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Benefits of a 14-year surgical site infections active surveillance programme in a French teaching hospital

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1 **Title page:**

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3 Benefits of a fourteen-year surgical site infections active surveillance program in a French
4 teaching hospital

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45 **Summary:**

46 ***Background***

47 Surgical site infections (SSI) are the second commonest healthcare-associated infections.

48 Active SSI surveillance can help inform preventative measures and assess the impact of
49 these measures.

50 ***Aim***

51 We aimed to describe the evolution in trends over fourteen years of prospective active SSI
52 surveillance and implementations of SSI prevention measures in a French Teaching Hospital.

53 ***Methods***

54 We monitored and included in the study all surgical procedures performed from 2003 to
55 2016 in eight surgical units. The semi-automated surveillance method consisted in weekly
56 collection of SSI declaration forms (pre-filled with patient and procedure administrative data
57 and microbiology laboratory data), filled-in by surgeons and then monitored by the infection
58 control practitioners.

59 ***Findings***

60 181,746 procedures were included in our analysis and 3,270 SSIs recorded (global SSI rate
61 1.8%). The SSI rate decreased significantly from 3.0% in 2003 to 1.1% in 2016. This decrease
62 was mainly in superficial SSIs and high infectious risk procedures. Higher SSI rates were
63 observed for procedures associated with the usual risk factors. During this fourteen-year
64 period, several evolutions in surgical practices occurred that might have contributed to this
65 decrease.

66 ***Conclusion***

67 With an overall decrease in SSI rate throughout the surveillance, our results revealed the
68 benefits of an active and comprehensive hospital SSI surveillance programme for

69 understanding the SSI rate trends, analysing local risk factors and assess effectiveness of
70 prevention strategies. These findings highlighted also the importance of the collaboration
71 between surgeons and infection control practitioners.

72

73 **Keywords:**

74 Surgical site infection; Healthcare-associated infection; Surveillance; Infection control

75 **Text:**

76

77 ***Introduction***

78

79 Surgical site infections (SSIs) are usually considered the second commonest
80 healthcare-associated infections (HAI) after respiratory tract infections. In the 2011–2012
81 European HAI point prevalence survey in acute care hospitals, SSIs accounted for 19.6% of
82 HAI. [1] In the 2017 annual report the European incidence density of in-hospital SSIs per 1
83 000 post-operative patient-days varied from 0.1 to 5.7, depending on the type of surgical
84 procedure. [2] Similarly, in an American multistate point prevalence survey of 2011, SSIs
85 accounted for 21.8% of HAI.[3] As SSIs are associated with a higher mortality and an increase
86 in the length of hospital stay and costs, they have an important economical and societal
87 burden.[4–9] Importantly, they have been shown to be amongst the most preventable
88 HAI.[10–12] Indeed, studies have reported the effectiveness of implementing an active HAI
89 surveillance programme, including feedback of appropriate data to surgeons, in reducing SSI
90 rate.[10,13–15] In France, SSI surveillance has been in place since 1992 as part of the
91 national program for HAI surveillance. It has been reported that this surveillance has led to a
92 33% decrease in the overall SSI rate and a 35% decrease for low infectious risk procedures
93 over the 2007-2011 period.[16]

94 In this paper we aim to describe the evolution of local trends and risk factors of fourteen
95 years of prospective active SSI surveillance and implementation of SSI prevention measures
96 in a French university hospital, with a total of more than 180,000 procedures monitored in 8
97 surgical units.

98

99

100 **Methods**

101

102 *Setting*

103 We implemented an active SSI surveillance programme in 2003 in the 1,306-bed
104 Teaching Hospital of Limoges; the hospital includes medical, emergency, intensive care and
105 surgical units. Participation in the surveillance by all surgical units in our hospital was
106 encouraged.

107

108 *Surveillance method*

109 Our surveillance relied on a weekly collection of SSI declaration forms. The forms
110 were generated using Excel® macro in a semi-automated method. We extracted surgery
111 procedures from the operating room software (AMELIBLOC®, Limoges Teaching Hospital)
112 and microbiology results from the microbiology software (GLIMS®, MIPS). We collected
113 patient, procedure and microbiology data (sex, age, date and type of procedure, duration,
114 Altemeier classification wound class,[17] American Society of Anesthesiologists (ASA)
115 preoperative assessment score,[18] surgeon name, surgical unit, French National Health
116 Insurance procedure coding, microbiology results). These data were used to automatically
117 generate SSI declaration forms. The infection control practitioner (ICP) highlighted SSI
118 suspected procedure with appropriate microbiology results. The SSI declaration forms listed
119 the procedure performed 4 weeks prior and were sent to each surgeon weekly.

120 The post-procedure follow-up period was one-month, excepted for orthopaedic
121 surgery, where the follow-up period was extended to at least 3 months because of the
122 frequency of implants. Surgeons completed the SSI declaration form with the presence /

123 absence of SSI for each procedure and returned it to the ICP for final review and validation.
124 Difficult cases were resolved by discussion between ICP and surgeons to determine whether
125 or not there was a SSI. The ICP then entered these data in an Excel® database stored on the
126 hospital IT system. The source data of our monitoring included the surgeon's clinical
127 examination of the patient, and the ICP's analysis of the patient's medical record.

128 *Feedback*

129 Every 6 months, each participating surgeon received a report containing the results
130 of the SSI surveillance analysis (SSI rate, participation, and administrative data) for their
131 surgical department.

132 133 *Definitions*

134 We used the French national SSI surveillance definitions,[18] adapted from the
135 Center for Disease Control definitions,[19] to classify infections as deep or superficial SSI.
136 Details of the definitions are available in the supplementary material.

137 The procedures documented by the surgeon and reviewed by the ICP for the
138 presence/absence of SSI were deemed validated procedures. We included validated
139 procedures in the analysis, and excluded re-interventions due to SSI.

140 141 *Analysis*

142 The participation rate was the ratio of the number of validated procedures to the
143 total number of procedures. This ratio assessed surgeon's participation and the surveillance
144 completeness.

145 The SSI rate was the ratio of the number of SSIs to the number of included
146 procedures.

147 We assessed the usually described SSI risk factors: age, gender, pre-intervention
148 length of hospital stay, intervention duration, ASA score, wound class, age,[21] and national
149 nosocomial infections surveillance risk index (NNIS) that was calculated according to the
150 usual definitions.[22]

151

152 *Statistical analysis*

153 The study database was created with Excel software and a p value <0.05 was deemed
154 statistically significant. Qualitative variables were described as numbers and percentages. SSI
155 rates were compared according to risk factor by using the Chi2 test or Student test or
156 Fisher's exact test, depending on the theoretical number. To adjust the results, we
157 performed a multivariate logistic regression. We selected the explanatory variables with a p-
158 value under 0.20. The selected variables were then computed with S-plus software to obtain
159 the final model, with the variable to explain being the presence or absence of SSI.

160

161

162 **Results**

163

164 *Participation and included surgeries*

165 Among the 195,746 surgical procedures performed in the participating surgical units
166 from January 2003 to December 2016, 184,779 were validated, giving an overall
167 participation rate of 94 %. The participation of the surgeons was excellent throughout the 14
168 years of the study period, albeit with a decrease over the last 3 years to a rate of 84.4% in
169 2016 (Figure 1). We eventually included 181,746 procedures in our analysis, as 3,033
170 procedures were identified as re-interventions due to SSI, and were thus non eligible.

171

172 *Population*

173 The sex ratio was 1.21 (M:F), with an average age at the time of surgery of 52
174 (standard deviation +/- 26.3) years. A total of 8 surgical units participated. Six surgical
175 departments participated since 2003: general, paediatric, otorhinolaryngological,
176 maxillofacial, ophthalmological and neurosurgery. Two additional departments joined the
177 surveillance program in 2009: orthopaedic and cardio-thoracic and vascular surgery. The
178 number of included procedures varied according to the surgical unit, from 3,764 procedures
179 for maxillofacial surgery to 42,514 for ophthalmological surgery (Table I).

180

181 *SSI rate*

182 During the surveillance period, 3,270 SSIs were recorded, which resulted a SSI rate of
183 1.8% that was distributed into 0.8% deep infections, 0.8% superficial infections, and 0.1%
184 unknown infections, and that varied from 0.2% for ophthalmological surgery to 5.0% for
185 general surgery (Table I).

186 The overall SSI rate decreased significantly, from 3.0% in 2003 to 1.1% in 2016
187 (p<0.0001) (Figure 2). Since 2009, 2 surgical units joined the surveillance (orthopaedic and
188 cardio-thoracic and vascular surgery). As shown in Figure 2, the SSI rates in these units
189 followed the same pattern as the other units..

190

191 *Implementation of prevention measures*

192 During our 14-year surveillance, there were several major changes in practice and infection
193 prevention measures, represented chronologically in Figure 2. Some of these were
194 associated with a reduction in infections in all surgeries, including surgical hand antisepsis
195 with alcohol-based hand rub (2007); a switch from reusable to disposable gowns (2007);
196 and progressive implementation of surgical site skin cleaning of the operating area (from
197 2009 to 2013). Other changes were specific to certain surgical units: the relocation of
198 paediatric operating theatres to a new building in 2007; neurosurgery morbidity-mortality
199 reviews including SSI from 2008 to 2016; and *Staphylococcus aureus* nasal decolonization
200 prior to cardiac surgery from 2013.

201

202 *SSIs types*

203 During the surveillance, we recorded a decrease by over 50% of the rate of superficial
204 SSIs (Figure 3), while the rate of deep SSIs remained stable. The rate of unclassified SSIs
205 decreased over the years.

206

207 *SSIs risk factors*

208 We classified the procedures according to NNIS score - that includes the ASA score,
209 wound class and duration of surgery – of 0 (n=60,466), 1 (n=39,901), 2 (n=8,718), 3 (n=634),

210 and unknown (n=72,027), with a higher score meaning at higher risk of infection. In our
211 study, higher SSI rates were correlated with increasing NNIS score (Figure 4). The magnitude
212 of decrease in SSI rates was greater for procedures on patients with higher NNIS scores. For
213 a NNIS score of 3, the SSI rate dropped from 19.3% in the 2003-2006 period to 7.1% in the
214 2012-2016 period (63.6% decrease, $p<0.01$), whereas for a NNIS score of 2, the rate of SSI
215 decreased from 8.9% in the 2003-2006 period to 5.3% in the 2012-2016 period (40.4%
216 decrease, $p<0.01$).

217 We also assessed the usually described SSI risk factors (Table II): male gender
218 ($p<0.01$), pre-intervention hospital length of stay of at least 2 days before surgery ($p<0.01$);
219 intervention duration higher than the 75th percentile for the type of intervention ($p<0.01$);
220 advanced age ($p<0.01$); and higher ASA score ($p<0.05$), wound class ($p<0.05$) or NNIS
221 ($p<0.01$). These results remained significant in the multivariate analysis. NNIS index was the
222 most associated factor to SSI (Table III).

223

224 **Discussion**

225

226 SSIs surveillance is a priority to improve quality and risk management in healthcare
227 facilities.[23,24] Additionally, it is instrumental in assessing the impact of preventive
228 measures implemented in any hospital (e.g. antibiotic prescription policy for preoperative
229 and perioperative prophylaxis, skin preparation protocol, surgical hand disinfection).

230 For over fourteen years, our surveillance programme, relying on collaboration
231 between the ICP and surgeons, has provided comprehensive data across a wide range of
232 surgeries (participation rate of 94%). Regular (6-monthly) feedback to surgeons reinforced
233 their motivation and played a key role in the high participation rate. Close collaboration
234 between the infection control and surgical teams facilitated addressing modifiable risk
235 factors. As an example, we performed a causal analysis of the SSI rate increase in cardiac
236 surgery and identified deviations from the *S. aureus* decolonization protocol. Moreover,
237 twice a year, we scheduled morbidity-mortality reviews with the neurosurgery unit with an
238 impact on the SSI rate decrease for craniotomy.

239 Integration of microbiological data in our surveillance methodology enabled the ICP
240 to suspect SSI; sharing these results with the surgeons helped to diagnose SSI. Surgical
241 clinical examination and medical record analysis by the ICP were instrumental components
242 of our surveillance programme that increased the quality of SSI definition. Moreover, our
243 surveillance method allowed detection of SSI after the patient discharge through post-
244 surgery consultations. The SSI definition did not change along the surveillance, allowing data
245 comparison over time.

246 In the French national ISO-RAISIN surveillance method, which was used to design our
247 surveillance (definitions, surveillance periods), orthopaedic patients were monitored for 3

248 months post-operatively. As our hospital is a reference centre for osteoarticular infections,
249 infections occurring after material implantation are discussed in multidisciplinary meetings
250 (infectiologists, orthopaedists, microbiologists), and reported to the ICP, conferring a much
251 longer follow-up period than 3 months in some cases.

252 Despite the high quality of the data obtained, the method is extremely time-
253 consuming for the ICP, with manual data entry in an Excel file, and requires a constant
254 surgeon involvement. Nevertheless, we noticed an increase in the participation over time, as
255 the surveillance was included in surgeons' routines, except over the last 3 years, when the
256 participation rate fell to 84.4% in 2016 (Figure 1). However, investigation identified errors
257 due to data entry modifications in the operating room software for one surgical ward.
258 Correction of these errors increased the participation rate to 90% in 2017 (data not shown),
259 leading us to believe that the apparent decrease in participation did not reflect a lack of
260 surgeon engagement and motivation.

261 Modifying the method by using a semi-automated or automated algorithm would
262 target the surveillance to the most at-risk procedures and decrease the time-consuming
263 workload of data collection. Automated methods of HAI surveillance have been reported
264 with equal or better specificity and sensitivity than conventional methods.[25–28] However,
265 these studies are usually based on electronic medical records or administrative data
266 including diagnosis codes combinations and the implementation depends on the extraction
267 capacity of these data.[29,30] Moreover, the weakness of an Excel database is also an
268 argument to evolve toward an automated and more secured tool. Indeed, misuse of our
269 database could induce data loss and evolutions of this software hampered the operability of
270 the macro designed for our surveillance program.

271 It has been demonstrated that a SSI surveillance programme on its own can decrease
272 the SSI rate.[10,11,24,31] Another study reported a moderate impact of SSI surveillance,
273 suggesting that surveillance does not automatically decrease the SSI rate over the time.[32]
274 In our establishment, the 14-year SSI surveillance program was associated with a significant
275 decrease of SSI rate, which was consistent with other studies.[13,16,33] It was interesting to
276 see that for the 2 surgical units that joined the surveillance in 2009, the decrease was
277 equivalent, with a higher initial rate than surgeries included since 2003. This suggested that
278 including these data in our analysis did not induce any bias in the overall trend. Surveillance
279 programmes that include regular feedback to surgeons are known to increase surgeon
280 awareness of SSI prevention [34] and likely contributed to the steadily decreasing SSI
281 incidence rate in our study. Even though the surveillance appears to have had an impact on
282 the SSI rate decrease some external factors over the 14 years may also have contributed to
283 the decrease. As noted earlier, these include the national French recommendation to use
284 alcohol-based hand rub for surgical hand antisepsis; relocation of paediatric surgery to a
285 new building; and nasal decolonization for patients with *S. aureus* prior to cardiac surgery in
286 2013 (mupirocin nasal ointment during 5 days from the day before the surgery) was also a
287 specific measure that might have had an impact on SSI rates in cardio-thoracic surgery. In
288 fact the decrease in SSI rates began during the period 2003-2006, before any specific
289 measures to reduce SSIs were introduced. This suggests that surveillance alone,
290 underpinned by collaboration between ICP and surgeons, was sufficient to raise surgeons'
291 awareness of SSIs and their prevention.

292

293 The NNIS score is proposed in the literature as a SSI risk factor index.[21] However,
294 we also found that the greatest reduction in the SSI rate was also in the NNIS 3 patient

295 group. It was also striking that the reduction in SSIs across all patient groups did not apply to
296 deep SSIs, the incidence of which remained constant. We do not think that this disparity
297 arose through poorer ascertainment of superficial infections (e.g. because of shorter length
298 of stay, or reduced microbiological sampling). Our observations around other risk factors for
299 SSI accord with those reported in other studies.[21]

300

301 Our surveillance study has several limitations. Although we were able to describe a
302 reduction in SSI rates over time, we did not establish the impact of specific preventative
303 measures. There was also some scope for inconsistency in the amount and impact of ICP and
304 surgical collaboration. However, although this was not assessed directly, we believe that the
305 regular 6-monthly feedback, and the priority given to infection surveillance across the
306 hospital, meant that we believe that surgeon awareness and engagement would have
307 changed little during the study period. Finally we note that in 2018, the surveillance
308 described here was discontinued due to incompatibilities in some of the system software.
309 Since then, a more secure and automated hospital-acquired infection surveillance software
310 is being deployed in our hospital's IT system. Nevertheless, our study has shown that long-
311 term non-automated SSI surveillance, although resource intensive, can have a significant
312 impact on reducing rates of superficial SSI.

313

314 **Conclusion**

315 Over the years, we built up an important SSI surveillance program and database
316 representing the surgery variety of a French teaching hospital. To our knowledge, this is a
317 unique surveillance database, whether in terms of number of interventions monitored, the
318 duration of monitoring or the variety of interventions represented. It allowed analysis of

319 local SSI risk factors and the description of SSI rate evolutions after new prevention
320 strategies implementation, with an overall decrease in SSI rate being demonstrated
321 throughout the surveillance. The success of this monitoring relied on the surgeons' and ICP
322 involvement in regular review of procedure and resulted in a good teamwork collaboration.
323 However, our method was time-consuming and the evolution toward automated methods
324 based on algorithm to target procedures of interest would reduce the workload dedicated to
325 the data collection and SSI evaluation. This would provide the ICP with more dedicated time
326 for analysis and would lead to design more appropriate SSI prevention strategies.

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330

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332

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335 **References**

- 336 [1] Point prevalence survey of healthcare-associated infections and antimicrobial use in
337 European acute care hospitals. European Centre for Disease prevention and Control;
338 2012.
- 339
- 340 [2] Healthcare-associated infections: surgical site infections Annual Epidemiological Report
341 for 2017. European Centre for Disease prevention and Control; 2019.
- 342 [3] Magill SS, Edwards JR, Bamberg W, Beldavs ZG, Dumyati G, Kainer MA, et al. Multistate
343 point-prevalence survey of health care-associated infections. *N Engl J Med*
344 2014;370:1198–208. <https://doi.org/10.1056/NEJMoa1306801>.
- 345 [4] Umscheid CA, Mitchell MD, Doshi JA, Agarwal R, Williams K, Brennan PJ. Estimating the
346 proportion of healthcare-associated infections that are reasonably preventable and the
347 related mortality and costs. *Infect Control Hosp Epidemiol* 2011;32:101–14.
348 <https://doi.org/10.1086/657912>.
- 349 [5] Parker B, Petrou S, Masters JPM, Achana F, Costa ML. Economic outcomes associated
350 with deep surgical site infection in patients with an open fracture of the lower limb.
351 *Bone Jt J* 2018;100-B:1506–10. [https://doi.org/10.1302/0301-620X.100B11.BJJ-2018-](https://doi.org/10.1302/0301-620X.100B11.BJJ-2018-0308.R1)
352 [0308.R1](https://doi.org/10.1302/0301-620X.100B11.BJJ-2018-0308.R1).
- 353 [6] Lamarsalle L, Hunt B, Schauf M, Szwarcensztein K, Valentine WJ. Evaluating the clinical
354 and economic burden of healthcare-associated infections during hospitalization for
355 surgery in France. *Epidemiol Infect* 2013;141:2473–82.
356 <https://doi.org/10.1017/s0950268813000253>.
- 357 [7] Haque M, Sartelli M, McKimm J, Abu Bakar MB. Health care-associated infections
358 – an overview. *Infect Drug Resist* 2018;Volume 11:2321–33.
359 <https://doi.org/10.2147/idr.s177247>.
- 360 [8] Badia JM, Casey AL, Petrosillo N, Hudson PM, Mitchell SA, Crosby C. Impact of surgical
361 site infection on healthcare costs and patient outcomes: a systematic review in six
362 European countries. *J Hosp Infect* 2017;96:1–15.
363 <https://doi.org/10.1016/j.jhin.2017.03.004>.
- 364 [9] Cassini A, Plachouras D, Eckmanns T, Abu Sin M, Blank H-P, Ducomble T, et al. Burden
365 of Six Healthcare-Associated Infections on European Population Health: Estimating
366 Incidence-Based Disability-Adjusted Life Years through a Population Prevalence-Based
367 Modelling Study. *PLoS Med* 2016;13:e1002150.
368 <https://doi.org/10.1371/journal.pmed.1002150>.
- 369 [10] Haley RW, Culver DH, White JW, Morgan WM, Emori TG, Munn VP, et al. The efficacy of
370 infection surveillance and control programs in preventing nosocomial infections in US
371 hospitals. *Am J Epidemiol* 1985;121:182–205.
- 372 [11] Harbarth S, Sax H, Gastmeier P. The preventable proportion of nosocomial infections:
373 an overview of published reports. *J Hosp Infect* 2003;54:258–66.
374 [https://doi.org/10.1016/S0195-6701\(03\)00150-6](https://doi.org/10.1016/S0195-6701(03)00150-6).
- 375 [12] Schreiber PW, Sax H, Wolfensberger A, Clack L, Kuster SP, Swissnoso. The preventable
376 proportion of healthcare-associated infections 2005–2016: Systematic review and
377 meta-analysis. *Infect Control Hosp Epidemiol* 2018;39:1277–95.
378 <https://doi.org/10.1017/ice.2018.183>.
- 379 [13] Choi HJ, Adiyani L, Sung J, Choi JY, Kim HB, Kim YK, et al. Five-year decreased incidence
380 of surgical site infections following gastrectomy and prosthetic joint replacement

- 381 surgery through active surveillance by the Korean Nosocomial Infection Surveillance
382 System. *J Hosp Infect* 2016;93:339–46. <https://doi.org/10.1016/j.jhin.2015.12.021>.
- 383 [14] Sykes PK, Brodribb RK, McLaws M-L, McGregor A. When continuous surgical site
384 infection surveillance is interrupted: the Royal Hobart Hospital experience. *Am J Infect*
385 *Control* 2005;33:422–7. <https://doi.org/10.1016/j.ajic.2005.04.244>.
- 386 [15] Abbas M, de Kraker MEA, Aghayev E, Astagneau P, Aupee M, Behnke M, et al. Impact of
387 participation in a surgical site infection surveillance network: results from a large
388 international cohort study. *J Hosp Infect* 2019;102:267–76.
389 <https://doi.org/10.1016/j.jhin.2018.12.003>.
- 390 [16] Rioux C, Grandbastien B, Astagneau P. Impact of a six-year control programme on
391 surgical site infections in France: results of the INCISO surveillance. *J Hosp Infect*
392 2007;66:217–23. <https://doi.org/10.1016/j.jhin.2007.04.005>.
- 393 [17] Altemeier WA, Infections AC of SC on C of S. Manual on control of infection in surgical
394 patients. Lippincott; 1984.
- 395 [18] Fitz-Henry J. The ASA classification and peri-operative risk. *Ann R Coll Surg Engl*
396 2011;93:185–7. <https://doi.org/10.1308/rcsann.2011.93.3.185a>.
- 397 [19] Définition des infections associées aux soins. Comité technique des infections
398 nosocomiales et des infections liées aux soins; 2007.
- 399 [20] Horan TC, Gaynes RP, Martone WJ, Jarvis WR, Emori TG. CDC definitions of nosocomial
400 surgical site infections, 1992: a modification of CDC definitions of surgical wound
401 infections. *Infect Control Hosp Epidemiol* 1992;13:606–8.
- 402 [21] Korol E, Johnston K, Waser N, Sifakis F, Jafri HS, Lo M, et al. A Systematic Review of Risk
403 Factors Associated with Surgical Site Infections among Surgical Patients. *PLoS ONE*
404 2013;8:e83743. <https://doi.org/10.1371/journal.pone.0083743>.
- 405 [22] Gaynes RP, Culver DH, Horan TC, Edwards JR, Richards C, Tolson JS, et al. Surgical Site
406 Infection (SSI) Rates in the United States, 1992–1998: The National Nosocomial
407 Infections Surveillance System Basic SSI Risk Index. *Clin Infect Dis* 2001;33:S69–77.
408 <https://doi.org/10.1086/321860>.
- 409 [23] Global guidelines for the prevention of surgical site infection. World Health
410 Organization; 2016.
- 411 [24] Abbas M, Pittet D. Surgical site infection prevention: a global priority. *J Hosp Infect*
412 2016;93:319–22. <https://doi.org/10.1016/j.jhin.2016.06.002>.
- 413 [25] Klompas M, Yokoe DS. Automated Surveillance of Health Care–Associated Infections.
414 *Clin Infect Dis* 2009;48:1268–75. <https://doi.org/10.1086/597591>.
- 415 [26] Cho SY, Chung DR, Choi JR, Kim DM, Kim S-H, Huh K, et al. Validation of semiautomated
416 surgical site infection surveillance using electronic screening algorithms in 38 surgery
417 categories. *Infect Control Hosp Epidemiol* 2018;39:931–5.
418 <https://doi.org/10.1017/ice.2018.116>.
- 419 [27] Sips ME, Bonten MJM, van Mourik MSM. Semiautomated Surveillance of Deep Surgical
420 Site Infections After Primary Total Hip or Knee Arthroplasty. *Infect Control Hosp*
421 *Epidemiol* 2017;38:732–5. <https://doi.org/10.1017/ice.2017.37>.
- 422 [28] Ciofi Degli Atti ML, Pecoraro F, Piga S, Luzi D, Raponi M. Developing a Surgical Site
423 Infection Surveillance System Based on Hospital Unstructured Clinical Notes and Text
424 Mining. *Surg Infect* 2020;21:716–21. <https://doi.org/10.1089/sur.2019.238>.
- 425 [29] van Mourik MSM, van Duijn PJ, Moons KGM, Bonten MJM, Lee GM. Accuracy of
426 administrative data for surveillance of healthcare-associated infections: a systematic
427 review. *BMJ Open* 2015;5:e008424. <https://doi.org/10.1136/bmjopen-2015-008424>.

- 428 [30] Perdiz LB, Yokoe DS, Furtado GH, Medeiros EAS. Impact of an Automated Surveillance
429 to Detect Surgical-Site Infections in Patients Undergoing Total Hip and Knee
430 Arthroplasty in Brazil. *Infect Control Hosp Epidemiol* 2016;37:991–3.
431 <https://doi.org/10.1017/ice.2016.86>.
- 432 [31] Geubbels ELPE, Nagelkerke NJD, Mintjes-De Groot AJ, Vandenbroucke-Grauls CMJE,
433 Grobbee DE, De Boer AS. Reduced risk of surgical site infections through surveillance in
434 a network. *Int J Qual Health Care* 2006;18:127–33.
435 <https://doi.org/10.1093/intqhc/mzi103>.
- 436 [32] Staszewicz W, Eisenring M-C, Bettschart V, Harbarth S, Troillet N. Thirteen years of
437 surgical site infection surveillance in Swiss hospitals. *J Hosp Infect* 2014;88:40–7.
438 <https://doi.org/10.1016/j.jhin.2014.06.003>.
- 439 [33] Mabit C, Marcheix PS, Mounier M, Dijoux P, Pestourie N, Bonneville P, et al. Impact of
440 a surgical site infection (SSI) surveillance program in orthopedics and traumatology.
441 *Orthop Traumatol Surg Res* 2012;98:690–5. <https://doi.org/10.1016/j.otsr.2012.08.001>.
- 442 [34] Ahuja S, Peiffer-Smadja N, Peven K, White M, Leather AJM, Singh S, et al. Use of
443 Feedback Data to Reduce Surgical Site Infections and Optimize Antibiotic Use in
444 Surgery: A Systematic Scoping Review. *Ann Surg*. 2021 Apr 21. doi:
445 10.1097/SLA.0000000000004909. Epub ahead of print. PMID: 33973886.

446 Format:

447

448

449 **Tables**

450

Surgical unit	Surgical Procedures included	SSI (rate per 100 procedures)
General	35,011	1,755 (5.0)
Maxillofacial	3,764	48 (1.3)
Paediatric	21,657	156 (0.7)
Cardio-thoracic / vascular	11,499	386 (3.4)
Neurosurgery	19,280	422 (2.2)
Ophthalmological	42,514	71 (0.2)
Otorhinolaryngological	24,823	172 (0.7)
Orthopaedics	23,198	260 (1.1)
Total	181,746	3,270 (1.8)

451

452 Table I. Number of surgical procedures included and rate of surgical site infection (SSI) in the
 453 participating surgical units

454

		Surgical procedures		Surgical site infection		
		N	Rate per 100 procedures	N	Rate per 100 procedures	
Gender	Male	99,596	54.8	2,028	2.0	p<0,01
	Female	82,149	45.2	1,242	1.5	
	Unknown	1				
Pre-intervention hospital stay	< 2 days	130,662	71.9	2,184	1.7	p<0,01
	≥ 2 days	23,306	12.8	1,057	4.5	
	Unknown	27,778	15.3	29	0.1	
Intervention duration	< 75th percentile	91,892	50.6	1,416	1.5	p<0,01
	≥ 75th percentile	33,445	18.4	1,334	4.0	
	Unknown	56,409	31.0	520	0.9	
Age	0-1	5,774	3.2	32	0.6	p<0,01
	5-15	23,244	12.8	136	0.6	
	16-25	8,945	4.9	99	1.1	
	26-45	23,983	13.2	368	1.5	
	46-65	50,081	27.6	1,160	2.3	
	66-85	61,191	33.7	1,344	2.2	
	> 85	8,519	4.7	131	1.5	
	Unknown	9	0.0	0	0.0	
ASA score	1	43,778	24.1	335	0.8	p<0,05
	2	46,511	25.6	1,137	2.4	
	3	16,716	9.2	866	5.2	

	4	5,004	2.8	260	5.2	
	5	487	0.3	22	4.5	
	Unknown	69,250	38.1	127	0.2	
Wound class	I	127,912	70.4	1,682	1.3	p<0,05
	II	30,448	16.8	1,043	3.4	
	III	4,668	2.6	263	5.6	
	IV	3,428	1.9	155	4.5	
	Unknown	15,290	8.4	127	0.8	
NNIS	0	60,466	33.3	612	1.0	p<0,01
	1	39,901	22.0	1,206	3.0	
	2	8,718	4.8	613	7.0	
	3	634	0.3	94	14.8	
	Unknown	72,027	39.6	745	1.0	

455 ASA = American Society of Anesthesiologists preoperative assessment score; NNIS = National

456 Nosocomial Infections Surveillance score

457 Table II. Main characteristics of the procedures recorded in our surveillance

458

	Coefficient	Standard error	Odds Ratio	p value
Intercept	-5.129	0.063		
Sex	0.214	0.041	1.239	0.00001
Pre-intervention hospital stay	0.003	0.001	1.003	0.00001
NNIS	0.83	0.026	2.309	0.00001
Age	0.013	0.001	1.013	0.00001

460 NNIS: national nosocomial infection score index (including the physical status score of the
461 American Society of Anaesthesiologists (ASA), surgical wound contamination potential and
462 duration of surgery).

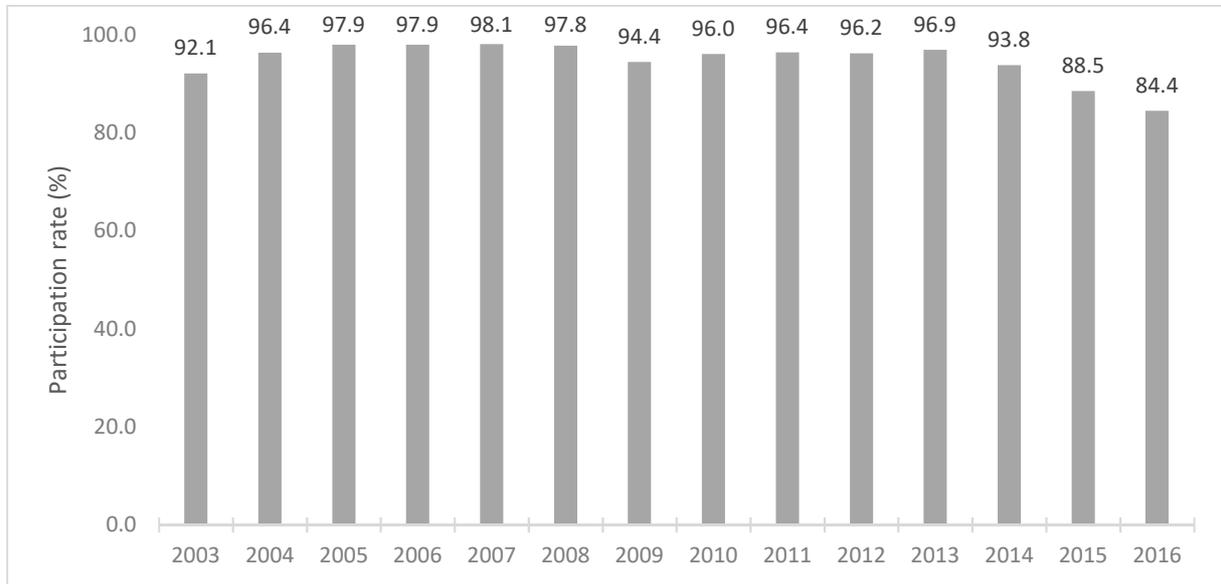
463 Table III. Influence of sex, age, NNIS index and pre-intervention hospital stay on surgical site
464 infection. Multivariate analysis.

465

466 **Figures**

467

468

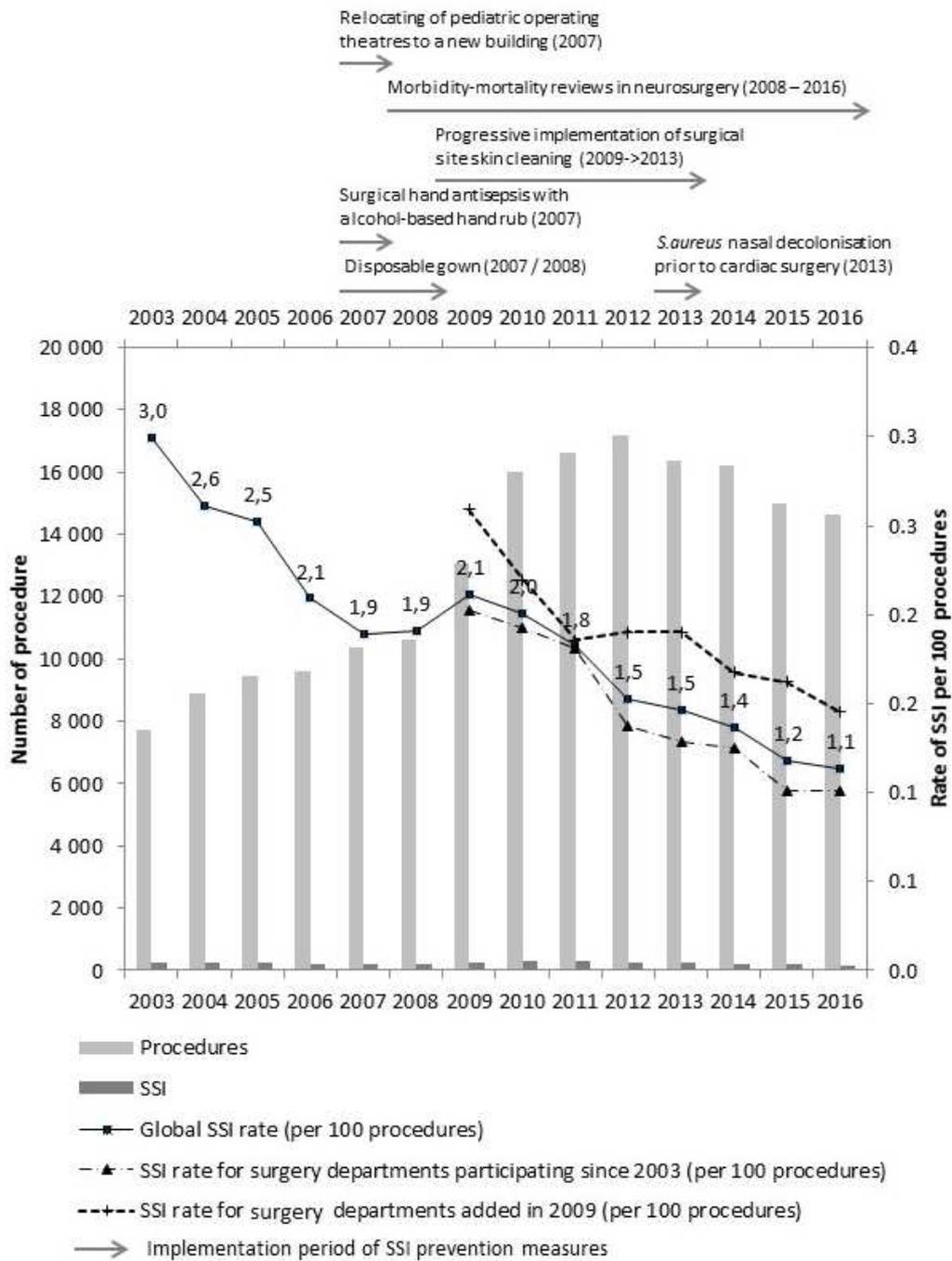


469

470 Figure 1. Evolution of the participation rate from 2003 to 2016

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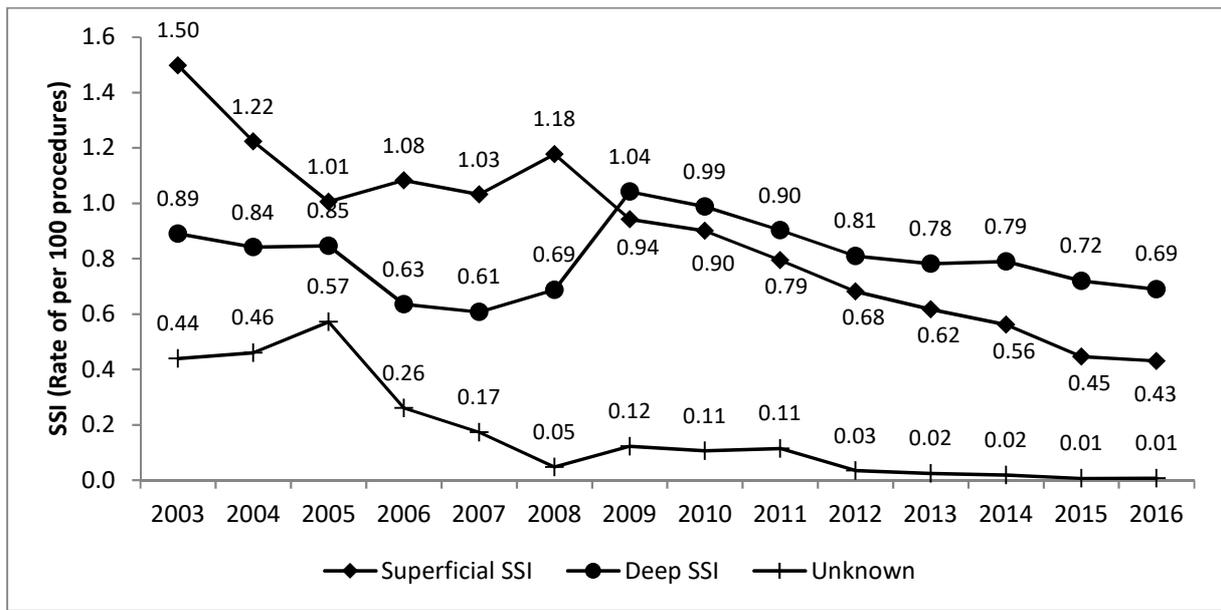


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Figure 2. Evolution of the surgical site infection (SSI) rate from 2003 to 2016 and

477 implementation of major SSI prevention measures.

478

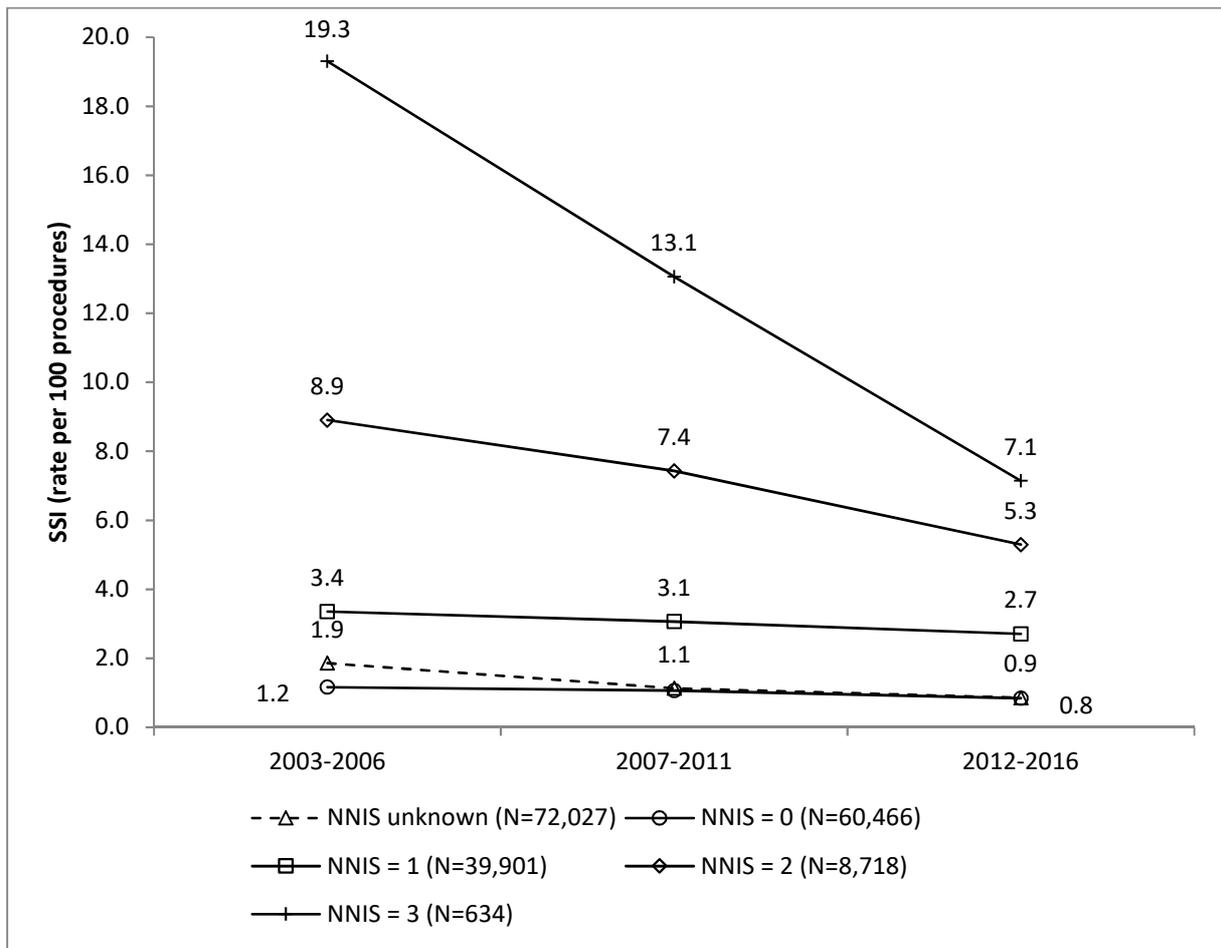


479

480 Figure 3. Evolution of the surgical site infection (SSI) rate from 2003 to 2016 according to the

481 type of infection

482



484

485 Figure 4. Evolution of the surgical site infection (SSI) rate from 2003 to 2016 according to the

486 National Nosocomial Infections Surveillance score (NNIS)

487

488

489 **Legends**

490 Figure 1. Evolution of the participation rate from 2003 to 2016

491 Figure 2. Evolution of the surgical site infection (SSI) rate from 2003 to 2016 and
492 implementation of major SSI prevention measures.

493 Figure 3. Evolution of the surgical site infection (SSI) rate from 2003 to 2016 according to the
494 type of infection

495 Figure 4. Evolution of the surgical site infection (SSI) rate from 2003 to 2016 according to the
496 National Nosocomial Infections Surveillance score (NNIS)

497 **Supplementary material**

498 *SSI definition*

499 A superficial surgical site infection was defined as an infection occurring within 30
500 days after the procedure and affecting the skin (or mucous membranes), subcutaneous
501 tissues or tissues located above the fascia; and at least one of the following:

- 502 - a purulent drainage from the incision;
- 503 - a microorganism associated with polymorphonuclear neutrophil on direct
504 examination, isolated from an aseptically obtained culture of fluid or tissue from
505 the superficial incision;
- 506 - the presence of one of the following signs: pain or tenderness, localized swelling,
507 redness, or heat and superficial incision deliberately opened by surgeon, unless
508 incision is culture-negative;
- 509 - diagnosis of superficial SSI made by a surgeon or attending physician.

510 A deep surgical site infection was defined as an infection occurring within 30 days of the
511 procedure, or within one year if prosthetic material has been implanted, affecting tissues or
512 organs or spaces, opened or handled during the procedure, located at or below the coating
513 fascia. It is diagnosed by:

- 514 - a purulent discharge from a drain under the fascia or placed in the organ or site
515 or space;
- 516 - a spontaneous dehiscence of the incision or opening by the surgeon and at least
517 one of the following signs: fever > 38°C, localized pain, or tenderness to palpation
518 and isolation of the microorganism by aseptic culture, organ or site sampling or
519 space sampling or culture not done;

520 - the presence of an abscess or other signs of infection observed during
521 reoperation, histopathological examination, imaging examination or
522 interventional radiology procedure.
523

524 *Surgeons that participated actively to the surveillance*

525 ABDEH Ali, ABITA Juvenal, ABRAS Nicolas, ADENIS J. Paul, ALCHAYEB Hani, ALFIERI

526 Alessandra, ALFIERI-BONNIER Camille, ALI BENALI Mustapha, ALTURKISTANY Wala,

527 ARMENDARIZ Matéo, ARNAUD J. Paul, ASLOUM Youcef, ASSELINEAU Kirwan, AUBRY Karine,

528 BALLOUHEY Quentin, BARREAU Germain, BAUDET Brune, BAUDONNET Romain, BAZIN

529 Isaline, BEDIN Bertrand, BEN AMMAR Jihane, BENASSAYAG Michaël, BENAYOUN Yohan,

530 BENHAMI Ali, BERAL Laurence, BERTIN François, BESSEDE J. Pierre, BEURDELEY Marion,

531 BILAND Guillaume, BLANC Philippe, BLOSSIER J. David, BOISSEAU Pierre-André, BOIVIN

532 Laetitia, BORDAS Mathieu, BOUNICAUD David, BOURMAULT Loïc, BOUVIER Stéphane, BRIE

533 Joël, CAIRE François, CAMEZIND Philippe, CARCAUZON Véronique, CASSE Guillaume,

534 CAZAVET Alexandre, CESSOT Christine, CHARISSOUX J. Louis, CHERRIERE Sylvain, CHEVALIER

535 Carine, CHRISTOU Niki, CHUFFART Etienne, CLERMIDI Pauline, CODRON Sandrine, COLLIN

536 Camille, COMPAGNON Roxane, CORDIER Guillaume, CORNU Elisabeth, COSTE Cédric,

537 CUENCA Céline, DANJON THOMAS Céline, DELMAS Juliette, DEMERLIAC Mailys, DERBAL

538 Sophiane, DESCLEE DE MAREDSOUS Romain, DESCOTTES Bernard, DEVO Novissi, DIJOUX

539 Pierrick, DOST Laura, DOTZIS Anthony, DOURLHES Nicolas, DURAND Anne, DURAND-

540 FONTANIER Sylvaine, EL SANHARAWI Ahmed, EVENO Claire, FABRE Anne, FAURE Laetitia,

541 FAURE Patrick, FELIX Marie, FIORENZA Fabrice, FISCHER-LOKOU David, FOURCADE Laurent,

542 FRED Kotsu, FREDON Fabien, GAGOS-ZAHARIA Oana, GAINANT Alain, GANTOIS Clément,

543 GARDET Emmanuel, GARMI Rachid, GHOULEM Mourad, GREFFE Guillaume, GRIMAUDO-

544 BENAÏSSA Asma, GROSOS Céline, GUEYE Edouard Marcel, GUY-MOYAT Benoit, HALLACQ

545 Paul, HARDY Jérémy, HATTAD Cécile, HAZANE Eric, HOUMAIDA Hassan, HUGUENY-PECH DE

546 LACLAUSE Brigitte, JOULIE Stéphane, KAPPELLA Michel, KEHLIFI Houcemeddine, KHALIFA

547 Nathaniel, KHEDER Ossama, LABROUSSE Nathalie, LACHACHI Fouzi, LARIBI Sofiane, LASKAR

548 Marc, LATHIERE Thomas, LE GUYADER Alexandre, LECLERC Olivia, LERAT Justine, LEURS
549 Hugo, LISII Dan, LONGIS Bernard, LOSSOUARN Adrien, LOUM Ousmane, MABIT Christian,
550 MAILLOCHON Edouard, MAISONNETTE Franck, MAMELI Arez, MANISOR Monica, MARCHEIX
551 Pierre – Sylvain, MARSAUDON Xavier, MATHIEU Pierre-Alain, MATHONNET Muriel, MERCE
552 Emilie, MEUNIER Amélie, MOREAU J. Jacques, MOULIES Dominique, MOURGUES Thierry,
553 NOUGON Gervais, ORSEL Stéphane, ORSONI Nathalie, OSENDA Pierre, OSTYN Emmanuel,
554 PATRON Vincent, PELINARD Louis, PELISSIER Maxime, PEREZ Anne Frédérique, PESTEIL
555 Francis, PETELLAT Fabien, PETITPAS Stéphanie, PEYROU Philippe, PICCARDO Alessandro,
556 PICOULEAU Alexandre, POMMIER Auriane, PONCHEL Corinne, PRECHOUX J. Marc, PUYRAUD
557 Stéphane, QUILBE Sébastien, RAMIN Lionel, RANDIER Emmanuelle, ROBERT Pierre-Yves,
558 ROGER Thomas, ROMAIN Julie, ROSENBERG Rémi, ROUGEOT Amélie, SABATIER Amelie,
559 SALLE Henri, SANNAJUST J. Philippe, SAUVAGE J. Pierre, SCHNEIDER Aurélien, SCOMPARIN
560 Aurelie, SEKKAL Seifeddine, SENGELEN J. Marie, SERVANTIE Rémi, SHAREI Vahid, SIEGLER
561 Julien, TABOURET Eva, TAIBI Abdelkader, TARDELLI Tommaso, THOMAS Céline, TIGAN
562 Leonardo, TURKI Khalil, USSEGLIO-GROSSO Julie, VACQUERIE Virginie, VALAGIER Alexandre,
563 VALLEIX Denis, VAYSSE-VIC Mathieu, VERGNENEGRE Guillaume, VERGNOLLES Vincent, VIDAL
564 Jean, VIDAL Thomas, VINH Damien, VIVENT Muriel, WAVREILLE Olivier, YACHINE Mehdi
565