliance. In order for this
757 approach to become reality, key organisational factors (e.g. greater dialogue
758 between relevant stakeholders, and staff engagement), as well as logistical factors
759 (e.g. end market development), need to be addressed. If these challenges can be
760 overcome, then there should be significant environmental and economic benefits
761 realised, not only for the management of laryngoscopes, but also for other used
762 medical devices as well.

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