

1 **Survival Estimates in European Cystic Fibrosis Patients and the Impact of**
2 **Socioeconomic Factors: A Retrospective Registry Cohort Study**

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30

31 **ABSTRACT**

32 **Background:** Median survival for cystic fibrosis (CF) patients in Europe is
33 unknown and is likely to be influenced by socioeconomic factors. Using the
34 European Cystic Fibrosis Society Patient Registry (ECFSPR), median survival
35 estimates were obtained for CF patients across Europe and the impact of
36 socioeconomic status on survival was examined.

37 **Methods.** CF subjects known to be alive and in the ECFSPR between 2010 and
38 2014 were included. Survival curves were estimated using the Kaplan-Meier (KM)
39 method. Differences in the survival curves were assessed using the log rank test.
40 Cox regression was used to estimate the association between socioeconomic
41 factors and the age-specific hazard of death, with adjustment for sex, age at
42 diagnosis, *CFTR* genotype and transplant status.

43 **Findings:** The final analysis included 13 countries with 31,987 subjects (135,833
44 person years of follow-up) and 1,435 deaths. Median survival age for these
45 patients in the ECFSPR was 51.7yrs (95% C.I. 50.0-53.4). After adjusting for
46 potential confounders age at diagnosis, sex, *CFTR* genotype and transplant status,
47 there remained strong evidence of an association between socioeconomic factors
48 and mortality ($p < 0.001$). Countries with higher health care spending had a 46%
49 lower hazard of mortality (HR: 0.54, 95% CI: 0.45-0.64) than countries with lowest
50 health care spending.

51 **Interpretation:** Median survival for patients with CF in Europe is comparable to
52 that reported in other jurisdictions and differs by socioeconomic factors.

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55 **KEY WORDS**

56 Survival, Epidemiology, Socioeconomic factors, F508del homozygotes, Cystic
57 fibrosis.

58

59 **ABBREVIATIONS**

60 CF = Cystic Fibrosis

61 CFTR = Cystic fibrosis Transmembrane Conductance Regulator

62 FEV₁ = Forced expiratory volume in one second

63 FVC = Forced Vital Capacity

64 ECFSR = European Cystic Fibrosis Society Patient Registry

65 ECFS = European Cystic Fibrosis Society

66 EU = European Union

67 HR = Hazard ratio

68 GNI = Gross National Income

69 GDP = Gross Domestic Product

70 SD = Standard deviation of the mean

71 SES = Socioeconomic Status

72 **INTRODUCTION:** Cystic fibrosis (CF) is one of the most common autosomal
73 recessive genetic conditions in Europe that causes progressive lung disease and
74 premature death. Median survival age for patients with CF is estimated to be in the
75 mid-40s although estimates can vary across countries¹. Reasons for this variation
76 in survival outcomes include genetic and environmental factors². A recent
77 comparison of CF survival between United States and Canadian CF registries³
78 identified differences in median survival that were attributed in part to differences
79 in nutrition, access to lung transplantation and socioeconomic factors⁴. To date,
80 median survival estimates for European CF patients as a whole are not known
81 although disparities in outcomes across Europe have been identified^{5,6}.

82

83 In 2003, the European Cystic Fibrosis Society (ECFS) developed a patient registry
84 to collect clinical and demographic data on CF patients attending specialised CF
85 centres throughout Europe^{7,8}. The European CF Society Patient Registry
86 (ECFSPR) now contains longitudinal data on more than 50,000 CF patients
87 attending CF centres in 38 European countries⁹. The goal of this study was to
88 estimate median survival for European CF patients and determine the association
89 between country-level socioeconomic factors and CF survival across European
90 countries.

91

92 **METHODS:** The study design is a retrospective cohort study using the ECFSPR
93 during the observation period from 2010 to 2014. The primary aim of the study was
94 to estimate median survival for CF patients throughout Europe and the secondary

95 aim was to examine the association between country-level socioeconomic factors
96 and survival. All procedures were approved by the St. Vincent's University Hospital
97 Research and Ethics Committee and by the ECFSPR Steering Committee.

98

99 *Patient Population.* Once a year, annual summary data for each CF patient
100 enrolled in the ECFSPR is uploaded to the registry⁹. Demographic and clinical
101 characteristics of the patient population were extracted from the ECFSPR for all
102 patients in the registry between 2010 and 2014. These characteristics were: sex,
103 age, vital status during year (alive/dead), transplant status, age at diagnosis, *CFTR*
104 genotype, highest annual forced expiratory volume in one second (FEV₁), forced
105 vital capacity (FVC), height and weight.

106

107 Due to concerns relating to incomplete data, only countries with national registries
108 and high enrolment (>80 of estimated percent of CF patient population enrolled)
109 with annual data for the 5-year period from 2010-2014 were included. Belgium, a
110 national registry with high enrolment, only had annual data from 2010-2013 and
111 was also included. The survival outcome of interest was all-cause mortality
112 including deaths post-transplant.

113

114 *Socioeconomic Factors.* Three validated metrics of country-level socioeconomic
115 status (SES) were used¹⁰. Two were measures of country healthcare spending
116 and one was a measure of country wealth. These were i) Proportion of Gross
117 Domestic Product (GDP) spent on Healthcare and ii) Average numbers of

118 physicians per 1,000 people and iii) Gross National Income (GNI) as estimated by
119 World Bank.¹¹ For the analysis, GDP spent on health care and average number of
120 physicians per 1,000 people were divided into thirds using terciles as the cut-off
121 points. GNI was also initially analysed in thirds using terciles as the cut-off points,
122 but as the highest and middle-income thirds were similar, this was dichotomised
123 into highest/middle versus lowest income.

124

125 *Statistical Analysis.* Descriptive statistics were used to present the demographics
126 and clinical data of the CF cohort. Definitions of clinical variables are as determined
127 by the ECFSPR¹². Overall survival curves were estimated using the Kaplan Meier
128 method and Cox proportional hazards modelling was used to estimate hazard
129 ratios in the cohort. The time scale was age. Patients were considered to be at
130 risk from age of entry into the cohort until the earliest of: age of exit, death or end
131 of follow-up period on 31st December 2014. Death was defined as all-cause
132 mortality either before or after transplant. Loss to follow-up was defined as present
133 if two or more years of observation were missing before the end-date for the cohort
134 (31st December 2014 for all countries except Belgium, whose end-date was 31st
135 December 2013)³. Due to incomplete follow-up of CF patients post-transplant in
136 many countries, analysis was repeated using the composite outcome of death or
137 transplant as well as censoring at time of transplant.

138

139 Univariable Cox regression analysis was carried out examining the association
140 between age at diagnosis, sex, cystic fibrosis transmembrane conductance

141 regulator (CFTR) genotype as well as transplant status and survival. *CFTR*
142 genotype was characterised by the presence or absence of *F508del* mutations and
143 by the presence of compound heterozygosity for two *CFTR* Class I-III mutations
144 using the classification system proposed by Welsh and Tsui^{13,14}. Transplant status
145 was defined as a transplant of any type (primarily lung and/or liver) and was used
146 as a time-dependent variable. Measures associated with survival in univariable
147 analysis were included in a multivariable model for the adjusted association
148 between SES and survival. Due to the difference in *CFTR* genotype across Europe
149 and the known association of *CFTR* genotypes with survival, sensitivity analyses
150 were also carried out limiting the population to CF patients homozygous for
151 *F508del* and to CF patients compound heterozygous for two *CFTR* Class I-III
152 mutations. Proportional hazards assumption was assessed using graphical
153 methods (log-log plot of survival) and methods based on Schoenfeld residuals with
154 no significant deviations found. All statistical analysis was carried out using Stata
155 (14.0) software (San Antonio, Texas).

156

157 *Role of the funding source.* There was no external funding to ECFSPR for this
158 study. Statistical analysis was supported through a grant from ECFSPR to the
159 London School of Hygiene & Tropical Medicine. The corresponding author had full
160 access to all the data and the final responsibility for the decision to publish. All
161 authors were involved in data collection or the study design as well as manuscript
162 preparation and review.

163

164 **RESULTS**

165 There were 31,987 CF patients in the ECFSPR between 2010 and 2014 from 13
166 countries that met all of the inclusion criteria. The ECFSPR patient population
167 included in the study is outlined in Table 1. There were 1,435 deaths with an
168 average patient follow-up of 4.2 years and 135,833 person-years at risk. There
169 were 983 (3.0%) lost to follow-up. Demographics of ECFSPR countries excluded
170 from the study are shown in Supplemental Table 1. Demographics and clinical
171 characteristics for patients during their first year of entry into the cohort are
172 summarised in Table 2. Standardised all-population survival rates for each county
173 and country classification of SES measures are shown in Table 3. As would be
174 expected, there was variation seen across European countries for the different
175 measures of SES.

176

177 *Survival Analysis:* Median age of survival for all European patients included in the
178 study was 51.7 years (95% C.I. 50.0-53.4, $p < 0.001$). The Kaplan Meier curve for
179 the study cohort all-cause mortality is shown in Figure 1. Results including median
180 survival for CF genetic subgroups and when transplant is considered as a death
181 are shown in Table 4. Median survival with the composite outcome of death or
182 transplant was 38.5 years (95% C.I. 37.5-39.4, $p < 0.001$). The Kaplan Meier curve
183 for the study cohort with the composite outcome of death or transplant is shown in
184 Figure 2. Median survival censoring at transplant was 56.8 years (95% C.I. 54.0-
185 60.2, $p < 0.001$). The Kaplan Meier curve for the study cohort censored at transplant
186 is shown in Figure 3.

187 In univariable analyses, age at diagnosis, gender, *CFTR* genotype and transplant
188 status were all strongly associated with differences in survival (Table 5). Female
189 gender was associated with a 28% increased hazard of death compared to males.

190

191 *Socioeconomic factors and survival.* All measures of country-level SES were
192 associated with increased hazard for death in univariable analyses. After adjusting
193 for age at diagnosis, sex, *CFTR* genotype and transplant status, the proportion of
194 GDP spent on healthcare and number of physicians per capita were each
195 independently associated with survival. Countries in the highest third of GDP
196 spend on healthcare had a 45% lower hazard than those in the lowest third (HR
197 0.544, 95% CI (0.448,0.641)). Similarly, countries in the highest third of physicians
198 per capita had a 47% lower hazard than those with the lowest third of physician
199 per capita ratio (HR 0.523, 95% CI (0.385, 0.661)). These results are shown in
200 Table 6. The Kaplan Meier curve for GDP spend on healthcare and physicians per
201 capita is shown in Figure 3. After multivariable adjustment high GNI was
202 associated with a lower hazard, however this finding was not statistically significant
203 (HR for high versus low GNI 0.859, 95% CI (0.667, 1.051)).

204

205 **DISCUSSION.**

206 We have shown that median survival in patients with cystic fibrosis across Europe
207 is comparable to that of Canada and the United States and that there is variation
208 across Europe that is associated with socioeconomic factors.

209

210 Survival for patients with CF is variable and is influenced by factors including
211 background *CFTR* genetics and environmental exposures². *CFTR* genotypes with
212 at least one Class IV-V *CFTR* mutation have a milder phenotype and better
213 survival^{15,16}. Likewise, environmental factors such as acquisition of *Pseudomonas*
214 *aeruginosa*¹⁷, *Staph aureus* and *Burkholderia cepacia complex*¹⁸ also influence
215 mortality. In the United States, there is a clear association between SES and CF
216 outcomes with absence of private medical insurance and lower median income
217 independently associated with higher mortality^{19,20}. This relationship between
218 SES and survival in CF is multi-factorial with access to healthcare, education,
219 adherence and expectations all contributing to differences in outcomes²¹. In
220 Europe, McCormick et al, using the European CF Demographics Registry dataset
221 (a precursor of ECFSPR), demonstrated differences in demographics across
222 Europe with a median patient age of 17.0 years in the European Union (EU)
223 countries compared to a median patient age of 12.1 years in non-European Union
224 countries⁶. The proportion of patients aged older than 40 years of age was twice
225 as high in EU countries than non-EU countries raising concerns about under-
226 diagnosis of CF and increased childhood mortality as a result of unequal access
227 to specialist CF care and CF medicines. This was consistent with the earlier work
228 of Fogarty et al who also found differences in median age of death for CF patients
229 across countries which they attributed to possible underdiagnosis and diagnostic
230 misclassification of CF as well as socioeconomic factors⁵.

231 One of the challenges of comparing differences in survival across countries has
232 been differences in statistical methodology in single country registry annual

233 reports.^{22,23} In a recent study looking at survival in the US and Canadian CF patient
234 registries, using the same methodology for survival analysis²⁴, there was an almost
235 10 year difference in median survival that has been increasing since 2005³.
236 Socioeconomic factors, nutrition and access to lung transplantation were all
237 considered to influence this difference in survival⁴. Median survival in CF patients
238 in the US was 40.6 years compared to 50.9 years in Canada. The median survival
239 estimated in our ECFSPR study, using a similar statistical methodology, was 51.7
240 years. However, a limitation of our study is that many European patients in the
241 ECFSPR have limited data after lung transplant as many transplant centres are
242 not enrolled in the ECFSPR. This results in individuals tending to be lost to follow-
243 up at the time of transplant, which is likely to induce some bias in the survival
244 estimates. In the US-Canada study, censoring at time of transplant resulted in
245 increased median survival in the US to 44.0 years and to 57.1 years in Canada³.
246 Our median survival censoring at transplant of 56.8 years lies between these
247 estimates for the United States and Canada which is likely to be a more accurate
248 comparison.

249 The difference between median survival including post-transplantation follow-up
250 (51.7 years) and using the composite outcome of death or transplant (38.5 years)
251 highlight the impact of transplantation and the improved survival after
252 transplantation²⁵. This difference may be due to uncounted deaths in patients lost
253 to follow-up post-transplant, as well as differences in access to transplantation in
254 some countries reflected by a highly different percentage of transplanted patients
255 among those seen in the year, which varied between 10% in France and 0% in

256 some Eastern European countries⁹. There were also differences in median survival
257 when we limited the cohort to those homozygous for F508del which is similar to
258 other reports¹⁵. The distribution of F508del differs across European countries⁹ and
259 because of this, the influence of SES on survival was adjusted for *CFTR* genotype
260 to account for differences in genotype frequencies in countries with lower
261 measures of SES.

262 Our study also demonstrates that survival outcomes vary depending on different
263 socioeconomic factors. Studies of SES and CF outcomes in the United States have
264 shown that medical insurance status²⁰ and median house household income¹⁹ are
265 both independently associated with difference in CF survival outcomes, even
266 within a country with a high GNI. In the UK, a validated deprivation score was
267 associated with poorer outcomes including increased infection with *Pseudomonas*
268 *aeruginosa* and decreased access to and use of CF medications, all of which are
269 associated with reduced CF survival²⁶. This is the first study in Europe to quantify
270 the association between national measures of SES and survival and shows that
271 countries with the lowest measures of health-care spending have hazard rates for
272 death that are almost twice that of countries with higher measures of health-care
273 spending. This increase in hazard with lower SES was consistent across three
274 separate measures of SES. Despite common European Standards of Care for CF
275 and a national health insurance systems in almost all European countries, access
276 to care and medication varies widely across Europe, especially in Eastern
277 Europe²⁷. The association between SES and CF survival is not unexpected as
278 standardised mortality from all causes differs across Europe (as shown in Table

279 3), although the magnitude of effect in CF is greater than that seen for the general
280 population and demonstrates the need for further research in this area within
281 Europe.

282 There are a number of limitations to our study. Missing data and data quality are
283 always challenging in studies using registry data. The analysis was limited to
284 countries with a national registry and coverage of >80% of their CF population. It
285 was assumed that missing data on covariates within countries were missing
286 completely at random. By restricting to countries with a national registry, we
287 assumed that the combined population is representative of that in Europe as a
288 whole. The overall median survival age could be subject to bias if this is not the
289 case. However, the findings about association between SES and survival would
290 only be biased if the association between SES and survival differed in countries
291 that were not a part of this study. All of the included national registries have
292 rigorous approaches to data quality. This, in addition to the data quality
293 requirements of the ECFSPR²⁸, increase the likelihood that the results are reliable.
294 At the time of the study completion, data from two large European countries
295 (Germany and Spain) were not available and it is possible that the survival
296 estimates may change with the inclusion of these large countries. This will require
297 a further follow-up study. Likewise, it is important that these survival estimates for
298 Europe cannot be extrapolated to an individual patient with CF or to all European
299 countries as the median estimates are influenced by the survivorship in the larger
300 European countries. The three largest countries (UK, France and Italy) contribute
301 23,849 patients (75%) and 1,093 deaths (76%) indicating that the median survival

302 largely reflects the median survival of these three countries. We chose not to
303 weight the survival estimates by country population as we were studying regional
304 differences and used a similar methodology to that of Canada and the United
305 States. Also, to ensure as accurate a survival estimate as possible, we restricted
306 the cohort to include countries with the highest coverage and the most complete
307 data. Future analysis including more countries, especially Eastern European
308 countries, will be planned once the ECFSPR has sufficient data to do so. It is also
309 worth noting that these estimates reflect a cohort of CF patients followed before
310 the widespread availability of CFTR modulator therapy, and future survival
311 estimates may change as these highly-effective novel CF therapies become more
312 widely used across Europe.

313 Finally, a number of deaths may have been missing. It is anticipated that this
314 number is low as most CF patients were attending CF centres who would generally
315 know each patient's vital status, although we acknowledge that outcomes post-
316 transplant may be incomplete. The absence of follow-up post-transplant in some
317 countries limits the interpretation of the overall survival estimates. The median
318 survival estimate may be biased due to the exclusion of post-transplant deaths. As
319 seen in Table 1, the proportion of deaths when censored at transplant compared
320 to total deaths is highly variable across European countries. This is likely to be due
321 to differences in European countries' access to transplant, post-transplant loss to
322 follow-up in the registry and transplant centre survival rates. As all of these factors
323 may all influence the median survival estimate, attempts are underway to audit
324 data quality and number of deaths as well as include post-transplant centre data

325 in the ECFSPR. We also included transplant status as a time-dependent covariate
326 in multivariable Cox regression analyses. However, this may be a mediator of the
327 association between SES and mortality, for example if access to transplant is
328 affected by SES. We also did not allow the hazard ratio for transplant to depend
329 on time-since-transplant. Another potential source of bias is non-informative
330 censoring. All survival models assume censoring (due to loss to follow-up) is
331 uninformative for the event of interest. Loss to follow-up rates were generally low
332 but it is possible that co-variables not included in our model may have influenced
333 differences in each countries loss to follow-up. Unfortunately, there is no way to
334 formally test this. This does not apply in the analysis in which we censor patients
335 at transplant, when the focus is on cause-specific hazards for pre-transplant
336 mortality.

337 In conclusion, this study demonstrates that median survival for patients with CF in
338 Europe is comparable to that reported in the US and Canada and that survival
339 across Europe is highly influenced by SES. A more detailed understanding of how
340 these differences in SES lead to poorer survival is critical to improving outcomes
341 for CF patients from European countries with lower health care spending.

342

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Table 1: Study Population in Cohort from 2010 to 2014*

Country	Patients	Person Years	Lost to Follow-up**	Total Deaths	Deaths (censoring at transplant)
All countries	31987	135833.3	983	1435	1086
Patient Country					
Belgium*	1276	4570.5	34	29	15
Czech Republic	643	2788.4	2	52	50
Denmark	514	2278.2	8	22	7
France	7133	30864.5	153	299	142
Hungary	691	2780.1	54	15	12
Ireland	1247	5141.4	25	88	77
Israel	755	2746.2	124	24	17
Italy	5627	23312.3	300	192	147
Netherlands	1618	6708.5	122	73	62
Portugal	321	1007.7	22	7	7
Slovak Republic	393	1282.3	117	9	8
Sweden	680	3055.4	8	23	9
United Kingdom	11089	49297.8	14	602	533

*Belgium - data was only present from 2010-2013

**Loss to follow up definition: patients who are alive but whose last year of data was >2 years before the cohort end year.

Table 2: Baseline Demographics and Clinical Data at time of entry into ECFSPR

Subject number (n)	31987
Age (yrs)	16.6 ± 13.8
Age at diagnosis (yrs)	4.6 ± 10.2
Male Sex (%)	53%
F508del homozygous (%)	40%
FEV ₁ (% predicted)	79 ± 25
FVC (% predicted)	86 ± 21
Height (cm)	145 ± 34
Weight (kg)	44.5 ± 22.7
BMI (kg/m ²) for Adults ≥18 yrs	21.8 (3.6)
BMI (%tile) for Children <18 yrs	-0.2 (1.1)
Pseudomonas aeruginosa	25%
CF Liver Disease	10%
CF Related Diabetes Mellitus	12%
Lung transplantation (%)	4.5%

Data are Mean ± SD unless otherwise stated

Table 3: Standardised Death Rates and Socioeconomic Measures by Country

Country	Standardised Death Rates/100,000*	GNI per capita (US\$000) 2015	Healthcare spend (% GDP) 2014	Physicians per 1,000 (2008-2014)
Belgium	1,036	44.3	10.6	4.9
Czech Republic	1,321	18.1	7.4	3.6
Denmark	1,091	58.5	10.8	3.5
France	874	40.5	11.5	3.2
Hungary	1,518	13.0	7.4	3.1
Ireland	1,035	52.6	7.8	2.7
Israel	N/A	35.8	7.8	3.3
Italy	906	32.8	9.2	3.8
Netherlands	1,008	48.9	10.9	2.9
Portugal	1,034	20.5	9.5	4.1
Slovak Republic	1,450	17.6	8.1	3.3
Sweden	964	57.9	11.9	3.9
United Kingdom	996	43.4	9.1	2.8

*data for 2013, accessed Oct 2020 from <https://ec.europa.eu/eurostat>

Table 4: Summary of time-to-event data and median survival estimate for 2010-2014 cohort

	Patients	Person Years	Deaths	Median survival age (years)	95% CI
All patients	31987	135833	1435	51.7	(50.0, 53.4)
F508del Homozygotes	12918	57023	698	45.5	(43.1, 47.6)
Two Class I-III Mutation	18267	80529	947	47.0	(44.8, 47.9)
Composite (Death/Transplant)	30885	129034	2177	38.5	(37.5, 39.5)
Censoring at Transplant	30885	129044	1086	56.8	(54.0, 60.2)

Table 5: Univariable Predictors of Survival

Variable	Patients	Person Years	Deaths	Hazard ratio	95% CI	p-value
Sex						
Male	16840	74106	687	1.000	-	<0.001
Female	15145	66535	748	1.281	(1.148, 1.414)	
Age category at diagnosis						
0-6 months	17292	76510	703	1.000	-	<0.001
6 - 12 months	2426	11148	142	0.952	(0.779, 1.125)	
1 - 6 years	6764	30004	343	0.810	(0.704, 0.917)	
6 - 18 years	2953	12771	129	0.554	(0.449, 0.660)	
18+ years	2552	10210	118	0.269	(0.204, 0.334)	
Transplant (any type)						
No	30877	131166	1086	1.000	-	<0.001
Yes	1110	9476	349	3.591	(3.137, 4.045)	
Presence of F508del mutation						
F508del - homozygotes	12918	59645	698	1.000	-	<0.001
F508del - heterozygotes	11227	49491	379	0.594	(0.519, 0.669)	
F508del/Unknown	1175	4861	102	1.289	(1.016, 1.562)	
Not F508del	4352	18333	132	0.558	(0.453, 0.664)	
Not F508del/Unknown	567	2211	22	0.624	(0.358, 0.891)	
Unknown	1748	6102	102	0.910	(0.718, 1.101)	

Notes: Hazard ratios, confidence intervals and p-values estimated from Cox regression models

Table 6: Socioeconomic Predictors of Survival: Results from multivariable Cox models*. The SES variables did not appear together in the same model.

Variable	Patients	Person Years	Deaths	Crude Hazard Ratio	95% CI	Adjusted* Hazard ratio	95% CI
Country level SES variables							
Healthcare Expenditure (% of GDP)							
Tercile 1: 7.4 – 7.8	3336	13919	179	1.000	-	1.000	-
Tercile 2: 8.1 – 9.5	17430	76440	810	0.695	(0.582, 0.809)	0.733	(0.613, 0.853)
Tercile 3 : 10.6 – 11.9	11221	50283	446	0.618	(0.510, 0.725)	0.544	(0.448, 0.641)
GNI per Capita (\$ per 1000 people)							
Lower: <32.8	2048	8101	83	1.000	-	1.000	-
Higher: ≥32.8	29939	132541	1352	0.811	(0.645, 1.013)	0.859	(0.667, 1.051)
Physicians (per 1000 people)							
Tercile 1: 2.7 – 3.2	21778	98465	1077	1.000	-	1.000	-
Tercile 2: 3.3 – 3.8	7932	33174	299	0.804	(0.700, 0.907)	0.983	(0.852, 1.113)
Tercile 3: 3.9 – 4.9	2277	9004	59	0.568	(0.419, 0.717)	0.523	(0.385, 0.661)

*adjusted for age at diagnosis, sex, *CFTR* genotype and transplant status.

Figure Legend.

Figure 1: Estimated Survival (all-cause mortality) and 95% confidence intervals for European CF Patients

Figure 2: Estimated Survival (composite outcome of all-cause mortality or transplant) and 95% confidence interval for European CF Patients.

Figure 3: Estimated Survival (censoring at transplant) and 95% confidence interval for European CF Patients.

Figure 4: Estimated Survival by SES and 95% confidence interval for European CF Patients.

Appendix 1: List of Collaborating Authors:

The ECFSPR contributors list consists of the representatives of the countries whose data is used in this manuscript, and the members Committee who reviewed the initial data-application and the final manuscript.

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Supplemental Table 1: Demographics and Socioeconomic Measures of ECFSPR Countries Excluded from the Analysis.

ECFSPR Data (2008-2014)				Country characteristics			
Country	Patients	Person Years	Deaths	Population (millions) 2015	GNI per capita (US\$000) 2015	Healthcare spend (% GDP) 2014	Doctors per 1,000 popn (2008-2014)
Austria	750	3622	15	9	47.4	11.2	4.8
Germany	6284	15643	100	81	45.9	11.3	3.9
Greece	537	1103	15	11	20.3	8.1	6.2
Latvia	43	222	3	2	15.0	5.9	3.6
Republic of Moldova	83	307	8	4	2.2	10.3	3.0
Serbia	196	941	15	7	5.5	10.4	2.1
Slovenia	108	513	1	2	22.2	9.2	2.5
Spain	1825	7781	61	46	28.5	9.0	4.9
Switzerland	856	3455	12	8	84.6	11.7	4.0
Russian Federation	2321	6596	114	144	11.5	7.1	4.3
Romania	44	143	1	20	9.5	5.6	2.4
Lithuania	14	48	2	3	14.9	6.6	4.1
Ukraine	146	420	7	45	2.6	7.1	3.5
Republic of Macedonia	108	380	0	2	5.1	9.7	3.5