

Serveur Académique Lausannois SERVAL serval.unil.ch

Author Manuscript

Faculty of Biology and Medicine Publication

This paper has been peer-reviewed but does not include the final publisher proof-corrections or journal pagination.

Published in final edited form as:

Title: Factors Associated with Readmission of Patients with Congenital Heart Disease in a Swiss University Hospital.

Authors: Chave M, Marques-Vidal P

Journal: Pediatric cardiology

Year: 2017 Apr

Volume: 38

Issue: 4

Pages: 650-655

DOI: 10.1007/s00246-016-1562-9

In the absence of a copyright statement, users should assume that standard copyright protection applies, unless the article contains an explicit statement to the contrary. In case of doubt, contact the journal publisher to verify the copyright status of an article.

1 **FACTORS ASSOCIATED WITH READMISSION OF PATIENTS WITH CONGENITAL HEART DISEASE IN A**
2 **SWISS UNIVERSITY HOSPITAL**

3 **Running title:** Readmission of patients with congenital heart disease

4 Morgane Chave, student ¹ and Pedro Marques-Vidal, MD, PhD, FESC¹

5 ¹ Department of medicine, internal medicine, Lausanne university hospital (CHUV), rue du
6 Bugnon 46, 1011 Lausanne, Switzerland

7
8 **Authors' emails:**

9 Morgane Chave: Morgane.Chave@unil.ch

10 Pedro Marques-Vidal: Pedro-Manuel.Marques-Vidal@chuv.ch

11
12 **Address for correspondence and reprints**

13 Pedro Marques-Vidal

14 Office BH10 - 642

15 Department of Internal Medicine, Internal Medicine

16 Rue du Bugnon 46

17 1011 Lausanne

18 **Switzerland**

19 Phone : +41 21 314 09 34

20 Fax : +41 21 314 04 51

21 Email : Pedro-Manuel.Marques-Vidal@chuv.ch

22
23 **Funding:** none

24 The authors report no conflict of interest.

25
26 **Word count:** 205 (abstract), 1,863 (main text)

27 **Number of tables:** 3 (+4)

Figures: 0

References: 15

28

29 **ABSTRACT**

30 **Background:** Congenital heart defects (CHD) lead to extensive use of healthcare resources. Still, there
31 is little information available regarding readmission rates or associated factors. We sought to
32 evaluate readmission rates and their determinants among patients with CHD hospitalized in a Swiss
33 university hospital.

34 **Methods:** Retrospective study using data from all non-adult (<18 years) patients hospitalised
35 between 2002 and 2014 at the University Hospital of Lausanne with an International Classification of
36 Diseases (ICD) version 10 code Q20 to Q25.

37 **Results:** 996 patients (460 girls, 332 undergoing surgery, mean age 2.7 years) were assessed, 96 of
38 whom (9.6%) were readmitted within 30 days after discharge. Among the 96 readmissions, 83
39 (86.5%) were related to the CHD. Median time to readmission was 10 days (interquartile range: 6 -
40 20) and median length of readmission was 12 days (interquartile range: 6 - 20). After multivariate
41 adjustment, foreign nationality, greater distance to hospital and length of index hospitalisation <14
42 days predisposed to readmission. Patients who underwent surgery were less likely to be readmitted
43 (8.7%).

44 **Conclusion:** Readmissions were frequent, almost 1 in 10 patients, and associated with several socio-
45 clinical factors. Providing patients who live far from hospital with specialized care closer to home may
46 help reduce the rate of readmission.

47

48 **Keywords:** Congenital heart disease; readmission; Switzerland.

49

50 INTRODUCTION

51 Congenital heart disease (CHD) is the most common form of congenital anomaly, with a live
52 birth prevalence ranging from 5 [1,2] to over 50 per 1,000 live births [2,3]. Patients with CHD
53 consume considerable medical resources [4,5], leading to high healthcare costs. Hospital readmission
54 rates are now widely cited as a surrogate measure of quality of care and of healthcare costs [6].
55 Indeed, several studies have shown that almost 7% of children are readmitted to hospital within 30
56 days of discharge [7], but only a few studies conducted in North America assessed readmission rates
57 and determinants among CHD patients [8-11]. Assessing the factors associated with readmission
58 rates is important in order to act upon them and to reduce unnecessary hospitalisations and health
59 costs. Importantly, none of the studies took place in Europe.

60 Thus, our objectives were 1) to evaluate the rate of readmission among patients with CHD
61 and 2) to analyse the factors associated with readmission.

62 MATERIALS AND METHODS

63 *Data sources and collection*

64 The Lausanne university hospital (Centre Hospitalier Universitaire Vaudois, CHUV) is large
65 university hospital with over 1,200 beds dedicated to the care of patients living in the canton of Vaud
66 and neighbour cantons. The CHUV has a unit specialized in paediatric CHD, and performs
67 approximately 200 surgeries per year on CHDs. Data were extracted from the hospital records and
68 included gender, age at examination, country of birth, canton of residence, length of stay (LOS) and
69 all other disease codes. Readmissions were considered if the patient was readmitted ≤ 30 days after
70 his/her previous hospitalization; if a patient had multiple readmissions, only the first one was
71 considered. Due to logistic constraints (no national database on hospital stays and lack of
72 harmonization of data between hospitals), the analysis had to be restricted to a single hospital, a
73 procedure also performed in other studies [9,10].

74 All hospitalizations with an International Classification of Diseases (ICD-10) code ranging from
75 Q20 to Q25 recorded between the 1st of January 2002 and 30th of March 2014 at the CHUV were
76 considered. The exact list of the ICD-10 codes included is provided in **Supplementary Table 1**.

77 *Inclusion and exclusion criteria*

78 Inclusion criteria were age at admission <18 years, living in Switzerland and CHD as the main
79 cause for hospitalization. As the CHUV participates in humanitarian actions aimed at children with
80 CHD, patients coming from other countries to benefit from CHD surgery at the CHUV were excluded.
81 Finally, all adult (aged ≥18 years) patients were also excluded.

82 *Statistical analysis*

83 Statistical analyses were performed using Stata version 14.0 for Windows (Stata Corp,
84 College Station, Texas, USA). Descriptive results were expressed as number of participants
85 (percentage), as mean ± standard deviation or as median and [interquartile range - IQR] as
86 appropriate. Bivariate analyses were performed using chi-square or Fisher's exact test for qualitative
87 variables and Student's t-test or Kruskal-Wallis test for continuous variables. Multivariate analysis for
88 readmission was performed using logistic regression and the results were expressed as Odds ratio
89 (OR) and 95% confidence interval (CI). Tests were two-tailed and statistical significance was assessed
90 for p<0.05.

91 *Ethical statement*

92 The study was approved by the *Commission cantonale d'éthique de la recherche sur l'être*
93 *humain* (protocol number 32/14; decision issued January 30th, 2014). No informed individual consent
94 was necessary as the study used only available administrative data.

95 RESULTS

96 *Comparison between excluded and included patients*

97 Overall, data from 1919 patients with CHD were extracted, of whom 645 (33.6%) were aged
98 ≥ 18 years and 278 (14.5%) were from humanitarian actions. Thus, the final sample included 996
99 patients (51.9% of the initial extracted sample), of whom 332 (33.3%) were hospitalized for surgery.
100 The characteristics of the final sample overall and according to surgery are summarized in **table 1**.
101 Over two-thirds of hospitalizations for non-surgical reasons included children aged less than one
102 year; similarly, over half of hospitalizations for non-surgical reasons included children with congenital
103 malformations of cardiac septa (**Table 1**). A multivariate analysis showed age less than one year,
104 congenital malformations of cardiac septa, of aortic and mitral valves and other congenital
105 malformations of heart to be significantly and positively associated, while living far from hospital to
106 be inversely associated with hospitalization for non-surgical reasons (**Supplementary Table 2**).

107 *Factors associated with readmission*

108 Of the 996 patients, 96 (9.6%) were readmitted within 30 days, 83 of which (86.5% of
109 readmissions, 8.3% of all patients) with CHD as main diagnosis. Median [IQR] time to readmission
110 was 10 [6 – 20] days and median [IQR] LOS for the readmission was 12 [6 – 20] days.

111 The bivariate association between readmission for CHD or for any cause and different socio-
112 clinical factors is summarized in **table 2**. Patients of non-Swiss nationality or living in a canton far
113 from Vaud had a higher readmission rate, as well as being discharged in the beginning of the week
114 (Monday or Tuesday); conversely, index hospitalizations with a LOS>14 days had a lower readmission
115 rate (**Table 2**). These findings were partly confirmed by multivariate analysis, where benefiting from
116 surgery and LOS>14 days were significantly associated with a lower odds of readmission for CHD,
117 while living in a canton far from Vaud was associated with a higher odds of readmission for CHD or
118 any other cause (**table 3**).

119 Restricting the analysis to surgical patients showed day of discharge to be significantly
120 associated with readmission on bivariate analysis (**supplementary table 3**), while no associations
121 were found on multivariate analysis (**supplementary table 4**).

122 **DISCUSSION**

123 Our results indicate that almost one out of ten children with CHD are readmitted 30 days
124 after a hospitalization; longer LOS of the index hospitalization and being hospitalized for surgery are
125 associated with a lower odds of readmission, while living far from the hospital was associated with a
126 higher likelihood of readmission.

127 Most hospitalizations for non-surgical reasons regarded very young children (<1 year) with
128 mild forms of CHD. Hence, it is likely these hospitalizations regarded mainly newly diagnosed CHD in
129 hospitalized newborns that do not need (neonatal) surgery. Unfortunately it was not possible to
130 confirm this hypothesis, as the data was anonymized prior to extraction and no access to the
131 individual medical files could be obtained.

132 *Readmission rates*

133 Of the 996 patients, 96 (9.6%) were readmitted within 30 days, 83 of which (8.3% of all
134 patients) with CHD as main diagnosis . These values are slightly lower than in reported by studies
135 conducted in North America, where readmission rates ranged from 10.5% [8] to 14.1% [11]. Among
136 surgical patients, the readmission rate was 8.7%, again lower than reported by studies that excluded
137 all non-surgical patients (i.e. Kogon et al with 10.8% [10], Saharan et al [9] with 11.3%, and Smith et
138 al [8] with 10.5%).

139 The vast majority of the patients of our study (86.5%) were readmitted on basis of a cardiac
140 diagnosis, which is higher than reported in the literature, where values range from 14.9% [10] to
141 58.7% [11]. Among surgical patients, 75.9% of the readmissions were caused by a cardiac diagnosis,
142 again higher than in studies including only surgical patients [9,10,8] (14.9% for Kogon et al [10],

143 24.8% for Smith et al [8], and 39.1% for Saharan et al [9]). A possible explanation is that issues
144 unrelated to the underlying CHD are managed close to the patient's home, hospitalizations in the
145 CHUV being conducted only if related to the CHD. As there is no centralized database with medical
146 records in canton Vaud, it is not possible to control if patients were hospitalized elsewhere. Further,
147 it was not possible to individually interview each patient after hospitalization. Thus, future studies
148 should try to prospectively assess status at 30 days after hospitalization among children with CHD so
149 to include all hospitalizations occurring outside the university hospital.

150 *Factors associated with readmission*

151 Median time to readmission was 10 days, comparable to other studies, where median time
152 to readmission ranged from 7 [9] to 12 days [11].

153 Patients hospitalized for surgery had lower readmission rates, a finding consistent with the
154 literature [10,11]. A likely explanation is that paediatric surgical wards prepare more intensively the
155 patients and their families to manage the disease than other wards, thus preventing readmissions.
156 Other explanations include the corrective nature of surgical procedure for CHD, reducing the
157 hemodynamic anomalies that lead to complications and therefore readmission to hospital.

158 There is no consensus in the literature regarding day of discharge and risk of readmission:
159 some studies reported a higher risk for end-of-week discharges [11], other studies reported a higher
160 risk for weekday discharges [8], and other studies found no association at all [12]. In our study,
161 discharges occurring in the beginning of the week were associated with a higher risk of readmission
162 on bivariate analysis, although this was no longer statistically significant after multivariate analysis.
163 Thus, our results suggest that readmission rates are not related to day of discharge.

164 Contrary to the literature, a longer LOS was associated with a lower risk of readmission. This
165 finding was surprising, as all studies conducted so far reported that an initial hospital LOS over 10
166 days was associated with a higher risk of readmission [9,10,8,11]. A possible explanation is certain

167 reluctance among paediatricians to discharge children at the end of a week after an index
168 hospitalisation for CHD, which would artificially lengthen the index stay. A longer LOS could also be
169 related to a better preparation of the patient and the family to manage the disease, thus leading to a
170 lower readmission rate. Still, it would be of interest to assess the reasons for a longer LOS and if it is
171 related with a better preparation of the patient and the family. Another explanation is the natural
172 timeline of complications after CHD surgery, namely the fact that pleural [13] and pericardial [14]
173 [15] effusions usually occur within two weeks of surgery. Thus, patients who remain in hospital for 14
174 days can have their complications treated within the same hospital stay, whereas patients discharged
175 earlier need to be readmitted for the management of their post-operative complication.

176 Patients living far from the hospital had a higher readmission risk than patients who live in
177 the canton of Vaud. This could in part be explained by the fact that patients living far from the CHUV
178 being sent because they present with more severe or complex disease or with more comorbidities,
179 while patients presenting with a milder disease can be managed in their local hospital. Indeed,
180 patients living far from the hospital had a higher prevalence of congenital malformations of cardiac
181 septa (including tetralogy of Fallot) and congenital malformations of aortic and mitral valves
182 (**Supplementary table 5**). Still, this higher risk persisted even after adjustment for type of disease,
183 suggesting that other factors not accounted for might intervene. A first possible explanation is that,
184 because of the disease, patients and their families prefer to come (or are even sent by their local
185 caregivers) to a tertiary, university hospital in case of any complication. Another possible explanation
186 is that patients who live far from the CHUV have had less follow-up due to lack of specialized care in
187 their area. Interestingly, the CHUV has developed specialized consultations in other hospitals outside
188 the Vaud canton, and it will be interesting to assess their impact on readmission rates among
189 patients living far from the CHUV.

190 *Study limitations*

191 The main limitation to our study is the small sample size, with few patients undergoing
192 surgery, leading to a relatively low statistical power. Still, our study is the first one performed in
193 Europe and the sample size is bigger than other studies on the same topic [9,10]. The fact that it was
194 conducted in a single institution might reduce its generalizability; still, most studies on the same
195 topic were also conducted within a single institution [9,10] or a single region [11]. Other limitations
196 are the lack of readmission data in other hospitals, thus precluding comparisons; also, the
197 retrospective character does not allow studying the reasons for readmission. Finally, a possible
198 referral bias cannot be ruled out, as our institution is a referring centre for management of children
199 with congenital heart disease; hence, it is possible that only children with the most severe forms of
200 disease are overrepresented. Further studies are needed to increase sample size, for example by
201 joining all data from Switzerland.

202 *Conclusion*

203 In a Swiss university hospital, slightly less than one out of ten children with CHD is readmitted
204 within 30 days after the index hospitalization. Distance from hospital and shorter LOS significantly
205 increase the risk of readmission.

206 **REFERENCES**

- 207 1. Bourdial H, Jamal-Bey K, Edmar A, Caillet D, Wuillai F, Bernede-Bauduin C, Boumahni B, Robillard
208 PY, Kauffmann E, Laffitte A, Touret Y, Cuillier F, Fourmaintraux A, Alessandri JL, Gerardin P,
209 Randrianaivo H (2012) Congenital heart defects in La Reunion Island: a 6-year survey within a
210 EUROCAT-affiliated congenital anomalies registry. *Cardiol Young* 22 (5):547-557.
211 doi:10.1017/S1047951112000054
- 212 2. Hoffman JI, Kaplan S (2002) The incidence of congenital heart disease. *J Am Coll Cardiol* 39
213 (12):1890-1900

- 214 3. Ishikawa T, Iwashima S, Ohishi A, Nakagawa Y, Ohzeki T (2011) Prevalence of congenital heart
215 disease assessed by echocardiography in 2067 consecutive newborns. *Acta Paediatr* 100 (8):e55-
216 60. doi:10.1111/j.1651-2227.2011.02248.x
- 217 4. Simeone RM, Oster ME, Cassell CH, Armour BS, Gray DT, Honein MA (2014) Pediatric inpatient
218 hospital resource use for congenital heart defects. *Birth Defects Res A Clin Mol Teratol* 100
219 (12):934-943. doi:10.1002/bdra.23262
- 220 5. Connor JA, Gauvreau K, Jenkins KJ (2005) Factors associated with increased resource utilization for
221 congenital heart disease. *Pediatrics* 116 (3):689-695. doi:10.1542/peds.2004-2071
- 222 6. Axon RN, Williams MV (2011) Hospital readmission as an accountability measure. *Jama* 305
223 (5):504-505. doi:10.1001/jama.2011.72
- 224 7. Berry JG, Toomey SL, Zaslavsky AM, Jha AK, Nakamura MM, Klein DJ, Feng JY, Shulman S, Chiang
225 VW, Kaplan W, Hall M, Schuster MA (2013) Pediatric readmission prevalence and variability
226 across hospitals. *Jama* 309 (4):372-380. doi:10.1001/jama.2012.188351
- 227 8. Smith AH, Doyle TP, Mettler BA, Bichell DP, Gay JC (2015) Identifying predictors of hospital
228 readmission following congenital heart surgery through analysis of a multiinstitutional
229 administrative Database. *Congenit Heart Dis* 10 (2):142-152. doi:10.1111/chd.12209
- 230 9. Saharan S, Legg AT, Armsby LB, Zubair MM, Reed RD, Langley SM (2014) Causes of readmission
231 after operation for congenital heart disease. *Ann Thorac Surg* 98 (5):1667-1673.
232 doi:10.1016/j.athoracsur.2014.05.043
- 233 10. Kogon B, Jain A, Oster M, Woodall K, Kanter K, Kirshbom P (2012) Risk factors associated with
234 readmission after pediatric cardiothoracic surgery. *Ann Thorac Surg* 94 (3):865-873.
235 doi:10.1016/j.athoracsur.2012.04.025
- 236 11. Mackie AS, Ionescu-Iltu R, Pilote L, Rahme E, Marelli AJ (2008) Hospital readmissions in children
237 with congenital heart disease: a population-based study. *Am Heart J* 155 (3):577-584.
238 doi:10.1016/j.ahj.2007.11.003

- 239 12. Beck CE, Khambalia A, Parkin PC, Raina P, Macarthur C (2006) Day of discharge and hospital
240 readmission rates within 30 days in children: A population-based study. *Paediatr Child Health* 11
241 (7):409-412
- 242 13. Katanyuwong P, Dearani J, Driscoll D (2009) The role of pleurodesis in the management of
243 chylous pleural effusion after surgery for congenital heart disease. *Pediatr Cardiol* 30 (8):1112-
244 1116. doi:10.1007/s00246-009-9515-1
- 245 14. Dalili M, Zamani H, Aarabi-Moghaddam M (2012) Pericardial effusion after pediatric cardiac
246 surgeries: a single center observation. *Res Cardiovasc Med* 1 (1):28-32.
247 doi:10.5812/cardiovascmed.4601
- 248 15. Cheung EW, Ho SA, Tang KK, Chau AK, Chiu CS, Cheung YF (2003) Pericardial effusion after open
249 heart surgery for congenital heart disease. *Heart* 89 (7):780-783

250

251

252

253 **TABLES**254 **Table 1:** characteristics of the sample, overall and according to surgery.

	All	No surgery	Surgery	P-value
N (%)	996 (100)	664 (66.7)	332 (33.3)	
Gender (%)				0.472
Boys	536 (53.8)	352 (65.8)	184 (34.2)	
Girls	460 (46.2)	312 (67.8)	148 (32.2)	
Swiss nationality (%)				0.416
No	438 (44.0)	286 (65.3)	152 (34.7)	
Yes	558 (56.0)	378 (67.7)	180 (32.3)	
Age (years)	2.7 ± 4.4	2.2 ± 3.9	3.8 ± 5.0	<0.001
Age groups (%)				<0.001
[0-1[	615 (61.8)	454 (73.8)	161 (26.2)	
[1-18[	381 (38.3)	210 (55.1)	171 (44.9)	
Type of disease §				<0.001
Q20	97 (9.7)	56 (57.7)	41 (42.3)	
Q21	531 (53.3)	380 (71.6)	151 (28.4)	
Q22	55 (5.5)	38 (69.1)	17 (30.9)	
Q23	66 (6.6)	26 (39.4)	40 (60.6)	
Q24	42 (4.2)	33 (78.6)	9 (21.4)	
Q25	205 (20.6)	131 (63.9)	74 (36.1)	
Length of stay (days)	6 [2 - 14]	4 [1 - 9]	10 [5.5 - 24.5]	<0.001 †

255 Results are expressed as number of participants (percentage), mean ± SD or median [interquartile
256 range]. Percentage are expressed per column for all participants, and by row for surgery / non-
257 surgery groups. Comparisons between surgery groups performed by chi-square for categorical values
258 and Student's t-test or Kruskal-Wallis (†) test; p-values are for a two-sided test. § ICD-10 codes: Q20,
259 congenital malformations of cardiac chambers and connections; Q21, congenital malformations of
260 cardiac septa; Q22, congenital malformations of pulmonary and tricuspid valves; Q23, congenital
261 malformations of aortic and mitral valves; Q24, other congenital malformations of heart; Q25,
262 congenital malformations of great arteries.

263 **Table 2:** bivariate analysis of the factors associated with readmission at 30 days for congenital heart
 264 disease or for any cause, non-adult patients with congenital heart disease hospitalized at the
 265 Lausanne university hospital between 1st of January 2002 and 30th of March 2014.

	Congenital heart disease			Any cause		
	No	Yes	P-value	No	Yes	P-value
N	913	83		900	96	
Gender (%)			0.592			0.773
Girl	424 (46.4)	36 (43.4)		417 (46.3)	43 (44.8)	
Boy	489 (53.6)	47 (56.6)		483 (53.7)	53 (55.2)	
Surgery (%)			0.168			0.494
No	603 (66.1)	61 (73.5)		597 (66.3)	67 (69.8)	
Yes	310 (34.0)	22 (26.5)		303 (33.7)	29 (30.2)	
Age groups (%)			0.087			0.345
[0-1[	571 (62.5)	44 (53.0)		560 (62.2)	55 (57.3)	
[1-18[	342 (37.5)	39 (47.0)		340 (37.8)	41 (42.7)	
Nationality (%)			0.008			0.057
Not Swiss	390 (42.7)	48 (57.8)		387 (43.0)	51 (53.1)	
Swiss	523 (57.3)	35 (42.2)		513 (57.0)	45 (46.9)	
Type of disease §			0.235 †			0.521 †
Q20	90 (9.9)	7 (8.4)		89 (9.9)	8 (8.3)	
Q21	475 (52.0)	56 (67.5)		471 (52.3)	60 (62.5)	
Q22	52 (5.7)	3 (3.6)		51 (5.7)	4 (4.2)	
Q23	62 (6.8)	4 (4.8)		59 (6.6)	7 (7.3)	
Q24	40 (4.4)	2 (2.4)		40 (4.4)	2 (2.1)	
Q25	194 (21.3)	11 (13.3)		190 (21.1)	15 (15.6)	
Canton of origin			0.004			0.034
Vaud	546 (59.8)	42 (50.6)		540 (60.0)	48 (50.0)	
Neighbour ‡	238 (26.1)	18 (21.7)		231 (25.7)	25 (26.0)	
Other	129 (14.1)	23 (27.7)		129 (14.3)	23 (24.0)	
LOS>14 days (%)			0.005			0.055
No	677 (74.2)	73 (88.0)		670 (74.4)	80 (83.3)	
Yes	236 (25.9)	10 (12.0)		230 (25.6)	16 (16.7)	
Day of discharge			0.009 †			0.039 †
Sunday	51 (5.6)	3 (3.6)		50 (5.6)	4 (4.2)	

Monday	184 (20.2)	27 (32.5)	182 (20.2)	29 (30.2)
Tuesday	217 (23.8)	27 (32.5)	214 (23.8)	30 (31.3)
Wednesday	150 (16.4)	7 (8.4)	147 (16.3)	10 (10.4)
Thursday	111 (12.2)	11 (13.3)	110 (12.2)	12 (12.5)
Friday	136 (14.9)	6 (7.2)	133 (14.8)	9 (9.4)
Saturday	64 (7)	2 (2.4)	64 (7.1)	2 (2.1)

266 Results are expressed as number of participants and (column percentage). Statistical analysis by chi-
267 square or Fisher's exact test (+); p-values are for a two-sided test. § ICD-10 codes: Q20, congenital
268 malformations of cardiac chambers and connections; Q21, congenital malformations of cardiac
269 septa; Q22, congenital malformations of pulmonary and tricuspid valves; Q23, congenital
270 malformations of aortic and mitral valves; Q24, other congenital malformations of heart; Q25,
271 congenital malformations of great arteries. ‡, Fribourg, Geneva, Neuchâtel and Valais.

272

273 **Table 3:** multivariate analysis of the factors associated with readmission at 30 days for congenital
 274 heart disease or for any cause, non-adult patients with congenital heart disease hospitalized at the
 275 Lausanne university hospital between 1st of January 2002 and 30th of March 2014.

	CHO	p-value	Any cause	p-value
Gender				
Girl	1 (ref.)		1 (ref.)	
Boy	1.1 (0.68 - 1.77)	0.693	1.05 (0.67 - 1.62)	0.844
Surgery				
No	1 (ref.)		1 (ref.)	
Yes	0.49 (0.25 - 0.97)	0.042	0.63 (0.34 - 1.18)	0.153
Age groups				
[0-1[	1 (ref.)		1 (ref.)	
[1-18[	0.97 (0.56 - 1.69)	0.916	0.83 (0.49 - 1.40)	0.491
Nationality				
Not Swiss	1 (ref.)		1 (ref.)	
Swiss	0.62 (0.38 - 1.02)	0.062	0.70 (0.44 - 1.10)	0.124
Type of disease §				
Q20	1 (ref.)		1 (ref.)	
Q21	1.08 (0.45 - 2.62)	0.861	1.19 (0.52 - 2.73)	0.680
Q22	0.55 (0.13 - 2.33)	0.418	0.75 (0.21 - 2.71)	0.661
Q23	0.74 (0.19 - 2.82)	0.655	1.36 (0.44 - 4.22)	0.589
Q24	0.60 (0.11 - 3.16)	0.545	0.55 (0.11 - 2.82)	0.477
Q25	0.62 (0.22 - 1.72)	0.357	0.81 (0.32 - 2.04)	0.659
Canton of origin				
Vaud	1 (ref.)		1 (ref.)	
Neighbour ‡	1.31 (0.70 - 2.44)	0.401	1.50 (0.86 - 2.60)	0.152
Other	2.96 (1.56 - 5.61)	0.001	2.34 (1.27 - 4.31)	0.006
LOS>14 days				
No	1 (ref.)		1 (ref.)	
Yes	0.42 (0.20 - 0.91)	0.028	0.63 (0.33 - 1.19)	0.156
Day of discharge				
Sunday	1 (ref.)		1 (ref.)	
Monday	3.06 (0.85 - 10.9)	0.086	2.35 (0.76 - 7.26)	0.138
Tuesday	2.72 (0.77 - 9.62)	0.121	2.07 (0.68 - 6.30)	0.202

Wednesday	0.94 (0.23 - 3.89)	0.936	0.96 (0.28 - 3.26)	0.945
Thursday	2.22 (0.58 - 8.52)	0.247	1.60 (0.48 - 5.34)	0.441
Friday	0.99 (0.23 - 4.20)	0.991	1.00 (0.29 - 3.44)	0.996
Saturday	0.74 (0.12 - 4.72)	0.754	0.47 (0.08 - 2.71)	0.398

276 CHO, congenital heart disease. Results are expressed as odds ratio and [95% confidence interval]. §
277 ICD-10 codes: Q20, congenital malformations of cardiac chambers and connections; Q21, congenital
278 malformations of cardiac septa; Q22, congenital malformations of pulmonary and tricuspid valves;
279 Q23, congenital malformations of aortic and mitral valves; Q24, other congenital malformations of
280 heart; Q25, congenital malformations of great arteries. ‡, Fribourg, Geneva, Neuchâtel and Valais.

281

1 **SUPPLEMENTARY DATA**

2 **Supplementary table 1:** international classification of diseases (ICD-10) codes used to define
3 congenital heart disease.

ICD-10 code	Designation
Q20	Congenital malformations of cardiac chambers and connections
Q21	Congenital malformations of cardiac septa
Q22	Congenital malformations of pulmonary and tricuspid valves
Q23	Congenital malformations of aortic and mitral valves
Q24	Other congenital malformations of heart
Q25	Congenital malformations of great arteries

4

5 **Supplementary table 2:** factors associated with hospitalization for non-surgical reasons

	Odds ratio and (95% CI)	P-value
Gender		
Girl	1 (ref)	
Boy	0.96 (0.73 - 1.27)	0.790
Swiss national		
No	1 (ref)	
Yes	1.06 (0.79 - 1.43)	0.684
Canton		
Vaud	1 (ref)	
Neighbour	0.51 (0.37 - 0.71)	<0.001
Distant	0.62 (0.41 - 0.92)	0.019
Age group		
1+ year	1 (ref)	
<1 year	2.16 (1.61 - 2.91)	<0.001
Type of disease §		
Q20	1 (ref)	
Q21	1.84 (1.16 - 2.93)	0.010
Q22	1.60 (0.78 - 3.29)	0.198
Q23	0.52 (0.27 - 1.00)	0.049
Q24	2.75 (1.16 - 6.51)	0.021
Q25	1.34 (0.81 - 2.23)	0.258

6 Results are expressed as odds ratio and (95% confidence interval). Statistical analysis by logistic
7 regression. § ICD-10 codes: Q20, congenital malformations of cardiac chambers and connections;
8 Q21, congenital malformations of cardiac septa; Q22, congenital malformations of pulmonary and
9 tricuspid valves; Q23, congenital malformations of aortic and mitral valves; Q24, other congenital
10 malformations of heart; Q25, congenital malformations of great arteries.

11 **Supplementary table 3:** bivariate analysis of the factors associated with readmission at 30 days for
 12 congenital heart disease or for any cause, surgical patients with congenital heart disease hospitalized
 13 at the Lausanne university hospital between 1st of January 2002 and 30th of March 2014.

	Congenital heart disease			Any cause		
	No	Yes	P-value	No	Yes	P-value
N	310	22		303	29	
Gender (%)			0.932			0.977
Girl	138 (44.5)	10 (45.5)		135 (44.6)	13 (44.8)	
Boy	172 (55.5)	12 (54.6)		168 (55.5)	16 (55.2)	
Age groups (%)			0.768			0.716
[0-1[	151 (48.7)	10 (45.5)		146 (48.2)	15 (51.7)	
[1-18[	159 (51.3)	12 (54.6)		157 (51.8)	14 (48.3)	
Nationality (%)			0.393			0.914
Not Swiss	140 (45.2)	12 (54.6)		139 (45.9)	13 (44.8)	
Swiss	170 (54.8)	10 (45.5)		164 (54.1)	16 (55.2)	
Type of disease §			0.279 †			0.715 †
Q20	40 (12.9)	1 (4.6)		39 (12.9)	2 (6.9)	
Q21	135 (43.6)	16 (72.7)		133 (43.9)	18 (62.1)	
Q22	16 (5.2)	1 (4.6)		16 (5.3)	1 (3.5)	
Q23	39 (12.6)	1 (4.6)		37 (12.2)	3 (10.3)	
Q24	9 (2.9)	0 (0)		9 (3.0)	0 (0)	
Q25	71 (22.9)	3 (13.6)		69 (22.8)	5 (17.2)	
Canton of origin			0.746			0.939
Vaud	147 (47.4)	10 (45.5)		144 (47.5)	13 (44.8)	
Neighbour ‡	99 (31.9)	6 (27.3)		95 (31.4)	10 (34.5)	
Other	64 (20.7)	6 (27.3)		64 (21.1)	6 (20.7)	
LOS>14 days (%)			0.150			0.483
No	192 (61.9)	17 (77.3)		189 (62.4)	20 (69.0)	
Yes	118 (38.1)	5 (22.7)		114 (37.6)	9 (31.0)	
Day of discharge			0.019 †			0.058 †
Sunday	11 (3.6)	0 (0)		11 (3.6)	0 (0)	
Monday	52 (16.8)	8 (36.4)		50 (16.5)	10 (34.5)	
Tuesday	87 (28.1)	10 (45.5)		85 (28.1)	12 (41.4)	

Wednesday	50 (16.1)	3 (13.6)	49 (16.2)	4 (13.8)
Thursday	45 (14.5)	0 (0)	44 (14.5)	1 (3.5)
Friday	48 (15.5)	0 (0)	47 (15.5)	1 (3.5)
Saturday	17 (5.5)	1 (4.6)	17 (5.6)	1 (3.5)

14 Results are expressed as number of participants and (column percentage). Statistical analysis by chi-
15 square or Fisher's exact test (†); p-values are for a two-sided test. § ICD-10 codes: Q20, congenital
16 malformations of cardiac chambers and connections; Q21, congenital malformations of cardiac
17 septa; Q22, congenital malformations of pulmonary and tricuspid valves; Q23, congenital
18 malformations of aortic and mitral valves; Q24, other congenital malformations of heart; Q25,
19 congenital malformations of great arteries. ‡, Fribourg, Geneva, Neuchâtel and Valais.

20

21 **Supplementary table 4:** multivariate analysis of the factors associated with readmission at 30 days
 22 for congenital heart disease or for any cause, surgical patients with congenital heart disease
 23 hospitalized at the Lausanne university hospital between 1st of January 2002 and 30th of March 2014.

	CHO	p-value	Any cause	p-value
Gender				
Girl	1 (ref.)		1 (ref.)	
Boy	1.21 (0.46 - 3.16)	0.700	1.08 (0.46 - 2.50)	0.866
Age groups				
[0-1[	1 (ref.)		1 (ref.)	
[1-18[	0.32 (0.10 - 1.07)	0.064	0.41 (0.14 - 1.17)	0.094
Nationality				
Not Swiss	1 (ref.)		1 (ref.)	
Swiss	0.63 (0.22 - 1.84)	0.401	0.91 (0.37 - 2.23)	0.839
Type of disease §				
Q20	1 (ref.)		1 (ref.)	
Q21	4.35 (0.48 - 39.8)	0.193	3.08 (0.58 - 16.5)	0.189
Q22	2.28 (0.11 - 46.0)	0.590	1.14 (0.08 - 15.6)	0.921
Q23	1.01 (0.05 - 18.8)	0.995	2.08 (0.29 - 15.0)	0.469
Q24	NA		NA	
Q25	1.26 (0.12 - 13.7)	0.850	1.23 (0.21 - 7.16)	0.818
Canton of origin				
Vaud	1 (ref.)		1 (ref.)	
Neighbour ‡	0.70 (0.22 - 2.26)	0.556	0.91 (0.35 - 2.33)	0.837
Other	1.28 (0.39 - 4.18)	0.679	0.97 (0.32 - 2.90)	0.952
LOS>14 days				
No	1 (ref.)		1 (ref.)	
Yes	0.52 (0.14 - 1.90)	0.323	0.88 (0.30 - 2.60)	0.822
Day of discharge				
Sunday	1 (ref.)		1 (ref.)	
Monday	3.34 (0.31 - 35.9)	0.320	4.53 (0.47 - 43.2)	0.190
Tuesday	2.16 (0.23 - 20.1)	0.497	2.85 (0.33 - 24.6)	0.340
Wednesday	1.27 (0.11 - 14.9)	0.849	1.84 (0.18 - 18.9)	0.607
Thursday	NA		0.43 (0.02 - 7.44)	0.561

Friday	NA	0.44 (0.03 - 7.65)	0.572
Saturday	NA	NA	

24 CHO, congenital heart disease. Results are expressed as odds ratio and (95% confidence interval).
25 Statistical analysis by logistic regression . § ICD-10 codes: Q20, congenital malformations of cardiac
26 chambers and connections; Q21, congenital malformations of cardiac septa; Q22, congenital
27 malformations of pulmonary and tricuspid valves; Q23, congenital malformations of aortic and mitral
28 valves; Q24, other congenital malformations of heart; Q25, congenital malformations of great
29 arteries. ‡, Fribourg, Geneva, Neuchâtel and Valais. NA, not assessable.

30

31 **Supplementary table 5:** type of disease according to canton of residence.

	Vaud	Neighbour ‡	Other	P-value
N (%)	588 (59.0)	256 (25.7)	152 (15.3)	
Type of disease §				<0.001
Q20	40 (6.8)	36 (14.1)	21 (13.8)	
Q21	347 (59.0)	111 (43.4)	73 (48.0)	
Q22	29 (4.9)	16 (6.3)	10 (6.6)	
Q23	38 (6.5)	13 (5.1)	15 (9.9)	
Q24	23 (3.9)	16 (6.3)	3 (2.0)	
Q25	111 (18.9)	64 (25.0)	30 (19.7)	

32 Results are expressed as number of participants and (column percentage). Statistical analysis by chi-
 33 square; p-values are for a two-sided test. § ICD-10 codes: Q20, congenital malformations of cardiac
 34 chambers and connections; Q21, congenital malformations of cardiac septa; Q22, congenital
 35 malformations of pulmonary and tricuspid valves; Q23, congenital malformations of aortic and mitral
 36 valves; Q24, other congenital malformations of heart; Q25, congenital malformations of great
 37 arteries. ‡, Fribourg, Geneva, Neuchâtel and Valais.