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**CANCER AMONG ADOLESCENTS AND YOUNG ADULTS BETWEEN 2000 AND 2016 IN FRANCE:  
INCIDENCE AND IMPROVED SURVIVAL**

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1 **CANCER AMONG ADOLESCENTS AND YOUNG ADULTS BETWEEN 2000 AND 2016 IN FRANCE:**  
2 **INCIDENCE AND IMPROVED SURVIVAL**

3 **ABSTRACT**

4 **Purpose:** This study was undertaken to determine cancer survival and describe the spectrum  
5 of cancers diagnosed among French adolescent and young adult (AYA) population.

6 **Methods:** All cases of cancer diagnosed in 15-24 years, recorded by all French population-  
7 based registries (18% of the French population), over the 2000-2016 period, were included.

8 Age-standardized incidences rates (ASR), conventional annual percentage change (cAPC) of  
9 incidence over time, and 5-year overall survival (5yOS) were calculated.

10 **Results:** We analyzed 2,734 cancer diagnoses in adolescents and 4,199 in young adults.

11 Overall incidence rates were 231.9/10<sup>6</sup> in 15-19 year olds and 354.0/10<sup>6</sup> in 20-24 year olds.

12 The most frequently diagnosed cancers in male AYA were malignant gonadal germ-cell  
13 tumors (GCT), Hodgkin lymphoma (HL), and malignant melanoma, and were HL, thyroid  
14 carcinoma, and malignant melanoma in females. Cancer incidence was stable over time with a

15 cAPC of 0.8% (p=0.72). For all cancers combined, 5yOS was 86.6% (95%CI: 85.8-87.4),

16 greater than 85% for HL, non-Hodgkin lymphomas (NHL), GCT, thyroid carcinomas, and  
17 malignant melanomas, and around 60% and lower for osteosarcomas, Ewing tumors, hepatic

18 carcinomas, and rhabdomyosarcomas. The 5yOS has significantly improved from 2000-2007

19 to 2008-2015 for all cancers pooled, with a substantial gain of 4% for 15-19 year-olds, and

20 3% for 20-24 year-olds.

21 **Conclusion:** Notwithstanding the encouraging results for some cancers, and overall,

22 persistent poorer survivals in AYA were shown compared to children for acute lymphoblastic

23 leukemia, osteosarcoma, Ewing tumor, rhabdomyosarcoma and malignant hepatic tumors.

24 These disparities require further investigation to identify and address the causes of these

25 inferior outcomes.

26

27 **Introduction**

28 Incidence and survival within the adolescents and young adults (AYA) population can be  
29 misleading when assessed across all tumor streams. The latest French report (2000-2008) <sup>1</sup>  
30 described an overall incidence rate (IR) 219.4 per million adolescents (age 15-19 years) and  
31 293.1 per million young adults (age 20-24 years). For all cancers combined, substantial  
32 survival gains were achieved, with an increase of 5-year overall survival (OS) from 62.0%  
33 (95%CI: 57.5-66.5) in the 1978-1982 period to 81.8% (95%CI: 79.5-83.9) in the 2000-2004  
34 period. An improvement in survival was found for leukemia, lymphoma, and central nervous  
35 system (CNS) tumors in subgroup analysis. Conversely, no increase in survival over time was  
36 observed for malignant bone tumors.<sup>1,2</sup> AYA had significantly worse 5-year OS, during the  
37 2000s, than children (0-14 years) for acute lymphoblastic leukemia (ALL, 62.8% vs. 89.8%),  
38 non-Hodgkin lymphomas (NHL, 78.9% vs. 88.3%), CNS tumors (67.3% vs. 71.9%), and  
39 bone sarcomas (50.0% vs. 74.4%).<sup>1,3</sup> To improve cancer outcomes for AYA, various  
40 initiatives have been implemented in France since 2011,<sup>4</sup> including promoting collaboration  
41 between pediatric and adult oncologists, developing French national policies for managing  
42 AYA with cancer, and setting up specific treatment units. Nevertheless it is unclear whether  
43 the adoption of pediatric-based protocols in adult centers has abolished disparities in AYA  
44 outcomes between pediatric and adult centers and improved outcomes at a population-level.  
45 Using a population-based cohort of AYA in France, the objectives were to provide updated  
46 statistics covering incidence and survival and to describe incidence and survival trends of  
47 these patients from 2000 to 2016.

48

49 **Methods**

50 *Source of data*

51 The registration of cancers in AYA is ensured by eighteen general and specialized  
52 population-based registries of the Francim network, covering 18% of the French population.  
53 Medico-administrative sources (health institution claims databases of public or private health  
54 institutions used to obtain hospital patient information coded on discharge, and health  
55 insurance schemes databases) and medical sources (multidisciplinary team meetings  
56 databases in oncology, histology reports databases) were used to identify cases. Vital status  
57 was obtained by active search in medical records and by matching the French Cancer  
58 Registries files and the national population register “Repertoire National d’Identification des  
59 Personnes Physiques” sorted by date and place of birth to obtain the mention of death and the  
60 date of death. The cut-off date was defined as June 30, 2018.

61

#### 62 *Population*

63 Data were taken from the common database of all Francim network registries, and included  
64 gender, age at diagnosis, and diagnostic information. In line with the recommendations of the  
65 European Network of Cancer Registries<sup>5</sup> and the third version of the International  
66 Classification of Childhood Cancer (ICCC-3),<sup>6</sup> eligibility criteria were: diagnosis of cancer,  
67 for CNS localization according to the first revision of the third edition of the International  
68 Classification of Disease for Oncology (ICDO-3),<sup>7</sup> benign and borderline tumors were also  
69 considered; from 15 to 24 years of age at diagnosis; and period of diagnosis between January  
70 1, 2000 and December 31, 2016. Cutaneous carcinomas were excluded.

71

#### 72 *Statistical Analyses*

73 All data were retrieved, tabulated by tumor type and categorized using the ICC-3 levels: 12  
74 main diagnostic groups, 47 diagnostic subgroups, and 2-11 divisions of selected subgroups.<sup>6</sup>  
75 The males/females (M/F) ratio was the ratio of number of cases in males to that in females.

76 The IR were calculated for the 17-year period, 2000-2016, and based on person-years derived  
77 from the annual estimates of population by age and sex provided by the Institute of Statistics  
78 and Economic Studies. Crude and age-specific IR were calculated and age-standardized rates  
79 (ASR) were estimated by the direct method using the world population for the age 15–24  
80 years.<sup>8</sup> Methods based on Poisson distribution were used to specify the 95% confidence  
81 interval (95%CI) for the IR.<sup>9</sup> Time trend in the incidence was estimated by the conventional  
82 annual percent change (cAPC) calculated as the slope of the linear regression used to model  
83 the natural logarithm of the IR as a function of the calendar year.<sup>10</sup> Survival analysis was  
84 performed on a dataset containing all cases diagnosed between January 1, 2000 and December  
85 31, 2015 and followed-up until June 30, 2018. The probability of OS was estimated using the  
86 Kaplan–Meier method.<sup>11</sup> The endpoint of interest was death from any cause for OS, with the  
87 date of diagnosis acting as the time origin. Survival curves between groups were compared  
88 using the log-rank test and the trend in survival over time periods was estimated using the log-  
89 rank test for trend.<sup>12,13</sup> Cox models were used to calculate the hazard ratios of death (HRs)  
90 and their 95%CI.<sup>14</sup> Statistical tests were two-sided with a significant level of 0.05. All  
91 statistical analyses were performed using the SAS version 9.4 (SAS Institute Inc., Cary, North  
92 Carolina, USA, 2013).

93

## 94 **Results**

### 95 *Patient characteristics*

96 Table 1 shows the number of cancers in AYA, diagnosed from 2000 to 2016, with main data  
97 quality indicators by French administrative areas where a French Cancer Registry is  
98 established. Most cancers were microscopically verified (98.6%) and only 2% had  
99 unspecified morphology. A total of 2,734 15-19-year-old adolescents (39.4%) and 4,199 20-  
100 24-year-old young adults (60.6%) were included. Table 2 shows the distribution of tumors by



101 age group and diagnostic group and the M/F ratios for each tumor type. The most common  
102 diagnoses in 15-19 year olds were lymphomas (27.7%): Hodgkin lymphoma (HL) 20.4%,  
103 NHL 6.0%. In young adults (20-24 years), the most frequent tumors were malignant epithelial  
104 tumors (33.8%): thyroid carcinomas (13.5%), malignant melanomas (10.2%). In 15-24-year-  
105 olds, approximately 30.7% of cancers were tumors of adulthood, especially thyroid  
106 carcinomas 11.6% and malignant melanomas 8.5%. Embryonal malignancies, including  
107 Wilms tumor, hepatoblastoma, neuroblastoma, and medulloblastoma, were rare accounting  
108 for less than 1% of cases. For all cancers combined, the M/F ratios were 1.0 for adolescents,  
109 for young adults, and for both. In male AYA, the most common cancers were malignant  
110 germ-cell tumors (GCT), malignant bone tumors, soft-tissue sarcomas, and leukemia, with  
111 M/F ratio of 5.0, 1.5, 1.4, and 1.4 respectively. Conversely, malignant melanomas and thyroid  
112 carcinomas were more frequent in female AYA (M/F ratio 0.6 and 0.2, respectively).

113

#### 114 *Incidence*

115 Table 2 shows the specific IR and ASR from 2000 to 2016 for the main tumor types by age  
116 group, computed with both genders. The ASR for the 15-24-year-old population was 289.4  
117 per million (95%CI: 279.8-299.2). The incidence (rate per million) was lowest in 15-19  
118 year olds: 232.2 (males) and 231.7 (females). This incidence increased to 351.4 (males) and  
119 372.2 (females) in 20-24 year olds. The highest ASR in males aged from 15 to 24 years was  
120 seen for malignant gonadal GCT (ASR = 89.2, 95%CI: 82.8-96.1). HL was the second most  
121 frequent tumor type in males (ASR = 51.7, 95%CI: 46.8-56.9), followed by malignant  
122 melanoma (ASR = 21.7, 95%CI: 18.5-25.2). In AYA females, HL represented the most  
123 frequent cancer type with an ASR of 58.6(95%CI: 52.6-65.2), thyroid carcinoma the second  
124 (ASR=54.1, 95%CI: 48.4-60.2), and malignant melanoma the third (ASR=30.7 95%CI: 26.6-  
125 35.4). Cancer incidence in AYA for both genders was stable over time with a cAPC of 0.8%

126 (95%CI: -3.5%;+5.3%, p=0.72, Fig.1). No variation in incidence was observed by age group,  
127 gender, or each ICCC-3 diagnostic group.

128

### 129 *Overall Survival*

130 Table 3 describes the 1-, 2-, and 5-year OS among AYA with cancer from 2000 to 2015 by  
131 ICCC-3 diagnostic groups and subgroups (n=6,480). With 2.9% lost to follow-up (Table 1),  
132 the median follow-up time in the cohort was 103 months (min-max: 0-222 months). At the  
133 end time, 983 AYA had died with a median time after diagnosis of 21 months (min-max: 0-  
134 194 months). For all cancers combined, OS was 95.3% (95%CI: 94.8-95.8) at 1 year, 91.3%  
135 (95%CI: 90.6-92.0) at 2 years, and 86.6% (95%CI: 85.8-87.4) at 5 years. The 5-year OS  
136 greater than 85% were observed for HL, NHL, GCT, thyroid carcinomas, cervix uteri  
137 carcinomas, and malignant melanomas whereas 5-year OS was around 60% and lower for  
138 osteosarcomas, Ewing tumors, hepatic carcinomas, and rhabdomyosarcomas. The 5-year OS  
139 were close to 65-80% for ALL, acute myeloid leukemia (AML), CNS tumors, and malignant  
140 renal tumors.

141 A comparison of 5-year OS in the studied periods (2000-2007 and 2008-2015) with those in  
142 earlier time periods (1972-1982, 1983-1987, 1988-1992, and 1993-1997 data from reference<sup>2</sup>)  
143 indicated that substantial survival gains were achieved for all tumors pooled (Table 4), with  
144 an increase from 62.0% (95%CI:57.5-66.5) in the 1978-82 period to 88.0% (95%CI:86.9-  
145 89.0) in the 2008-15 period. Since 1997, survival improvement was especially seen in  
146 leukemia and CNS tumors. For malignant bone tumors, the increase in survival was only  
147 observed during the last analyzed period (2008-15). Since 1993, survival was stable for soft-  
148 tissue sarcomas.

149 The 5-year OS has significantly improved from 2000-2007 to 2008-2015 for all cancers  
150 pooled, with a substantial gain of about 4% for 15-19 year-olds, and 3% for 20-24 year-olds

151 (Table 5). Increases in 5-year OS concerned most of diagnostic groups and were especially  
152 apparent for osteosarcomas in both age groups ( $p<0.01$ ), and carcinomas in 20-24 year-olds  
153 ( $p=0.04$ ). Conversely, a significant decrease over time was observed for astrocytomas in 20-  
154 24 year-olds ( $p=0.01$ ), due to differences in percentage of pilocytic astrocytoma and  
155 glioblastoma, respectively 51% vs. 12% during the 2000-2007 period, and 24% vs. 45%  
156 during the 2008-2015 period.

157 During the 2000-2007 period, there were no statistically significant differences in 5-year OS  
158 between adolescents (15-19 years) and young adults (20-24 years) whatever the main  
159 diagnostic group (Table 5). However, during the latest studied period, young adults (20-24  
160 years) diagnosed with ALL, astrocytoma, or Ewing's sarcoma had significantly a higher risk  
161 of dying from the disease compared to adolescents (15-19 years): HR=2.0 (IC95%: 1.1-3.5),  
162 HR=2.2 (IC95%: 1.2-3.9), and HR=2.3 (IC95%: 1.1-4.8), respectively. The histologic  
163 distribution of pilocytic astrocytoma and glioblastoma were significantly different between  
164 adolescents and young adults: 61% and 12% in 15- to 19-year-olds, vs. 24% and 45% in 20-  
165 to 24-year-olds ( $p<0.01$ ).

166

## 167 **Discussion**

168 Considering the emergence of interest in oncology in the AYA group, we examined incidence  
169 and survival of 15-24 year olds in order to better define the burden of the cancer for this age  
170 group. The two major findings in the present study were that cancer incidence in AYA  
171 remained stable during the 2000-2016 period, and the 5-year OS combined has significantly  
172 improved over time, especially for osteosarcoma. Another major finding of our study was  
173 that, during the latest studied period, adolescents had significantly better 5-year OS than  
174 young adults for ALL, Ewing's sarcomas, and astrocytomas.

175 The major strength of this study is its homogenization of compulsory registration based to  
176 various sources of notification of 18 population-based cancer registries providing a nonbiased  
177 and valid view of the situation in France during the studied period, compared to clinical series  
178 which report better survival than population-based studies. The coverage is 18% of the whole  
179 country. However, these registries have provided the estimates of national rates for decades  
180 and they are the gold standard referred to by all descriptive studies. Roughly 2,300 new cases  
181 of cancers in AYA are currently diagnosed each year in France (900 in adolescents and 1,400  
182 in young adults).

183 Several studies have described cancer incidence and survival in AYA, but few of them were  
184 based on the same period and the same age ranges.<sup>10,15-21</sup> Our incidence rates in 15-19 year  
185 olds were comparable to those reported in other countries.<sup>10,15-18</sup> In 20-24 year olds, highest  
186 incidence was observed in the United States (US): 386 per million.<sup>10</sup> Marked differences  
187 between France and the US occurred for thyroid carcinoma (IR per million: 78 versus 122 for  
188 young females, no difference for males) and for melanoma (IR per million: 47 versus 57 for  
189 young white females, no difference for males). In the US, the incidence of thyroid carcinoma  
190 in AYA population increased by 4.0% per year from 1988 to 2006, 8.6% per year from 2006  
191 to 2009, and 1.4% from 2009 to 2016, likely a consequence of ultrasound screening.<sup>22</sup> For  
192 melanoma, this suggests that American white female young adults may share high exposures  
193 that are associated with malignant melanoma. Jones et al<sup>23</sup> have reported that, during 1999-  
194 2009, the percentage of white American students who never or rarely wore sunscreen when  
195 outside on a sunny day for >1 hour increased from 57.5% to 69.4% (with an increase most  
196 pronounced among white female students). We reported a non-significant increase of +0.8 in  
197 incidence for all malignancies over time in 15- to 24-year olds. Vast differences between  
198 countries were observed in the incidence trend for all cancers combined. Gupta et al<sup>24</sup> have  
199 reported that the incidence of AYA (15-39 years) cancer rose over the 1998-2012 period in 23

200 countries, decreased in two countries, and remained stable in the other 16. Striking increases  
201 were noted for thyroid and testicular in 33 and 22 countries respectively, including France.  
202 The 5-year observed survivals in this study were similar to those reported for AYA in the US  
203 (2009-2015)<sup>10</sup>, in Australia (2000-2014)<sup>18</sup>, in the United-Kingdom (UK: 2005-2010)<sup>19</sup>, and in  
204 27 European countries participating in EUROCORE-5 (2000-2007)<sup>21</sup>. However marked  
205 differences between France and the UK occurred for NHL (88% vs. 79%), bone sarcomas  
206 (65% vs. 56%), soft-tissue sarcomas (67% vs. 61%), and GCT (93% vs. 82%). Compared to  
207 EUROCORE-5 study<sup>21</sup>, we reported higher survival for ALL, CNS tumors, Ewing's sarcoma,  
208 and soft-tissue sarcomas especially in 15-19 years. These survival disparities may be due to  
209 differences in tumor classification used (ICDO-2 vs. ICDO-3), in tumor selection (inclusion  
210 or not of benign/borderline CNS tumors), in distribution of cases by stages at diagnosis, by  
211 histological or biological subtypes, or by grades of neoplasm, and in treatment strategies by  
212 age over time.

213 Compared to results of the latest French reports among AYA,<sup>1,2</sup> we found an improvement in  
214 survival from 1978 to 2015, to achieve a 5-year OS of 88.0% (95%CI: 86.9-89.0) for all  
215 cancers combined during the 2008-2015 period. Increases in survival over time have been  
216 observed for all diagnostic groups, except for soft-tissue sarcomas with a 5-year OS around  
217 70% since the mid-90s. Compared to children and older adults, AYA with soft-tissue  
218 sarcomas have not experienced an improvement in survival.<sup>25,26</sup> The reasons for this disparity  
219 remain unclear, but following issues have been mentioned: delays in diagnosis, trial  
220 availability and participation, aspects of the organization of care, national centralization of  
221 sarcoma care, international consortia, and factors related to tumor biology.<sup>27</sup> In our series,  
222 comparison of 5-year OS of osteosarcoma AYA treated during 2000 to 2007 and 2008 to  
223 2015 revealed a significant improvement of 14% in adolescents and 40% in young adults.  
224 One of the most crucial factors contributing to the increase in survival is the setting up of the

225 French OS2006/sarcome-09 study using methotrexate-etoposide-ifosfamide based regimen,  
226 randomized to receive or not high doses of zoledronic acid adapted from those given for  
227 pediatric osteosarcoma patients.<sup>28,29</sup>

228 During the latest studied period, 5-year OS was worse in young adults than in adolescents and  
229 in children<sup>3</sup> for ALL (63.2%, 79.3%, and 89.8%, respectively), for astrocytoma (49.6%,  
230 74.8%, and 87.0%, respectively), and Ewing tumor (38.1%, 70.4%, and 73.8%, respectively).

231 Interest has recently been paid to AYA with ALL, particularly because all reports so far  
232 published indicate that these patients have a better outcome when treated with pediatric rather  
233 than adult therapeutic protocols.<sup>30</sup> In France since 2003, adolescents with ALL have been  
234 treated in or according to pediatric trials (either the FRALLE-2000 or EORTC-58951 trials)<sup>31</sup>  
235 and young adults markedly benefited from a pediatric approach by the Group for Research on  
236 Adult Acute Lymphoblastic Leukemia (GRAALL).<sup>32,33</sup> This may explain the difference in  
237 survival between adolescents and young adults. Although the inclusion of asparaginase in  
238 pediatric-inspired chemotherapy regimens has a positive impact on survival in AYA patients,  
239 factors accounting for differences in outcome compared to children include incidence of  
240 adverse events<sup>34</sup> and heterogeneity in ALL biology.<sup>35</sup> Differences in survival between  
241 children, adolescents and young adults with astrocytoma result of different distribution of  
242 gliomas with varying prognosis depending on tumor grade. Low-grade astrocytomas (WHO  
243 grades I and II including especially pilocytic astrocytomas) are the most frequently  
244 encountered brain tumors in early childhood and adolescence, while high-grade astrocytomas  
245 (WHO grades III and IV, such as anaplastic astrocytomas and glioblastomas) tend to occur at  
246 increasing rates with increasing age.<sup>36</sup> Several studies have analyzed potential correlations  
247 between Ewing sarcoma patients' ages and prognosis, but results have been inconsistent, and  
248 it remains unproven whether age in the AYA range by itself truly confers inferior survival.<sup>37</sup>

249 For this reason, European cooperative group trials have included patients up to the age of 50

250 years.<sup>38</sup> Moreover, in the EURO-EWING99 clinical trial, it has been observed that some  
251 toxicities (neutropenia, thrombocytopenia and stomatitis) may even decrease with age.<sup>38</sup> It  
252 remains to be determined whether less toxicity represents less treatment administered to older  
253 patients, or whether age distribution of biologic factors and Ewing-like tumor entities, treated  
254 as Ewing sarcoma and having different clinical behavior, can be held responsible.<sup>39</sup> Even  
255 though the survival between adolescents and young adults seemed to be similar for the other  
256 cancers, these AYA patients had persistent worse 5-year overall survival than children for  
257 osteosarcoma, rhabdomyosarcoma, and malignant hepatic tumors.<sup>1,3</sup> Several factors are  
258 believed to have influenced the lack of survival improvement noted for AYA: access to  
259 clinical trials, biologic characteristics of these cancers, access to health-care professionals and  
260 services, and specific treatment strategies.<sup>4,40,41</sup>

261

## 262 **Conclusion**

263 We have presented updated data representing a comprehensive analysis of cancer incidence  
264 and survival in AYA in France during the 2000-2016 period. Notwithstanding the  
265 encouraging results for some cancers, and overall, persistent poorer survivals in AYA were  
266 shown compared to children for ALL, osteosarcoma, Ewing tumor, rhabdomyosarcoma and  
267 malignant hepatic tumors. These survival disparities observed require further investigation to  
268 identify and address the causes of these inferior outcomes.

269

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271 No competing financial interests exist.

272

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282

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395 TABLE 1. CANCER CASES IN ADOLESCENTS AND YOUNG ADULTS DIAGNOSED IN 2000–2016, IN  
396 19 FRENCH ADMINISTRATIVE AREAS, WITH DATA QUALITY INDICATORS

397 Abbreviations: ICCC-3, third version of the International Classification of Childhood Cancer.

398

399 TABLE 2. NUMBER OF TUMORS, SEX RATIO, AND CANCER IRs PER MILLION IN AYA IN FRANCE  
400 FROM 2000 TO 2016 DETAILED BY DIAGNOSTIC GROUPS AND SUBGROUPS

401 Abbreviations: AYA, adolescents and young adults; ICCC-3, third version of the International  
402 Classification of Childhood Cancer; GCT, Germ-Cell tumors; cPNET, central primitive  
403 neuroectodermal tumors; pPNET, peripheral primitive neuroectodermal tumors; M/F ratio,  
404 Male/Female ratio; IR, Incidence rates per million; ASR, age-standardized incidence rates per  
405 million; 95%CI, 95% confidence interval.

406

407 **FIG. 1.** Time trend in age-standardized incidence rates estimated by the conventional annual  
408 percent change, in AYA (15–24 years) in France between 2000 and 2016

409 Abbreviations: cAPC, conventional annual percent change; ASR, age-standardized incidence  
410 rates per million; AYA, adolescents and young adults.

411

412 TABLE 3. ONE-, TWO-, AND FIVE-YEAR OVERALL SURVIVAL AMONG AYA WITH CANCER  
413 FROM 2000 TO 2015 BY ICCC-3 DIAGNOSTIC GROUPS

414 Abbreviations: AYA, adolescents and young adults; ICCC-3, third version of the International  
415 Classification of Childhood Cancer; GCT, Germ-Cell tumors; cPNET, central primitive  
416 neuroectodermal tumors; pPNET, peripheral primitive neuroectodermal tumors; OS, Overall  
417 Survival; 95%CI, 95% confidence interval.

418

419 TABLE 4. TRENDS IN FIVE-YEAR OVERALL SURVIVAL AMONG ADOLESCENTS AND YOUNG  
420 ADULTS WITH CANCER FROM 1978 TO 2015 BY ICCC-3 DIAGNOSTIC GROUPS  
421 Abbreviations: ICCC-3: third version of the International Classification of Childhood Cancer;  
422 OS: Overall Survival; 95%CI: 95% confidence interval  
423 \* Data from reference <sup>2</sup>  
424 # Only malignant CNS tumors were included (exclusion of benign or borderline tumors)  
425 <sup>a</sup> p<0.05 Comparison between diagnostic periods (2000-2007 vs 2008-2015)

426

427 TABLE 5. TRENDS IN FIVE-YEAR OVERALL SURVIVAL AMONG ADOLESCENTS AND YOUNG  
428 ADULTS WITH CANCER FROM 2000-2007 TO 2008-2015 BY ICCC-3 DIAGNOSTIC GROUPS  
429 Abbreviations: ICCC-3, third version of the International Classification of Childhood Cancer;  
430 5yOS, Five-year Overall Survival; 95%CI, 95% confidence interval.  
431 <sup>a</sup> p<0.05 Comparison between diagnostic periods (2000-2007 vs 2008-2015)  
432 <sup>b</sup> p<0.05 Comparison between age groups (15-19 years vs 20-24 years)

TABLE 1. CANCER CASES IN ADOLESCENTS AND YOUNG ADULTS DIAGNOSED IN 2000–2016, IN 19 FRENCH ADMINISTRATIVE AREAS, WITH DATA

QUALITY INDICATORS

French Administrative Areas	Registered period	Incidence analysis (2000-2016)			Survival analysis (2000-2015)	
		Patient included N	Microscopically Verified N (%)	Unspecified cases according to ICCC-3 N (%)	Patient included N	Lost to follow-up N (%)
14-Calvados	2000-2015	396	391 (98.7)	6 (1.5)	392	5 (1.3)
16-Charente	2008-2016	123	120 (97.6)	1 (0.8)	110	5 (4.5)
17-Charente/Maritime	2008-2016	189	187 (98.9)	2 (1.1)	164	19 (11.6)
25-Doubs	2000-2016	336	326 (97.0)	10 (3.0)	320	0 (0.0)
33-Gironde	2005,2008-2016	594	579 (97.5)	7 (1.2)	532	18 (3.4)
34-Hérault	2000-2016	632	624 (98.7)	12 (1.9)	573	25 (4.4)
38-Isère	2000-2016	816	810 (99.3)	7 (0.9)	775	17 (2.2)
44-Loire Atlantique	2000-2016	836	830 (99.3)	10 (1.2)	780	22 (2.8)
50-Manche	2000-2016	245	242 (98.8)	4 (1.6)	234	14 (6.0)
59-Lille Area	2008-2016	315	313 (99.4)	4 (1.3)	284	4 (1.4)
67- Bas Rhin	2000-2014	644	631 (98.0)	10 (1.6)	642	13 (2.0)
68- Haut Rhin	2000-2016	457	454 (99.3)	1 (0.2)	429	19 (4.4)
79-Deux-Sèvres	2008-2016	124	122 (98.4)	3 (2.4)	108	2 (1.9)
80-Somme	2000-2016	325	320 (98.5)	7 (2.2)	309	9 (2.9)
81-Tarn	2000-2016	173	171 (98.8)	1 (0.6)	157	3 (1.9)
85-Vendée	2000-2016	429	427 (99.5)	3 (0.7)	404	7 (1.7)
86-Vienne	2008-2016	151	146 (96.7)	2 (1.3)	133	3 (2.3)
87-Haute Vienne	2009-2016	99	97 (98.0)	2 (2.0)	89	2 (2.2)
90- Territoire de Belfort	2007-2016	49	48 (98.0)	1 (2.0)	45	1 (2.2)
Total	2000-2016	6933	6838 (98.6)	93 (1.3)	6480	188 (2.9)

Abbreviations: ICCC-3, third version of the International Classification of Childhood Cancer.

TABLE 2. NUMBER OF TUMORS, SEX RATIO, AND CANCER IRS PER MILLION IN AYA IN FRANCE FROM 2000 TO 2016 DETAILED BY DIAGNOSTIC

GROUPS AND SUBGROUPS

Diagnostic groups and subgroups (ICCC-3)	Adolescents (15–19 years)			Young adults (20–24 years)			AYA (15–24 years)		
	n (%)	M/F ratio	IR [95%CI]	n (%)	M/F ratio	IR [95%CI]	n (%)	M/F ratio	ASR [95%CI]
<b>I. Leukemias, myeloproliferative/dysplastic diseases</b>	<b>365 (13.4)</b>	<b>1.5</b>	<b>31.0 [27.9-34.3]</b>	<b>318 (7.6)</b>	<b>1.2</b>	<b>26.8 [23.9-29.9]</b>	<b>683 (9.9)</b>	<b>1.4</b>	<b>29.0 [26.0-32.2]</b>
Ia. Lymphoblastic leukemias	196 (7.2)	2.1	16.6 [14.4-19.1]	111 (2.6)	2.2	9.4 [7.7-11.3]	307 (4.4)	2.1	13.2 [11.2-15.4]
Ia1. Precursor cell leukemias	195 (7.1)	2.1	16.5 [14.3-19]	100 (2.4)	2.2	8.4 [6.9-10.3]	295 (4.3)	2.1	12.7 [10.8-14.9]
Ia2. Mature B-cell leukemias	1 (0.0)	0.0	0.1 [0.0-0.5]	8 (0.2)	3.0	0.7 [0.3-1.3]	9 (0.1)	2.0	0.4 [0.1-0.9]
Ia3. Mature T-cell and NK cell leukemias	0 (0.0)	-	0.0 [0.1-0.3]	3 (0.1)	0.5	0.3 [0.0-0.7]	3 (0.0)	0.5	0.1 [0.1-0.5]
Ib. Acute myeloid leukemias	102 (3.7)	1.1	8.7 [7.1-10.5]	87 (2.1)	0.9	7.3 [5.9-9.0]	189 (2.7)	1.0	8.0 [6.5-9.8]
Ic. Chronic myeloproliferative diseases	42 (1.5)	1.0	3.6 [2.6-4.8]	96 (2.3)	1.0	8.1 [6.6-9.9]	138 (2.0)	1.0	5.7 [4.4-7.2]
Id. Myelodysplastic diseases	16 (0.6)	0.8	1.4 [0.8-2.2]	19 (0.5)	0.7	1.6 [1.0-2.5]	35 (0.5)	0.8	1.5 [0.9-2.3]
Ie. Unspecified and other specified leukemias	9 (0.3)	3.5	0.8 [0.3-1.5]	5 (0.1)	0.3	0.4 [0.1-1.0]	14 (0.2)	1.3	0.6 [0.2-1.2]
<b>II. Lymphomas and lymphoreticular neoplasms</b>	<b>758 (27.7)</b>	<b>0.9</b>	<b>64.3 [59.8-69.1]</b>	<b>956 (22.8)</b>	<b>1.0</b>	<b>80.6 [75.6-85.9]</b>	<b>1714 (24.7)</b>	<b>0.9</b>	<b>72.0 [67.2-77.0]</b>
IIa. Hodgkin disease	557 (20.4)	0.8	47.3 [43.4-51.3]	703 (16.7)	0.9	59.3 [55-63.8]	1260 (18.2)	0.8	52.9 [48.8-57.2]
IIb. Non-Hodgkin lymphomas	164 (6.0)	1.0	13.9 [11.9-16.2]	227 (5.4)	1.2	19.1 [16.7-21.8]	391 (5.6)	1.1	16.4 [14.2-18.8]
IIb1. Precursor-cell lymphomas	12 (0.4)	5.0	1.0 [0.5-1.8]	14 (0.3)	2.5	1.2 [0.6-2.0]	26 (0.4)	3.3	1.1 [0.6-1.9]
IIb2. Mature B-cell lymphomas	101 (3.7)	0.9	8.6 [7.0-10.4]	160 (3.8)	1.3	13.5 [11.5-15.8]	261 (3.8)	1.1	10.9 [9.1-12.9]
IIb3. Mature T-cell and NK-cell lymphomas	47 (1.7)	1.0	4.0 [2.9-5.3]	46 (1.1)	0.8	3.9 [2.8-5.2]	93 (1.3)	0.9	3.9 [2.9-5.2]
IIb4. Unspecified Non-Hodgkin lymphomas	4 (0.1)	0.0	0.3 [0.1-0.9]	7 (0.2)	0.8	0.6 [0.2-1.2]	11 (0.2)	0.4	0.5 [0.2-1.0]
IIc. Burkitt lymphoma	23 (0.8)	3.6	2.0 [1.2-2.9]	15 (0.4)	4.0	1.3 [0.7-2.1]	38 (0.5)	3.8	1.6 [1.0-2.5]
IId. Miscellaneous lymphoreticular neoplasms	13 (0.5)	3.3	1.1 [0.6-1.9]	8 (0.2)	1.0	0.7 [0.3-1.3]	21 (0.3)	2.0	0.9 [0.4-1.6]
IIe. Unspecified lymphoma	1 (0.0)	0.0	0.1 [0.0-0.5]	3 (0.1)	0.0	0.3 [0.0-0.7]	4 (0.1)	0.0	0.2 [0.0-0.6]



TABLE 2. (CONTINUED)

Diagnostic groups and subgroups (ICCC-3)	Adolescents (15–19 years)			Young adults (20–24 years)			AYA (15–24 years)		
	n (%)	M/F ratio	IR [95%CI]	n (%)	M/F ratio	IR [95%CI]	n (%)	M/F ratio	ASR [95%CI]
<b>III. Central nervous system tumors</b>	<b>332 (12.1)</b>	<b>1.1</b>	<b>28.2 [25.2-31.4]</b>	<b>411 (9.8)</b>	<b>1.3</b>	<b>34.6 [31.4-38.2]</b>	<b>743 (10.7)</b>	<b>1.2</b>	<b>31.2 [28.1-34.6]</b>
IIIa. Ependymomas and choroid plexus tumor	31 (1.1)	1.6	2.6 [1.8-3.7]	25 (0.6)	1.5	2.1 [1.4-3.1]	56 (0.8)	1.5	2.4 [1.6-3.4]
IIIa1. Ependymomas	26 (1.0)	1.9	2.2 [1.4-3.2]	23 (0.5)	1.3	1.9 [1.2-2.9]	49 (0.7)	1.6	2.1 [1.3-3.1]
IIIa2. Choroid plexus tumor	5 (0.2)	0.7	0.4 [0.1-1.0]	2 (0.0)	-	0.2 [0.0-0.6]	7 (0.1)	1.3	0.3 [0.1-0.8]
IIIb. Astrocytomas	106 (3.9)	1.3	9.0 [7.4-10.9]	122 (2.9)	1.7	10.3 [8.5-12.3]	228 (3.3)	1.5	9.6 [7.9-11.5]
IIIc. Intracranial and intraspinal embryonal tumors	26 (1.0)	2.3	2.2 [1.4-3.2]	25 (0.6)	5.3	2.1 [1.4-3.1]	51 (0.7)	3.3	2.2 [1.4-3.2]
IIIc1. Medulloblastomas	18 (0.7)	3.5	1.5 [0.9-2.4]	19 (0.5)	8.5	1.6 [1.0-2.5]	37 (0.5)	5.2	1.6 [0.9-2.5]
IIIc2. ePNET	5 (0.2)	0.7	0.4 [0.1-1.0]	5 (0.1)	4.0	0.4 [0.1-1.0]	10 (0.1)	1.5	0.4 [0.1-1.0]
IIIc3. Medulloepithelioma	1 (0.0)	0.0	0.1 [0.0-0.5]	1 (0.0)	0.0	0.1 [0.0-0.5]	2 (0.0)	0.0	0.1 [0.0-0.5]
IIIc4. Atypical teratoid/rhabdoid tumor	2 (0.1)	-	0.2 [0.0-0.6]	0 (0.0)	-	0.0 [0.1-0.3]	2 (0.0)	-	0.1 [0.0-0.5]
IIId. Other gliomas	43 (1.6)	0.7	3.6 [2.6-4.9]	101 (2.4)	1.2	8.5 [6.9-10.3]	144 (2.1)	1.1	5.9 [4.7-7.5]
IIId1. Oligodendrogliomas	20 (0.7)	0.8	1.7 [1.0-2.6]	58 (1.4)	1.2	4.9 [3.7-6.3]	78 (1.1)	1.1	3.2 [2.3-4.4]
IIId2. Mixed and unspecified gliomas	22 (0.8)	0.7	1.9 [1.2-2.8]	42 (1)	1.2	3.5 [2.6-4.8]	64 (0.9)	1.0	2.7 [1.8-3.8]
IIId3. Neuroepithelial glial tumors	1 (0.0)	0.0	0.1 [0.0-0.5]	1 (0.0)	-	0.1 [0.0-0.5]	2 (0.0)	1.0	0.1 [0.0-0.5]
IIIe. Other specified intracranial and intraspinal tumors	115 (4.2)	0.9	9.8 [8.1-11.7]	121 (2.9)	0.8	10.2 [8.5-12.2]	236 (3.4)	0.9	10.0 [8.2-11.9]
IIIe1. Pituitary adenomas and carcinomas	6 (0.2)	2.0	0.5 [0.2-1.1]	4 (0.1)	0.3	0.3 [0.1-0.9]	10 (0.1)	1.0	0.4 [0.1-1.0]
IIIe2. Tumors of sellar region	10 (0.4)	0.7	0.8 [0.4-1.6]	20 (0.5)	1.2	1.7 [1.0-2.6]	30 (0.4)	1.0	1.2 [0.7-2.1]
IIIe3. Pineal parenchymal tumors	2 (0.1)	1.0	0.2 [0.0-0.6]	1 (0.0)	0.0	0.1 [0.0-0.5]	3 (0.0)	0.5	0.1 [0.0-0.6]
IIIe4. Neuronal and mixed neuronal-glial tumors	68 (2.5)	0.9	5.8 [4.5-7.3]	51 (1.2)	1.0	4.3 [3.2-5.7]	119 (1.7)	0.9	5.1 [3.9-6.5]
IIIe5. Meningiomas	29 (1.1)	0.9	2.5 [1.6-3.5]	45 (1.1)	0.7	3.8 [2.8-5.1]	74 (1.1)	0.8	3.1 [2.2-4.3]
IIIff. Unspecified intracranial and intraspinal neoplasms	11 (0.4)	0.8	0.9 [0.5-1.7]	17 (0.4)	1.4	1.4 [0.8-2.3]	28 (0.4)	1.2	1.2 [0.6-2.0]
<b>IV. Neuroblastoma</b>	<b>13 (0.5)</b>	<b>1.6</b>	<b>1.1 [0.6-1.9]</b>	<b>12 (0.3)</b>	<b>0.3</b>	<b>1.0 [0.5-1.8]</b>	<b>25 (0.4)</b>	<b>0.8</b>	<b>1.1 [0.6-1.8]</b>
IVa. Neuroblastoma and ganglioneuroblastoma	6 (0.2)	2.0	0.5 [0.2-1.1]	3 (0.1)	0.5	0.3 [0.0-0.7]	9 (0.1)	1.3	0.4 [0.1-0.9]
IVb. Other peripheral nervous cell tumors	7 (0.3)	1.3	0.6 [0.2-1.2]	9 (0.2)	0.3	0.8 [0.3-1.4]	16 (0.2)	0.6	0.7 [0.3-1.3]
<b>VI. Renal tumors</b>	<b>20 (0.7)</b>	<b>0.7</b>	<b>1.7 [1.0-2.6]</b>	<b>42 (1)</b>	<b>1.2</b>	<b>3.5 [2.6-4.8]</b>	<b>62 (0.9)</b>	<b>1.0</b>	<b>2.6 [1.7-3.6]</b>
VIa. Nephroblastoma, other nonepithelial renal tumors	6 (0.2)	0.0	0.5 [0.2-1.1]	7 (0.2)	1.3	0.6 [0.2-1.2]	13 (0.2)	0.4	0.5 [0.2-1.2]
VIa1. Nephroblastoma	4 (0.1)	0.0	0.3 [0.1-0.9]	6 (0.1)	2.0	0.5 [0.2-1.1]	10 (0.1)	0.7	0.4 [0.1-1.0]
VIa2. Rhabdoid renal tumors	1 (0.0)	0.0	0.1 [0.0-0.5]	1 (0.0)	0.0	0.1 [0.0-0.5]	2 (0.0)	0.0	0.1 [0.0-0.5]
VIa4. pPNET of kidney	1 (0.0)	0.0	0.1 [0.0-0.5]	0 (0.0)	-	0.0 [0.1-0.3]	1 (0.0)	0.0	0.0 [0.0-0.4]
VIb. Renal carcinoma	14 (0.5)	1.3	1.2 [0.6-2.0]	34 (0.8)	1.3	2.9 [2.0-4.0]	48 (0.7)	1.3	2.0 [1.3-2.9]
VIc. Unspecified malignant renal tumors	0 (0.0)	-	0.0 [0.1-0.3]	1 (0.0)	0.0	0.1 [0.0-0.5]	1 (0.0)	0.0	0.0 [0.0-0.4]

TABLE 2. (CONTINUED)

Diagnostic groups and subgroups (ICCC-3)	Adolescents (15–19 years)			Young adults (20–24 years)			AYA (15–24 years)		
	n (%)	M/F ratio	IR [95%CI]	n (%)	M/F ratio	IR [95%CI]	n (%)	M/F ratio	ASR [95%CI]
<b>VII. Hepatic tumors</b>	<b>11 (0.4)</b>	<b>0.8</b>	<b>0.9 [0.5-1.7]</b>	<b>20 (0.5)</b>	<b>1.9</b>	<b>1.7 [1.0-2.6]</b>	<b>31 (0.4)</b>	<b>1.4</b>	<b>1.3 [0.7-2.1]</b>
VIIa. Hepatoblastoma	1 (0.0)	-	0.1 [0.0-0.5]	0 (0.0)	-	0.0 [0.1-0.3]	1 (0.0)	-	0.0 [0.0-0.4]
VIIb. Hepatic carcinoma	9 (0.3)	0.5	0.8 [0.3-1.5]	20 (0.5)	1.9	1.7 [1.0-2.6]	29 (0.4)	1.2	1.2 [0.7-2.0]
VIIc. Unspecified malignant hepatic tumors	1 (0.0)	-	0.1 [0.0-0.5]	0 (0.0)	-	0.0 [0.1-0.3]	1 (0.0)	-	0.0 [0.0-0.4]
<b>VIII. Malignant bone tumors</b>	<b>217 (7.9)</b>	<b>1.5</b>	<b>18.4 [16.0-21.0]</b>	<b>122 (2.9)</b>	<b>1.6</b>	<b>10.3 [8.5-12.3]</b>	<b>339 (4.9)</b>	<b>1.5</b>	<b>14.6 [12.5-16.9]</b>
VIIIa. Osteosarcomas	107 (3.9)	1.7	9.1 [7.4-11.0]	48 (1.1)	1.4	4.0 [3.0-5.4]	155 (2.2)	1.6	6.7 [5.3-8.3]
VIIIb. Chondrosarcomas	17 (0.6)	0.9	1.4 [0.8-2.3]	32 (0.8)	0.9	2.7 [1.8-3.8]	49 (0.7)	0.9	2.0 [1.3-3.0]
VIIIc. Ewing tumor and related sarcomas of bone	83 (3.0)	1.5	7.0 [5.6-8.7]	36 (0.9)	3.5	3.0 [2.1-4.2]	119 (1.7)	1.9	5.2 [4.0-6.6]
VIII d. Other specified malignant bone tumors	8 (0.3)	0.3	0.7 [0.3-1.3]	6 (0.1)	2.0	0.5 [0.2-1.1]	14 (0.2)	0.8	0.6 [0.2-1.2]
VIII d2. Malignant chordomas	6 (0.2)	0.0	0.5 [0.2-1.1]	2 (0.0)	-	0.2 [0.0-0.6]	8 (0.1)	0.3	0.3 [0.1-0.9]
VIII d3. Odontogenic malignant tumors	1 (0.0)	-	0.1 [0.0-0.5]	0 (0.0)	-	0.0 [0.1-0.3]	1 (0.0)	-	0.0 [0.0-0.4]
VIII d4. Miscellaneous malignant bone tumors	1 (0.0)	-	0.1 [0.0-0.5]	4 (0.1)	1.0	0.3 [0.1-0.9]	5 (0.1)	1.5	0.2 [0.0-0.7]
VIII e. Unspecified malignant bone tumors	2 (0.1)	-	0.2 [0.0-0.6]	0 (0.0)	-	0.0 [0.1-0.3]	2 (0.0)	-	0.1 [0.0-0.5]
<b>IX. Soft tissue and other extrasosseous sarcomas</b>	<b>134 (4.9)</b>	<b>1.4</b>	<b>11.4 [9.5-13.5]</b>	<b>165 (3.9)</b>	<b>1.4</b>	<b>13.9 [11.9-16.2]</b>	<b>299 (4.3)</b>	<b>1.4</b>	<b>12.6 [10.6-14.8]</b>
IXa. Rhabdomyosarcomas	33 (1.2)	1.5	2.8 [1.9-3.9]	23 (0.5)	2.8	1.9 [1.2-2.9]	56 (0.8)	1.9	2.4 [1.6-3.5]
IXb. Fibrosarcomas, and other fibrous neoplasms	26 (1.0)	0.9	2.2 [1.4-3.2]	26 (0.6)	0.9	2.2 [1.4-3.2]	52 (0.8)	0.9	2.2 [1.4-3.2]
IXb1. Fibroblastic and myofibroblastic tumors	17 (0.6)	1.4	1.4 [0.8-2.3]	13 (0.3)	0.6	1.1 [0.6-1.9]	30 (0.4)	1.0	1.3 [0.7-2.1]
IXb2. Nerve sheath tumors	9 (0.3)	0.3	0.8 [0.3-1.5]	13 (0.3)	1.2	1.1 [0.6-1.9]	22 (0.3)	0.7	0.9 [0.5-1.7]
IXc. Kaposi sarcoma	0 (0.0)	-	0.0 [0.1-0.3]	1 (0.0)	0.0	0.1 [0.0-0.5]	1 (0.0)	0.0	0.0 [0.0-0.4]
IXd. Other specified soft tissue sarcomas	62 (2.3)	1.6	5.3 [4.0-6.7]	87 (2.1)	1.4	7.3 [5.9-9.0]	149 (2.1)	1.4	6.2 [4.9-7.8]
IXd1-2. Ewing tumors and pPNET of soft tissue	16 (0.6)	1.7	1.4 [0.8-2.2]	11 (0.3)	1.8	0.9 [0.5-1.7]	27 (0.4)	1.7	1.2 [0.6-2.0]
IXd3. Extrarenal rhabdoid tumor	0 (0.0)	-	0.0 [0.1-0.3]	3 (0.1)	0.5	0.3 [0.0-0.7]	3 (0.0)	0.5	0.1 [0.1-0.5]
IXd4. Liposarcomas	8 (0.3)	0.6	0.7 [0.3-1.3]	14 (0.3)	1.3	1.2 [0.6-2.0]	22 (0.3)	1.0	0.9 [0.5-1.6]
IXd5. Fibrohistiocytic tumors	2 (0.1)	1.0	0.2 [0.0-0.6]	5 (0.1)	0.7	0.4 [0.1-1.0]	7 (0.1)	0.8	0.3 [0.1-0.8]
IXd6. Meitomyosarcomas	6 (0.2)	-	0.5 [0.2-1.1]	10 (0.2)	1.0	0.8 [0.4-1.6]	16 (0.2)	2.2	0.7 [0.3-1.3]
IXd7. Synovial sarcomas	19 (0.7)	1.4	1.6 [1.0-2.5]	23 (0.5)	1.9	1.9 [1.2-2.9]	42 (0.6)	1.6	1.8 [1.1-2.7]
IXd8. Blood vessel tumors	4 (0.1)	0.3	0.3 [0.1-0.9]	5 (0.1)	0.3	0.4 [0.1-1.0]	9 (0.1)	0.3	0.4 [0.1-0.9]
IXd9. Osseous and chondromatous neoplasms	1 (0.0)	-	0.1 [0.0-0.5]	5 (0.1)	0.7	0.4 [0.1-1.0]	6 (0.1)	1.0	0.2 [0.1-0.7]
IXd10. Alveolar soft parts sarcoma	1 (0.0)	0.0	0.1 [0.0-0.5]	4 (0.1)	-	0.3 [0.1-0.9]	5 (0.1)	4.0	0.2 [0.0-0.7]
IXd11. Miscellaneous soft tissue sarcomas	5 (0.2)	-	0.4 [0.1-1.0]	7 (0.2)	2.5	0.6 [0.2-1.2]	12 (0.2)	5.0	0.5 [0.2-1.1]
IXe. Unspecified soft tissue sarcomas	13 (0.5)	2.3	1.1 [0.6-1.9]	28 (0.7)	1.5	2.4 [1.6-3.4]	41 (0.6)	1.7	1.7 [1.0-2.6]

TABLE 2. (CONTINUED)

Diagnostic groups and subgroups (ICCC-3)	Adolescents (15–19 years)			Young adults (20–24 years)			AYA (15–24 years)		
	n (%)	M/F ratio	IR [95%CI]	n (%)	M/F ratio	IR [95%CI]	n (%)	M/F ratio	ASR [95%CI]
<b>X. Germ-cell tumors, and other neoplasms of gonads</b>	<b>292 (10.7)</b>	<b>2.7</b>	<b>24.8 [22.0-27.8]</b>	<b>721 (17.2)</b>	<b>7.0</b>	<b>60.8 [56.4-65.4]</b>	<b>1013 (14.6)</b>	<b>5.0</b>	<b>41.7 [38.2-45.5]</b>
Xa. Intracranial and intraspinal germ cell tumors	31 (1.1)	6.8	2.6 [1.8-3.7]	16 (0.4)	7.0	1.3 [0.8-2.2]	47 (0.7)	6.8	2.0 [1.3-3.0]
Xa1. germinomas	20 (0.7)	19.0	1.7 [1-2.6,0]	9 (0.2)	-	0.8 [0.3-1.4]	29 (0.4)	28.0	1.3 [0.7-2.1]
Xa2. teratomas	3 (0.1)	0.5	0.3 [0.0-0.8]	5 (0.1)	1.5	0.4 [0.1-1.0]	8 (0.1)	1.0	0.3 [0.1-0.9]
Xa3. embryonal carcinomas	0 (0.0)	-	0.0 [0.1-0.3]	1 (0.0)	-	0.1 [0.0-0.5]	1 (0.0)	-	0.0 [0.0-0.4]
Xa4. yolk sac tumor	1 (0.0)	-	0.1 [0.0-0.5]	0 (0.0)	-	0.0 [0.1-0.3]	1 (0.0)	-	0.0 [0.0-0.6]
Xa5. choriocarcinomas	3 (0.1)	2.0	0.3 [0.0-0.8]	1 (0.0)	-	0.1 [0.0-0.5]	4 (0.1)	3.0	0.2 [0.0-0.6]
Xa6. tumors of mixed forms	4 (0.1)	-	0.3 [0.1-0.9]	0 (0.0)	-	0.0 [0.1-0.3]	4 (0.1)	-	0.2 [0.1-0.6]
Xb. Malignant extracranial and extragonadal GCT	14 (0.5)	2.5	1.2 [0.6-2.0]	35 (0.8)	2.5	3.0 [2.1-4.1]	49 (0.7)	2.5	2.0 [1.3-3.0]
Xb1. germinomas	8 (0.3)	1.7	0.7 [0.3-1.3]	10 (0.2)	9.0	0.8 [0.4-1.6]	18 (0.3)	3.5	0.8 [0.3-1.4]
Xb2. teratomas	3 (0.1)	-	0.3 [0.0-0.8]	3 (0.1)	2.0	0.3 [0.0-0.7]	6 (0.1)	5.0	0.3 [0.0-0.8]
Xb3. Embryonal carcinomas	0 (0.0)	-	0.0 [0.1-0.3]	1 (0.0)	-	0.1 [0.0-0.5]	1 (0.0)	-	0.0 [0.0-0.4]
Xb4. Yolk sac tumor	0 (0.0)	-	0.0 [0.1-0.3]	7 (0.2)	-	0.6 [0.2-1.2]	7 (0.1)	-	0.3 [0.2-0.8]
Xb5. Choriocarcinomas	1 (0.0)	0.0	0.1 [0.0-0.5]	10 (0.2)	0.4	0.8 [0.4-1.6]	11 (0.2)	0.4	0.4 [0.2-1.0]
Xb6. Other and unspecified malignant mixed GCT	2 (0.1)	-	0.2 [0.0-0.6]	4 (0.1)	3.0	0.3 [0.1-0.9]	6 (0.1)	5.0	0.2 [0.0-0.7]
Xc. Malignant gonadal germ cell tumors	224 (8.2)	3.5	19.0 [16.6-21.7]	626 (14.9)	15.1	52.8 [48.7-57.1]	850 (12.3)	8.6	34.9 [31.7-38.3]
Xc1. germinomas	48 (1.8)	1.2	4.1 [3.0-5.4]	189 (4.5)	9.5	15.9 [13.7-18.4]	237 (3.4)	4.9	9.7 [8.1-11.5]
Xc2. teratomas	49 (1.8)	2.3	4.2 [3.1-5.5]	106 (2.5)	8.6	8.9 [7.3-10.8]	155 (2.2)	5.0	6.4 [5.1-8.0]
Xc3. embryonal carcinomas	37 (1.4)	36.0	3.1 [2.2-4.3]	133 (3.2)	132.0	11.2 [9.4-13.3]	170 (2.5)	84.0	6.9 [5.6-8.5]
Xc4. yolk sac tumor	12 (0.4)	1.4	1.0 [0.5-1.8]	20 (0.5)	2.3	1.7 [1.0-2.6]	32 (0.5)	1.9	1.3 [0.8-2.2]
Xc5. choriocarcinomas	7 (0.3)	2.5	0.6 [0.2-1.2]	9 (0.2)	-	0.8 [0.3-1.4]	16 (0.2)	7.0	0.7 [0.3-1.3]
Xc6. tumors of mixed forms	71 (2.6)	13.2	6.0 [4.7-7.6]	169 (4.0)	55.3	14.2 [12.2-16.6]	240 (3.5)	29.0	9.9 [8.2-11.8]
Xd. Gonadal carcinoma	17 (0.6)	0.0	1.4 [0.8-2.3]	38 (0.9)	0.0	3.2 [2.3-4.4]	55 (0.8)	0.0	2.3 [1.5-3.3]
Xe. Other and unspecified malignant gonadal tumors	6 (0.2)	0.5	0.5 [0.2-1.1]	6 (0.1)	2.0	0.5 [0.2-1.1]	12 (0.2)	1.0	0.5 [0.2-1.1]

TABLE 2. (CONTINUED)

Diagnostic groups and subgroups (ICCC-3)	Adolescents (15–19 years)			Young adults (20–24 years)			AYA (15–24 years)		
	n (%)	M/F ratio	IR [95%CI]	n (%)	M/F ratio	IR [95%CI]	n (%)	M/F ratio	ASR [95%CI]
<b>XI. Epithelial neoplasms and malignant melanomas</b>	<b>580 (21.2)</b>	<b>0.5</b>	<b>49.2 [45.3-53.4]</b>	<b>1419 (33.8)</b>	<b>0.4</b>	<b>119.6 [113.5-126]</b>	<b>1999 (28.8)</b>	<b>0.4</b>	<b>82.3 [77.4-87.6]</b>
XIa. Adenocarcinomas	4 (0.1)	1.0	0.3 [0.1-0.9]	10 (0.2)	0.4	0.8 [0.4-1.6]	14 (0.2)	0.6	0.6 [0.2-1.2]
XIb. Thyroid carcinomas	241 (8.8)	0.3	20.4 [17.9-23.2]	566 (13.5)	0.2	47.7 [43.9-51.8]	807 (11.6)	0.2	33.3 [30.1-36.7]
XIc. Nasopharyngeal carcinomas	21 (0.8)	3.2	1.8 [1.1-2.7]	14 (0.3)	1.0	1.2 [0.6-2.0]	35 (0.5)	1.9	1.5 [0.9-2.4]
XId. Malignant melanomas	156 (5.7)	0.7	13.2 [11.2-15.5]	430 (10.2)	0.5	36.3 [32.9-39.8]	586 (8.5)	0.6	24.1 [21.4-26.9]
XIf. Other and unspecified carcinomas	158 (5.8)	0.6	13.4 [11.4-15.7]	399 (9.5)	0.4	33.6 [30.4-37.1]	557 (8)	0.4	22.9 [20.3-25.8]
XIf1. Carcinomas of salivary glands	21 (0.8)	0.4	1.8 [1.1-2.7]	22 (0.5)	0.7	1.9 [1.2-2.8]	43 (0.6)	0.5	1.8 [1.1-2.8]
XIf2. Carcinomas of colon and rectum	16 (0.6)	0.3	1.4 [0.8-2.2]	49 (1.2)	0.5	4.1 [3.1-5.5]	65 (0.9)	0.5	2.7 [1.8-3.7]
XIf3. Carcinomas of appendix	67 (2.5)	0.7	5.7 [4.4-7.2]	55 (1.3)	0.4	4.6 [3.5-6.0]	122 (1.8)	0.6	5.2 [4.0-6.7]
XIf4. Carcinomas of lung	13 (0.5)	1.2	1.1 [0.6-1.9]	41 (1.0)	1.0	3.5 [2.5-4.7]	54 (0.8)	1.0	2.2 [1.5-3.2]
XIf5. Carcinomas of thymus	5 (0.2)	0.7	0.4 [0.1-1.0]	6 (0.1)	1.0	0.5 [0.2-1.1]	11 (0.2)	0.8	0.5 [0.2-1.0]
XIf6. Carcinomas of breast	4 (0.1)	0.0	0.3 [0.1-0.9]	90 (2.1)	0.0	7.6 [6.1-9.3]	94 (1.4)	0.0	3.8 [2.9-4.9]
XIf7. Carcinomas of cervix uteri	1 (0.0)	0.0	0.1 [0.0-0.5]	40 (1)	0.0	3.4 [2.4-4.6]	41 (0.6)	0.0	1.6 [1.1-2.4]
XIf8. Carcinomas of bladder	1 (0.0)	-	0.1 [0.0-0.5]	1 (0.0)	-	0.1 [0.0-0.5]	2 (0.0)	-	0.1 [0.0-0.5]
XIf9. Carcinomas of eye	0 (0.0)	-	0.0 [0.1-0.3]	2 (0.0)	1.0	0.2 [0.0-0.6]	2 (0.0)	1.0	0.1 [0.1-0.5]
XIf10. Carcinomas of other specified sites	29 (1.1)	0.7	2.5 [1.6-3.5]	82 (2.0)	0.6	6.9 [5.5-8.6]	111 (1.6)	0.6	4.6 [3.5-5.9]
XIf11. Carcinomas of unspecified sites	1 (0)	-	0.1 [0.0-0.5]	11 (0.3)	2.7	0.9 [0.5-1.7]	12 (0.2)	3.0	0.5 [0.2-1.0]
<b>XII. Other and unspecified malignant neoplasms</b>	<b>12 (0.4)</b>	<b>3.0</b>	<b>1.0 [0.5-1.8]</b>	<b>13 (0.3)</b>	<b>1.2</b>	<b>1.1 [0.6-1.9]</b>	<b>25 (0.4)</b>	<b>1.8</b>	<b>1.1 [0.6-1.8]</b>
XIIa. Other specified malignant tumors	9 (0.3)	3.5	0.8 [0.3-1.5]	6 (0.1)	1.0	0.5 [0.2-1.1]	15 (0.2)	2.0	0.6 [0.3-1.3]
XIIa1. Gastrointestinal stromal tumor	5 (0.2)	4.0	0.4 [0.1-1.0]	2 (0.0)	1.0	0.2 [0.0-0.6]	7 (0.1)	2.5	0.3 [0.1-0.8]
XIIa4. Other complex mixed and stromal neoplasms	1 (0.0)	0.0	0.1 [0.0-0.5]	1 (0.0)	0.0	0.1 [0.0-0.5]	2 (0.0)	0.0	0.1 [0.0-0.5]
XIIa5. Mesothelioma	3 (0.1)	-	<b>0.3 [0.0-0.8]</b>	<b>3 (0.1)</b>	<b>2.0</b>	<b>0.3 [0.0-0.7]</b>	<b>6 (0.1)</b>	<b>5.0</b>	<b>0.3 [0.0-0.8]</b>
XIIb. Other unspecified malignant tumors	3 (0.1)	2.0	0.3 [0.0-0.8]	7 (0.2)	1.3	0.6 [0.2-1.2]	10 (0.1)	1.5	0.4 [0.1-1.0]
<b>Total</b>	<b>2734 (100.0)</b>	<b>1.0</b>	<b>231.9 [223.3-240.8]</b>	<b>4199 (100.0)</b>	<b>1.0</b>	<b>354.0 [343.4-364.9]</b>	<b>6933 (100.0)</b>	<b>1.0</b>	<b>289.4 [279.8-299.2]</b>

Abbreviations: AYA, adolescents and young adults; ICC-3, third version of the International Classification of Childhood Cancer; GCT, Germ-Cell tumors; cPNET, central primitive neuroectodermal tumors; pPNET, peripheral primitive neuroectodermal tumors; M/F ratio, Male/Female ratio; IR, Incidence rates per million; ASR, age-standardized incidence rates per million; 95%CI, 95% confidence interval.

TABLE 3. ONE-, TWO-, AND FIVE-YEAR OVERALL SURVIVAL AMONG AYA WITH CANCER FROM 2000 TO 2015 BY ICCC-3 DIAGNOSTIC GROUPS

ICCC-3 diagnostic groups and subgroups	n	1-year OS % [95%CI]	2-year OS % [95%CI]	5-year OS % [95%CI]
<b>I. Leukemias, myeloproliferative/dysplastic diseases</b>	<b>645</b>	<b>88.4 [85.6-90.6]</b>	<b>80.4 [77.1-83.3]</b>	<b>73.4 [69.7-76.6]</b>
Ia. Lymphoblastic leukemias	292	87.3 [82.9-90.6]	78.7 [73.5-83.0]	69.6 [63.9-74.6]
Ia1. Precursor cell leukemias	280	87.8 [83.4-91.2]	79.2 [74.0-83.5]	69.8 [63.9-74.9]
Ia2. Mature B-cell leukemias	9	77.8 [36.5-93.9]	66.7 [28.2-87.8]	66.7 [28.2-87.8]
Ia3. Mature T-cell and NK cell leukemias	3	66.7 [5.4-94.5]	66.7 [5.4-94.5]	66.7 [5.4-94.5]
Ib. Acute myeloid leukemias	176	83 [76.5-87.8]	72.2 [64.9-78.2]	64.4 [56.8-71.0]
Ic. Chronic myeloproliferative diseases	130	100.0 [-]	99.2 [94.7-99.9]	96.8 [91.7-98.8]
Id. Myelodysplastic diseases	34	91.2 [75.1-97.1]	82.1 [64.3-91.5]	75.6 [57.0-87.0]
Ie. Unspecified and other specified leukemias	14	64.3 [34.3-83.3]	42.9 [17.7-66.0]	42.9 [17.7-66.0]
<b>II. Lymphomas and reticuloendothelial neoplasms</b>	<b>1594</b>	<b>98.1 [97.3-98.7]</b>	<b>96.0 [94.9-96.8]</b>	<b>94.1 [92.8-95.1]</b>
IIa. Hodgkin disease	1170	99.7 [99.1-99.9]	98.0 [97.0-98.7]	96.5 [95.3-97.4]
IIb. Non-Hodgkin lymphomas	365	94.5 [91.5-96.4]	91.1 [87.7-93.6]	87.6 [83.7-90.6]
IIb1. Precursor-cell lymphomas	25	84 [62.8-93.7]	76.0 [54.2-88.4]	68.0 [46.1-82.5]
IIb2. Mature B-cell lymphomas	239	95.3 [91.7-97.4]	92.4 [88.1-95.1]	88.7 [83.8-92.2]
IIb3. Mature T-cell and NK-cell lymphomas	91	95.5 [88.5-98.3]	93.3 [85.7-96.9]	91.0 [82.8-95.4]
IIb4. Unspecified Non-Hodgkin lymphomas	10	90.0 [47.3-98.5]	80.0 [40.9-94.6]	80.0 [40.9-94.6]
IIc. Burkitt lymphoma	38	94.7 [80.6-98.7]	89.5 [74.3-95.9]	89.5 [74.3-95.9]
IId. Miscellaneous lymphoreticular neoplasms	17	88.2 [60.6-96.9]	82.4 [54.7-93.9]	82.4 [54.7-93.9]
IIe. Unspecified lymphoma	4	50.0 [5.8-84.5]	50.0 [5.8-84.5]	50.0 [5.8-84.5]
<b>III. Central nervous system tumors</b>	<b>695</b>	<b>92.7 [90.5-94.4]</b>	<b>86.4 [83.6-88.7]</b>	<b>78.1 [74.7-81]</b>
IIIa. Ependymomas and choroid plexus tumor	52	98 [86.9-99.7]	96.1 [85.2-99.0]	89.2 [76.0-95.4]
IIIa1. Ependymomas	45	100.0 [-]	97.7 [84.9-99.7]	90.0 [75.4-96.1]
IIIa2. Choroid plexus tumor	7	85.7 [33.4-97.9]	85.7 [33.4-97.9]	85.7 [33.4-97.9]
IIIb. Astrocytomas	213	90.9 [86.2-94.1]	78.0 [71.7-83.0]	66.7 [59.8-72.8]
IIIc. Intracranial and intraspinal embryonal tumors	47	89.4 [76.3-95.4]	85.1 [71.3-92.6]	71.1 [55.3-82.1]
IIIc1. Medulloblastomas	34	97.1 [80.9-99.6]	91.2 [75.1-97.1]	81.7 [63.6-91.4]
IIIc2. cPNET	9	66.7 [28.2-87.8]	66.7 [28.2-87.8]	20.0 [1.2-55.7]
IIIc3. Medulloepithelioma	2	100.0 [-]	100.0 [-]	100.0 [-]
IIIc4. Atypical teratoid/rhabdoid tumor	2	50.0 [0.6-91.0]	50.0 [0.6-91.0]	50.0 [0.6-91.0]
IIId. Other gliomas	141	85.6 [78.6-90.5]	77.7 [69.8-83.8]	63.7 [55.0-71.1]
IIId1. Oligodendrogliomas	78	85.5 [75.4-91.7]	78.9 [68.0-86.5]	68.4 [56.7-77.6]
IIId2. Mixed and unspecified gliomas	61	85.2 [73.6-92.0]	77.0 [64.3-85.7]	59.7 [46.1-71.0]
IIId3. Neuroepithelial glial tumors	2	100.0 [-]	50.0 [0.6-91.0]	50.0 [0.6-91.0]
IIIe. Other intracranial and intraspinal tumors	217	98.1 [95.1-99.3]	97.2 [93.9-98.7]	96.1 [92.4-98]
IIIe1. Pituitary adenomas and carcinomas	10	100.0 [-]	100.0 [-]	100 [100-100]
IIIe2. Tumors of sellar region	29	100.0 [-]	100.0 [-]	95.5 [71.9-99.3]
IIIe3. Pineal parenchymal tumors	3	100.0 [-]	100.0 [-]	100.0 [-]
IIIe4. Neuronal and mixed neuronal-glial tumors	112	98.2 [93.0-99.5]	97.3 [91.8-99.1]	96.3 [90.4-98.6]
IIIe5. Meningiomas	63	96.8 [87.8-99.2]	95.2 [85.8-98.4]	95.2 [85.8-98.4]
IIIe6. Unspecified neoplasms	27	92.3 [72.6-98.0]	92.3 [72.6-98.0]	88.5 [68.4-96.1]
<b>IV. Neuroblastoma</b>	<b>24</b>	<b>87.5 [66.1-95.8]</b>	<b>83.3 [61.5-93.4]</b>	<b>79.2 [57.0-90.8]</b>
IVa. Neuroblastoma and ganglioneuroblastoma	9	66.7 [28.2-87.8]	66.7 [28.2-87.8]	55.6 [20.4-80.5]
IVb. Other peripheral nervous cell tumors	15	100 -	93.3 [61.3-99.0]	93.3 [61.3-99.0]

Table 3. (CONTINUED)

ICCC-3 diagnostic groups and subgroups	n	1-year OS % [95%CI]	2-year OS % [95%CI]	5-year OS % [95%CI]
<b>VI. Renal tumors</b>	<b>55</b>	<b>90.7 [79.2-96.0]</b>	<b>88.9 [76.9-94.8]</b>	<b>79.1 [65.4-87.9]</b>
VIa. Nephroblastoma and other nonepithelial tumors	11	81.8 [44.7-95.1]	81.8 [44.7-95.1]	71.6 [35.0-89.9]
VIa1. Nephroblastoma	8	100.0 [-]	100.0 [-]	85.7 [33.4-97.9]
VIa2. Rhabdoid renal tumors	2	0.0 [-]	0.0 [-]	0.0 [-]
VIa4. pPNET of kidney	1	100.0 [-]	100.0 [-]	100.0 [-]
VIb. Renal carcinoma	43	92.9 [79.5-97.6]	90.5 [76.6-96.3]	80.5 [64.6-89.7]
VIc. Unspecified malignant renal tumors	1	100.0 [-]	100.0 [-]	100.0 [-]
<b>VII. Hepatic tumors</b>	<b>31</b>	<b>71.0 [51.6-83.7]</b>	<b>58.1 [39.0-73.1]</b>	<b>33.4 [17.3-50.4]</b>
VIIa. Hepatoblastoma	1	100.0 [-]	100.0 [-]	100.0 [-]
VIIb. Hepatic carcinoma	29	69.0 [48.8-82.5]	55.2 [35.6-71.0]	28.4 [13.0-46.0]
VIIf. Unspecified malignant hepatic tumors	1	100.0 [-]	100.0 [-]	100.0 [-]
<b>VIII. Malignant bone tumors</b>	<b>313</b>	<b>94.2 [90.9-96.3]</b>	<b>82.2 [77.5-86.1]</b>	<b>65.1 [59.4-70.3]</b>
VIIIa. Osteosarcomas	145	93.8 [88.3-96.7]	82.6 [75.3-87.9]	60.3 [51.5-67.9]
VIIIb. Chondrosarcomas	42	100.0 [-]	92.7 [79.0-97.6]	90.0 [75.6-96.1]
VIIIc. Ewing tumor and related sarcomas of bone	113	92.9 [86.3-96.4]	77.0 [68.1-83.7]	61.1 [51.3-69.5]
VIIfd. Other specified malignant bone tumors	12	90.9 [50.8-98.7]	90.9 [50.8-98.7]	72.7 [37.1-90.3]
VIIfd2. Malignant chordomas	6	80.0 [20.4-96.9]	80.0 [20.4-96.9]	40.0 [5.2-75.3]
VIIfd3. Odontogenic malignant tumors	1	100.0 [-]	100.0 [-]	100.0 [-]
VIIfd4. Miscellaneous malignant bone tumors	5	100.0 [-]	100.0 [-]	100.0 [-]
VIIfe. Unspecified malignant bone tumors	1	100.0 [-]	100.0 [-]	100.0 [-]
<b>IX. Soft tissue and other extraosseous sarcomas</b>	<b>288</b>	<b>90.5 [86.5-93.4]</b>	<b>79.9 [74.8-84.2]</b>	<b>66.8 [60.9-72.1]</b>
IXa. Rhabdomyosarcomas	52	84.6 [71.6-92.0]	61.5 [47.0-73.2]	48.1 [34.1-60.8]
IXb. Fibrosarcomas, and other fibrous neoplasms	50	89.8 [77.2-95.6]	85.7 [72.4-92.9]	79.1 [64.6-88.2]
IXb1. Fibroblastic and myofibroblastic tumors	29	100.0 [-]	96.4 [77.2-99.5]	89.0 [69.7-96.3]
IXb2. Nerve sheath tumors	21	76.2 [51.9-89.3]	71.4 [47.2-86.0]	66.7 [42.5-82.5]
IXc. Kaposi sarcoma	1	100.0 [-]	100.0 [-]	100.0 [-]
IXd. Other specified soft tissue sarcomas	144	93.6 [88.1-96.6]	84.4 [77.3-89.5]	70.6 [62.1-77.6]
IXd1-2. Ewing tumors and pPNET of soft tissue	27	92.6 [73.5-98.1]	74.1 [53.2-86.7]	58.3 [37.4-74.4]
IXd3. Extrarenal rhabdoid tumor	3	33.3 [0.9-77.4]	0.0 [-]	0.0 [-]
IXd4. Liposarcomas	22	100.0 [-]	100.0 [-]	95.2 [70.7-99.3]
IXd5. Fibrohistiocytic tumors	7	100.0 [-]	100.0 [-]	100.0 [-]
IXd6. Meiofibrosarcomas	16	100.0 [-]	100.0 [-]	87.5 [58.6-96.7]
IXd7. Synovial sarcomas	39	97.4 [82.8-99.6]	89.3 [73.8-95.8]	65.7 [47.3-78.9]
IXd8. Blood vessel tumors	8	75 [31.5-93.1]	62.5 [22.9-86.1]	50.0 [15.2-77.5]
IXd9. Osseous and chondromatous neoplasms	6	100.0 [-]	100.0 [-]	100.0 [-]
IXd10. Alveolar soft parts sarcoma	4	100.0 [-]	100.0 [-]	100.0 [-]
IXd11. Miscellaneous soft tissue sarcomas	12	81.8 [44.7-95.1]	54.5 [22.9-78.0]	36.4 [11.2-62.7]
IXe. Unspecified soft tissue sarcomas	41	87.8 [73.2-94.7]	80.5 [64.8-89.7]	62.6 [45.7-75.6]

Table 3. (CONTINUED)

ICCC-3 diagnostic groups and subgroups	n	1-year OS % [95%CI]	2-year OS % [95%CI]	5-year OS % [95%CI]
<b>X. Germ-cell tumors, and other neoplasms of gonads</b>	<b>948</b>	<b>97.0 [95.7-97.9]</b>	<b>94.5 [92.9-95.8]</b>	<b>92.9 [91-94.4]</b>
Xa. Intracranial and intraspinal germ cell tumors	42	97.6 [84.3-99.7]	88.1 [73.7-94.9]	83.3 [68.2-91.7]
Xa1. germinomas	26	100.0 [-]	92.3 [72.6-98.0]	88.5 [68.4-96.1]
Xa2. teratomas	7	100.0 [-]	100.0 [-]	100.0 [-]
Xa4. yolk sac tumor	1	100.0 [-]	0.0 [-]	0.0 [-]
Xa5. choriocarcinomas	4	75.0 [12.8-96.1]	75.0 [12.8-96.1]	75.0 [12.8-96.1]
Xa6. tumors of mixed forms	4	100.0 [-]	75.0 [12.8-96.1]	50.0 [5.8-84.5]
Xb. Malignant extracranial and extragonadal GCT	47	85.1 [71.3-92.6]	72.3 [57.2-82.9]	69.4 [53.8-80.7]
Xb1. germinomas	17	88.2 [60.6-96.9]	88.2 [60.6-96.9]	88.2 [60.6-96.9]
Xb2. teratomas	6	66.7 [19.5-90.4]	33.3 [4.6-67.6]	33.3 [4.6-67.6]
Xb3. Embryonal carcinomas	1	100.0 [-]	100.0 [-]	100.0 [-]
Xb4. Yolk sac tumor	6	100.0 [-]	50.0 [11.1-80.4]	50.0 [11.1-80.4]
Xb5. Choriocarcinomas	11	81.8 [44.7-95.1]	72.7 [37.1-90.3]	72.7 [37.1-90.3]
Xb6. Other and unspecified malignant mixed GCT	6	83.3 [27.3-97.5]	83.3 [27.3-97.5]	62.5 [14.2-89.3]
Xc. Malignant gonadal germ cell tumors	798	98.2 [97.0-98.9]	96.9 [95.5-97.9]	95.7 [94.0-96.9]
Xc1. germinomas	220	99.5 [96.7-99.9]	99.1 [96.3-99.8]	99.1 [96.3-99.8]
Xc2. teratomas	148	99.3 [95.2-99.9]	96.6 [91.9-98.6]	93.5 [87.9-96.6]
Xc3. embryonal carcinomas	159	100.0 [-]	99.4 [95.5-99.9]	98.0 [94.1-99.4]
Xc4. yolk sac tumor	29	96.4 [77.2-99.5]	96.4 [77.2-99.5]	96.4 [77.2-99.5]
Xc5. choriocarcinomas	16	87.1 [57.3-96.6]	73.7 [44.1-89.2]	73.7 [44.1-89.2]
Xc6. tumors of mixed forms	226	96.0 [92.4-97.9]	95.1 [91.3-97.2]	93.7 [89.6-96.2]
Xd. Gonadal carcinoma	50	88.0 [75.2-94.4]	82.0 [68.3-90.2]	77.9 [63.6-87.1]
Xe. Other and unspecified malignant gonadal tumors	11	100.0 [-]	100.0 [-]	100.0 [-]
<b>XI. Epithelial neoplasms and malignant melanomas</b>	<b>1883</b>	<b>97.1 [96.2-97.8]</b>	<b>95.3 [94.2-96.1]</b>	<b>92.5 [91.2-93.7]</b>
XIa. Adrenocortical carcinomas	14	78.6 [47.2-92.5]	57.1 [28.4-78.0]	57.1 [28.4-78.0]
XIb. Thyroid carcinomas	746	99.7 [98.9-99.9]	99.7 [98.9-99.9]	99.4 [98.5-99.8]
XIc. Nasopharyngeal carcinomas	33	90.9 [74.4-97.0]	84.8 [67.4-93.4]	77.8 [58.7-88.8]
XId. Malignant melanomas	560	98.9 [97.6-99.5]	97.8 [96.2-98.7]	95.3 [93.1-96.8]
XIf. Other and unspecified carcinomas	531	92.3 [89.7-94.3]	87.9 [84.8-90.4]	81.7 [78.1-84.8]
XIf1. Carcinomas of salivary glands	40	100.0 [-]	100.0 [-]	100.0 [-]
XIf2. Carcinomas of colon and rectum	64	92.2 [82.2-96.7]	85.9 [74.7-92.4]	67.9 [54.7-78.0]
XIf3. Carcinomas of appendix	109	100.0 [-]	100.0 [-]	100.0 [-]
XIf4. Carcinomas of lung	54	90.6 [78.8-96.0]	88.6 [76.4-94.7]	82.7 [69.4-90.6]
XIf5. Carcinomas of thymus	11	100.0 [-]	90.9 [50.8-98.7]	81.8 [44.7-95.1]
XIf6. Carcinomas of breast	91	94.5 [87.3-97.7]	91.2 [83.2-95.5]	82.7 [73.0-89.2]
XIf7. Carcinomas of cervix uteri	40	97.5 [83.5-99.6]	87.5 [72.5-94.6]	87.5 [72.5-94.6]
XIf8. Carcinomas of bladder	2	50.0 [0.6-91.0]	50.0 [0.6-91.0]	50.0 [0.6-91.0]
XIf9. Carcinomas of eye	2	100.0 [-]	100.0 [-]	100.0 [-]
XIf10. Carcinomas of other specified sites	107	84.1 [75.7-89.8]	75.7 [66.4-82.8]	70.7 [61.0-78.4]
XIf11. Carcinomas of unspecified sites	11	40.9 [12.7-67.9]	30.7 [7.3-58.6]	0.0 [-]
<b>XII. Other and unspecified malignant neoplasms</b>	<b>24</b>	<b>74.6 [51.9-87.7]</b>	<b>70.2 [47.4-84.5]</b>	<b>65.5 [42.6-81.1]</b>
XIIa. Other specified malignant tumors	14	92.9 [59.1-99.0]	92.9 [59.1-99.0]	85.1 [52.3-96.1]
XIIa1. Gastrointestinal stromal tumor	6	100.0 [-]	100.0 [-]	100.0 [-]
XIIa4. Other complex mixed and stromal neoplasms	2	50.0 [0.6-91.0]	50.0 [0.6-91.0]	50.0 [0.6-91.0]
XIIa5. Mesothelioma	6	100.0 [-]	100.0 [-]	83.3 [27.3-97.5]
XIIb. Other unspecified malignant tumors	10	46.7 [15.0-73.7]	35.0 [8.5-64.0]	35.0 [8.5-64.0]
<b>Total</b>	<b>6480</b>	<b>95.3 [94.8-95.8]</b>	<b>91.3 [90.6-92.0]</b>	<b>86.6 [85.8-87.4]</b>

Abbreviations: AYA, adolescents and young adults; ICC-3, third version of the International Classification of Childhood Cancer; GCT, Germ-Cell tumors; cPNET, central primitive neuroectodermal tumors; pPNET, peripheral primitive neuroectodermal tumors; OS, Overall Survival; 95%CI, 95% confidence interval.

TABLE 4. TRENDS IN FIVE-YEAR OVERALL SURVIVAL AMONG ADOLESCENTS AND YOUNG ADULTS WITH CANCER FROM 1978 TO 2015 BY

ICCC-3 DIAGNOSTIC GROUPS

ICCC-3 diagnostic groups	5-year OS % (95%CI)					
	1978-82*	1983-87*	1988-92*	1993-97*	2000-07	2008-15
<b>I. Leukemia</b>	28.6 (16.1-41.1)	25.3 (13.9-36.7)	30.3 (20.3-40.3)	49.5 (38.9-60.1)	69.5 (63.5-74.7)	76.2 (71.5-80.2)
<b>II. Lymphomas</b>	72.0 (63.8-80.2)	77.9 (71.4-84.4)	86 (80.3-91.7)	87.6 (82.9-92.3)	93.4 (91.6-95.5)	94.2 (92.5-95.5)
<b>III. Central Nervous System tumors</b>	47.4 (32.5-62.3)#	61.7 (46.4-77.0)#	63.3 (51.3-75.3)#	60.1 (47.9-72.3)#	77.6 (72.1-82.2)	78.3 (73.9-82.1)
<b>VIII. Malignant bone tumors</b>	59.3 (40.7-77.9)	48.4 (30.8-66.0)	58.6 (43.5-73.7)	60.3 (47.2-73.4)	58.2 (48.9-66.4)	70.0 (62.7-76.2) <sup>a</sup>
<b>IX. Soft tissue and other extraosseous sarcomas</b>	56.1 (36.3-75.9)	50.7 (33.8-67.6)	49.2 (35.7-62.7)	73.1 (60.0-86.2)	65.6 (56.6-73.2)	67.5 (59.3-74.5)
<b>X. Germ-cell tumors</b>	73.2 (63.4-83.0)	78 (69.4-86.6)	88.5 (83.2-93.8)	91.1 (86.6-95.6)	91.2 (87.9-93.6)	94.3 (91.9-96.0) <sup>a</sup>
<b>XI. epithelial neoplasms and melanomas</b>	75.9 (66.7-85.1)	74.6 (66.6-82.6)	85.7 (80.4-91.0)	89.9 (86.2-93.6)	90.9 (88.5-92.9)	93.5 (91.8-94.7) <sup>a</sup>
<b>All tumors</b>	62.0 (57.5-66.5)	66.0 (61.9-70.1)	73.2 (70.1-76.3)	80.2 (77.7-82.8)	81.8 (79.5-83.9)	88.0 (86.9-89.0) <sup>a</sup>

Abbreviations: ICCC-3: third version of the International Classification of Childhood Cancer; OS: Overall Survival; 95%CI: 95% confidence interval

\* Data from reference <sup>2</sup>

# Only malignant CNS tumors were included (exclusion of benign or borderline tumors)

<sup>a</sup> p<0.05 Comparison between diagnostic periods (2000-2007 vs 2008-2015)



TABLE 5. TRENDS IN FIVE-YEAR OVERALL SURVIVAL AMONG ADOLESCENTS AND YOUNG ADULTS WITH CANCER FROM 2000-2007 TO 2008-2015 BY

ICCC-3 DIAGNOSTIC GROUPS

ICCC-3 diagnostic groups and subgroups	Adolescents (15-19 years)						Young adults (20-24 years)					
	2000-2007			2008-2015			2000-2007			2008-2015		
	n	5yOS [95%CI]	n	5yOS [95%CI]	n	5yOS [95%CI]	n	5yOS [95%CI]	n	5yOS [95%CI]	n	5yOS [95%CI]
<b>I. Leukemias, myeloproliferative/myelodysplastic diseases</b>												
Ia. Lymphoblastic leukemias	83	69.6 [58.4-78.3]	100	79.3 [69.8-86.2] <sup>b</sup>	39	59.0 [42.0-72.5]	36	63.9 [46.1-77.2]	70	63.2 [50.4-73.5] <sup>b</sup>	46	71.4 [55.9-82.3]
Ib. Acute myeloid leukemias	39	59.0 [42.0-72.5]	55	62.4 [47.7-74.0]	35	94.3 [61.3-99.0]	35	94.3 [79.0-98.5]	54	98.1 [87.6-99.7]	54	98.1 [87.6-99.7]
Ic. Chronic myeloproliferative diseases	2	50.0 [0.6-91.0]	14	77.9 [45.9-92.3]	9	77.8 [36.5-93.9]	9	77.8 [36.5-93.9]	9	76.2 [33.2-93.5]	9	76.2 [33.2-93.5]
Id. Myelodysplastic / myeloproliferative diseases	3	33.3 [0.9-77.4]	6	50.0 [11.1-80.4]	3	33.3 [0.9-77.4]	3	33.3 [0.9-77.4]	2	50.0 [0.6-91.0]	2	50.0 [0.6-91.0]
Ie. Unspecified and other specified leukemias	286	94.4 [91.0-96.5]	409	95.0 [92.4-96.8]	335	93.4 [90.2-95.6]	335	93.4 [90.2-95.6]	564	93.6 [91.2-95.4]	564	93.6 [91.2-95.4]
<b>II. Lymphomas and reticuloendothelial neoplasms</b>												
IIa. Hodgkin disease	210	97.6 [94.3-99.0]	300	98.0 [95.5-99.1]	241	95.8 [92.4-97.7]	241	95.8 [92.4-97.7]	419	95.5 [93.0-97.2]	419	95.5 [93.0-97.2]
IIb. Non-Hodgkin lymphomas	66	86.2 [75.1-92.5]	85	86.8 [77.5-92.5]	82	87.8 [78.5-93.2]	82	87.8 [78.5-93.2]	132	88.2 [80.8-92.9]	132	88.2 [80.8-92.9]
IIc. Burkitt lymphoma	7	100.0 [-]	16	81.3 [52.5-93.5]	8	100.0 [-]	8	100.0 [-]	7	85.7 [33.4-97.9]	7	85.7 [33.4-97.9]
IId. Miscellaneous lymphoreticular neoplasms	3	33.3 [0.9-77.4]	7	100.0 [-]	3	66.7 [5.4-94.5]	3	66.7 [5.4-94.5]	4	100.0 [-]	4	100.0 [-]
IIe. Unspecified lymphoma	-	-	-	-	1	0.0 [-]	1	0.0 [-]	2	50.0 [0.6-91.0]	2	50.0 [0.6-91.0]
<b>III. Central nervous system tumors</b>												
IIIa. Ependymomas and choroid plexus tumor	119	80.3 [71.9-86.5]	187	81.3 [74.7-86.4]	151	75.4 [67.6-81.6]	151	75.4 [67.6-81.6]	238	76.0 [69.8-81.1]	238	76.0 [69.8-81.1]
IIIb. Astrocytomas	6	83.3 [27.3-97.5]	22	85.7 [53.9-96.2]	6	83.3 [27.3-97.5]	6	83.3 [27.3-97.5]	18	94.4 [66.6-99.2]	18	94.4 [66.6-99.2]
IIIc. Intracranial and intraspinal embryonal tumors	37	77.8 [60.4-88.2]	61	74.8 [61.6-84.0] <sup>b</sup>	43	73.7 [57.5-84.5] <sup>a</sup>	43	73.7 [57.5-84.5] <sup>a</sup>	72	49.6 [37.0-61.0] <sup>a,b</sup>	72	49.6 [37.0-61.0] <sup>a,b</sup>
IIId. Other gliomas	9	66.7 [28.2-87.8]	14	85.7 [53.9-96.2]	10	50.0 [18.4-75.3]	10	50.0 [18.4-75.3]	14	76.6 [43.3-91.9]	14	76.6 [43.3-91.9]
IIIe. Other specified intracranial and intraspinal neoplasms	16	43.8 [19.8-65.6]	24	47.8 [26.8-66.1]	50	67.3 [52.3-78.6]	50	67.3 [52.3-78.6]	51	73.6 [58.7-83.9]	51	73.6 [58.7-83.9]
IIIf. Unspecified intracranial and intraspinal neoplasms	45	97.7 [84.9-99.7]	61	96.7 [87.3-99.2]	38	94.4 [79.5-98.6]	38	94.4 [79.5-98.6]	73	95.3 [85.9-98.5]	73	95.3 [85.9-98.5]
<b>IV. Neuroblastoma, other peripheral nervous cell tumors</b>												
IVa. Neuroblastoma and ganglioneuroblastoma	6	83.3 [27.3-97.5]	5	100.0 [-]	5	80.0 [20.4-96.9]	5	80.0 [20.4-96.9]	11	90.0 [47.3-98.5]	11	90.0 [47.3-98.5]
IVb. Other peripheral nervous cell tumors	5	60.0 [12.6-88.2]	7	100.0 [-]	6	66.7 [19.5-90.4]	6	66.7 [19.5-90.4]	6	83.3 [27.3-97.5]	6	83.3 [27.3-97.5]
<b>VI. Renal tumors</b>												
VIa. Neuroblastoma and other nonepithelial renal tumors	2	0.0 [-]	4	100.0 [-]	1	100.0 [-]	1	100.0 [-]	2	50.0 [0.6-91.0]	2	50.0 [0.6-91.0]
VIb. Other peripheral nervous cell tumors	3	100.0 [-]	3	100.0 [-]	5	80.0 [20.4-96.9]	5	80.0 [20.4-96.9]	4	100.0 [-]	4	100.0 [-]
<b>VII. Renal tumors</b>												
VIIa. Nephroblastoma and other nonepithelial renal tumors	-	-	-	-	1	100.0 [-]	1	100.0 [-]	4	37.5 [1.1-80.8]	4	37.5 [1.1-80.8]
VIIb. Renal carcinoma	6	80.0 [20.4-96.9]	5	80.0 [20.4-96.9]	11	81.8 [44.7-95.1]	11	81.8 [44.7-95.1]	21	80.0 [54.9-92.0]	21	80.0 [54.9-92.0]
<b>VIII. Hepatic tumors</b>												
VIIIa. Hepatic carcinoma	6	33.3 [4.6-67.6]	5	60.0 [12.6-88.2]	6	16.7 [0.8-51.7]	6	16.7 [0.8-51.7]	14	35.7 [13.0-59.4]	14	35.7 [13.0-59.4]
VIIIb. Hepatic carcinoma	5	20.0 [0.8-58.2]	4	50.0 [5.8-84.5]	6	16.7 [0.8-51.7]	6	16.7 [0.8-51.7]	14	35.7 [13.0-59.4]	14	35.7 [13.0-59.4]

TABLE 5. (CONTINUED)

	15-19 years						20-24 years					
	2000-2007			2008-2015			2000-2007			2008-2015		
	n	5yOS	95%CI	n	5yOS	95%CI	n	5yOS	95%CI	n	5yOS	95%CI
<b>VIII. Malignant bone tumors</b>	<b>82</b>	<b>60.5</b>	<b>[49.0-70.2]<sup>a</sup></b>	<b>120</b>	<b>72.1</b>	<b>[62.8-79.4]<sup>a</sup></b>	<b>41</b>	<b>53.7</b>	<b>[37.4-67.4]</b>	<b>70</b>	<b>66.5</b>	<b>[53.7-76.6]</b>
VIIIa. Osteosarcomas	46	55.6	[40-68.6] <sup>a</sup>	56	69.8	[55.3-80.4] <sup>a</sup>	14	28.6	[8.8-52.4] <sup>b</sup>	29	68.4	[47.9-82.2] <sup>b</sup>
VIIIb. Chondrosarcomas	8	75.0	[31.5-93.1]	7	100.0	[-]	8	100.0	[-]	19	87.7	[58.8-96.8]
VIIIc. Ewing tumor and related sarcomas of bone	25	64.0	[42.2-79.4]	53	70.4	[55.6-81.1] <sup>b</sup>	17	52.9	[27.6-73.0]	18	38.1	[16.6-59.5] <sup>b</sup>
VIII d. Other specified malignant bone tumors	3	66.7	[5.4-94.5]	3	66.7	[5.4-94.5]	2	50.0	[0.6-91.0]	4	100.0	[-]
<b>IX. Soft tissue and other extrasosseous sarcomas</b>	<b>52</b>	<b>70.6</b>	<b>[56.0-81.1]</b>	<b>76</b>	<b>67.7</b>	<b>[55.3-77.4]</b>	<b>74</b>	<b>62.2</b>	<b>[50.1-72.1]</b>	<b>86</b>	<b>67.4</b>	<b>[55.7-76.6]</b>
IXa. Rhabdomyosarcomas	12	41.7	[15.2-66.5]	17	58.8	[32.5-77.8]	13	38.5	[14.1-62.8]	10	50.0	[18.4-75.3]
IXb. Fibrosarcomas, and other fibrous neoplasms	10	77.8	[36.5-93.9]	16	80.8	[51.4-93.4]	13	76.9	[44.2-91.9]	11	81.8	[44.7-95.1]
IXd. Other specified soft tissue sarcomas	24	79.2	[57.0-90.8]	36	66.8	[47.6-80.3]	37	70.3	[52.8-82.3]	47	67.9	[50.8-80.2]
IXe. Unspecified soft tissue sarcomas	6	83.3	[27.3-97.5]	7	68.6	[21.3-91.2]	10	40.0	[12.3-67.0]	18	65.8	[39.1-83.0]
<b>X. Germ-cell tumors, and other neoplasms of gonads</b>	<b>112</b>	<b>88.0</b>	<b>[80.2-92.8]</b>	<b>156</b>	<b>93.4</b>	<b>[88.1-96.4]</b>	<b>293</b>	<b>92.4</b>	<b>[88.7-94.9]</b>	<b>387</b>	<b>94.6</b>	<b>[91.8-96.5]</b>
Xa. Intracranial and intraspinal germ cell tumors	12	75.0	[40.8-91.2]	17	82.4	[54.7-93.9]	5	80.0	[20.4-96.9]	8	100.0	[-]
Xb. Malignant extracranial and extragonadal germ cell tumors	7	71.4	[25.8-92.0]	6	66.7	[19.5-90.4]	12	66.7	[33.7-86.0]	22	72.7	[49.1-86.7]
Xc. Malignant gonadal germ cell tumors	88	92.9	[84.9-96.8]	118	96.4	[90.7-98.6]	255	94.4	[90.7-96.6]	337	97.2	[94.7-98.5]
Xd. Gonadal carcinoma	5	60.0	[12.6-88.2]	10	90.0	[47.3-98.5]	16	81.3	[52.5-93.5]	19	73.3	[47.2-87.9]
Xe. Other and unspecified malignant gonadal tumors	-	-	[-]	-	-	[-]	5	100.0	[-]	1	100.0	[-]
<b>XI. Other malignant epithelial neoplasms and melanomas</b>	<b>207</b>	<b>92.1</b>	<b>[87.5-95.1]</b>	<b>342</b>	<b>93.7</b>	<b>[90.3-95.9]</b>	<b>463</b>	<b>90.4</b>	<b>[87.3-92.8]<sup>a</sup></b>	<b>871</b>	<b>93.4</b>	<b>[91.4-94.9]<sup>a</sup></b>
XIa. Adrenocortical carcinomas	2	0.0	[-]	2	0.0	[-]	2	50.0	[0.6-91.0]	8	87.5	[38.7-98.1]
XIb. Thyroid carcinomas	94	100.0	[-]	136	100.0	[-]	166	99.4	[95.8-99.9]	350	99.1	[97.3-99.7]
XIc. Nasopharyngeal carcinomas	5	60.0	[12.6-88.2]	15	78.0	[45.5-92.5]	4	75.0	[12.8-96.1]	9	87.5	[38.7-98.1]
XId. Malignant melanomas	61	94.9	[85.1-98.3]	86	95.9	[87.8-98.7]	168	93.4	[88.4-96.3]	245	96.4	[93.0-98.2]
XIf. Other and unspecified carcinomas	45	79.8	[64.8-89.0]	103	87.3	[78.6-92.6]	123	75.4	[66.7-82.1]	260	83.2	[78.0-87.3]
<b>XII. Other and unspecified malignant neoplasms</b>	<b>7</b>	<b>71.4</b>	<b>[25.8-92.0]</b>	<b>5</b>	<b>80.0</b>	<b>[20.4-96.9]</b>	<b>7</b>	<b>51.4</b>	<b>[11.8-81.3]</b>	<b>5</b>	<b>60.0</b>	<b>[12.6-88.2]</b>
XIIa. Other specified malignant tumors	5	100.0	[-]	4	100.0	[-]	1	0.0	[-]	4	75.0	[12.8-96.1]
XIIb. Other unspecified malignant tumors	2	0.0	[-]	1	0.0	[-]	6	62.5	[14.2-89.3]	1	0.0	[-]
<b>Total</b>	<b>1028</b>	<b>83.3</b>	<b>[80.8-85.5]<sup>a</sup></b>	<b>1511</b>	<b>87.0</b>	<b>[85.2-88.7]<sup>a</sup></b>	<b>1509</b>	<b>85.5</b>	<b>[83.6-87.2]<sup>a</sup></b>	<b>2432</b>	<b>88.6</b>	<b>[87.2-89.8]<sup>a</sup></b>

Abbreviations: ICCC-3, third version of the International Classification of Childhood Cancer; 5yOS, Five-year Overall Survival; 95%CI, 95% confidence interval.

<sup>a</sup> p<0.05 Comparison between diagnostic periods (2000-2007 vs 2008-2015)<sup>b</sup> p<0.05 Comparison between age groups (15-19 years vs 20-24 years)

