

Supplementary materials

A Regression models of exponential growth

A.1 General equations

During the first part of the development of an epidemic, we can assume an exponential growth according to Equation 1

$$y = \alpha\beta^{\gamma x} = \alpha e^{(\gamma \log \beta)x} \quad (1)$$

where: y = is the cumulative case count, x = number of days since the start of the series

This equation can be linearized using logarithms, shown in Equation 2, and its equivalent Equation 3

$$\log y = \log \alpha + (\gamma \log \beta)x \quad (2)$$

$$\log y = A + Bx \quad (3)$$

where: $A = \log \alpha$, $B = \gamma \log \beta$

A.2 Model data selection

The MPX data obtained from the Global Health Data Science Initiative, was filtered using the following procedure:

1. Only cases with a confirmed status were kept
2. Data for which the confirmation date ranged from the epidemiological weeks 20 to 33 of 2022 were used. This allowed us to consider only cases in non-endemic countries
3. Data was combined by confirmation date at the country level, and, after ordering each country timeseries, a cumulative number of cases was calculated

4. Data from countries with 200 or more cumulative cases, up to the most recent reported date, were considered for modeling
5. From the selected countries, we used only dates for which the number of cumulative cases was equal or greater than 10.
6. For each country timeseries, we created a days count series which reflected the difference between the earliest date in the series and the current one.

At the end of this selection procedure, we obtained the list in the following table:

Table 1: Countries selected for modeling

Country	Confirmation dates		N° Obs. ¹
	Earliest	Latest	
<i>Austria</i>	2022-06-17	2022-08-19	16
<i>Belgium</i>	2022-06-01	2022-08-15	14
<i>Brazil</i>	2022-06-22	2022-08-20	51
<i>Canada</i>	2022-05-23	2022-08-19	49
<i>Chile</i>	2022-07-04	2022-08-18	17
<i>England</i>	2022-05-20	2022-08-15	32
<i>France</i>	2022-05-28	2022-08-18	27
<i>Germany</i>	2022-05-24	2022-08-19	69
<i>Italy</i>	2022-05-26	2022-08-19	31
<i>Mexico</i>	2022-06-28	2022-08-15	10
<i>Netherlands</i>	2022-05-25	2022-08-18	24
<i>Northern Ireland</i>	2022-07-04	2022-08-15	9
<i>Peru</i>	2022-07-04	2022-08-20	35
<i>Portugal</i>	2022-05-18	2022-08-10	36
<i>Scotland</i>	2022-06-06	2022-08-15	21
<i>Spain</i>	2022-05-20	2022-08-16	37
<i>Switzerland</i>	2022-06-07	2022-08-16	48
<i>United States</i>	2022-05-26	2022-08-18	74
<i>Wales</i>	2022-06-30	2022-08-15	12

¹ Number of days with reports of confirmed cases in the date range

A.3 Regression results

Using Equation 3, we performed a regression of the logarithm (base 10) of the cumulative number of cases versus the days counts (*vide supra*)

The results of the regressions can be seen in the following table

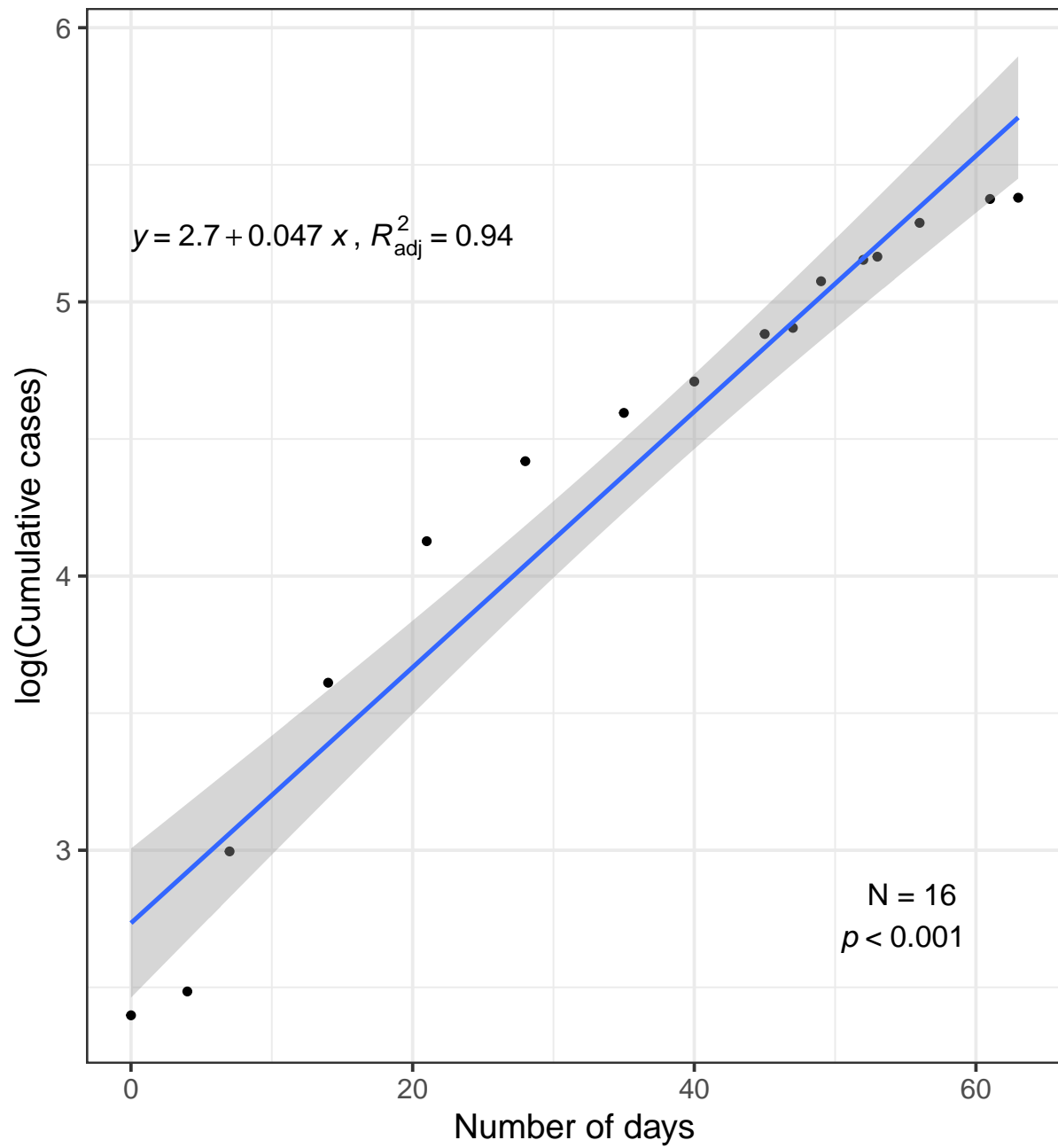
Table 2: Regression results for the selected countries

Country	Parameters				Statistics		
	Intercept	S.E. _{inter.}	Slope	S.E. _{slope}	R^2_{adj}	p-value	N° Obs. ¹
<i>Austria</i>	2.7343	0.1268	0.0466	0.0031	0.9387	< 0.001	16
<i>Belgium</i>	3.0941	0.1394	0.0509	0.0034	0.9451	< 0.001	14
<i>Brazil</i>	3.2741	0.1095	0.0948	0.0031	0.9487	< 0.001	51
<i>Canada</i>	3.8949	0.0944	0.0406	0.0018	0.9164	< 0.001	49
<i>Chile</i>	2.3947	0.0335	0.0666	0.0014	0.9933	< 0.001	17
<i>England</i>	4.5412	0.1522	0.0498	0.0035	0.8668	< 0.001	32
<i>France</i>	3.7041	0.1572	0.0611	0.0035	0.9231	< 0.001	27
<i>Germany</i>	3.9707	0.1493	0.0589	0.0030	0.8500	< 0.001	69
<i>Italy</i>	2.9108	0.1089	0.0501	0.0024	0.9353	< 0.001	31
<i>Mexico</i>	2.6138	0.1198	0.0571	0.0042	0.9530	< 0.001	10
<i>Netherlands</i>	3.4176	0.1576	0.0508	0.0032	0.9181	< 0.001	24
<i>Northern Ireland</i>	2.3369	0.0621	0.0253	0.0026	0.9201	< 0.001	9
<i>Peru</i>	3.2141	0.0839	0.0859	0.0028	0.9649	< 0.001	35
<i>Portugal</i>	3.9802	0.1311	0.0419	0.0035	0.8011	< 0.001	36
<i>Scotland</i>	2.5533	0.0755	0.0300	0.0020	0.9192	< 0.001	21
<i>Spain</i>	4.1544	0.1020	0.0602	0.0023	0.9513	< 0.001	37
<i>Switzerland</i>	3.0812	0.0895	0.0482	0.0022	0.9091	< 0.001	48
<i>United States</i>	2.8221	0.0498	0.0868	0.0011	0.9892	< 0.001	74
<i>Wales</i>	2.5697	0.0579	0.0288	0.0023	0.9344	< 0.001	12

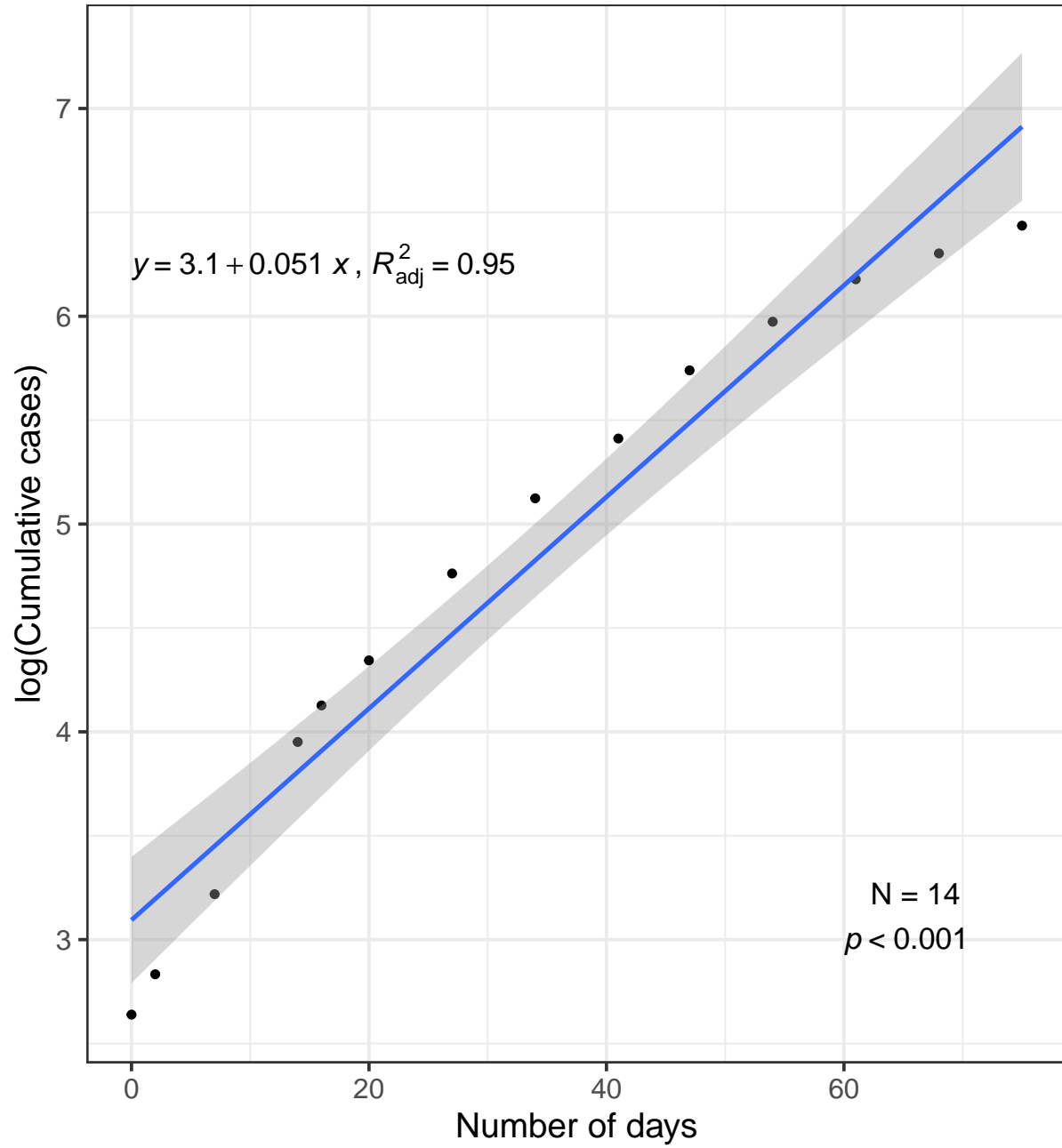
¹ Number of days with reports of confirmed cases in the date range

A.4 Plots of the regression results per country

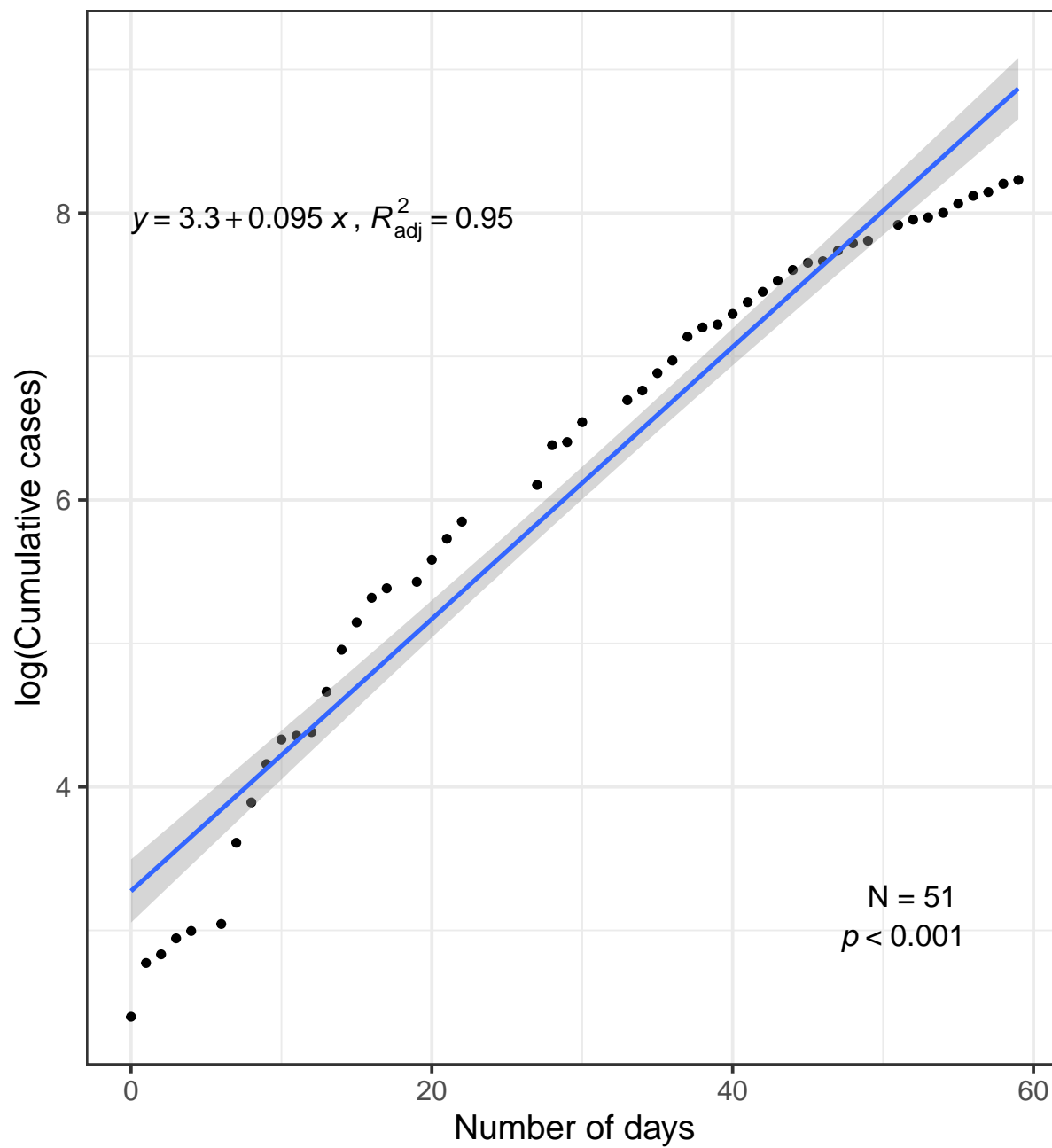
Austria



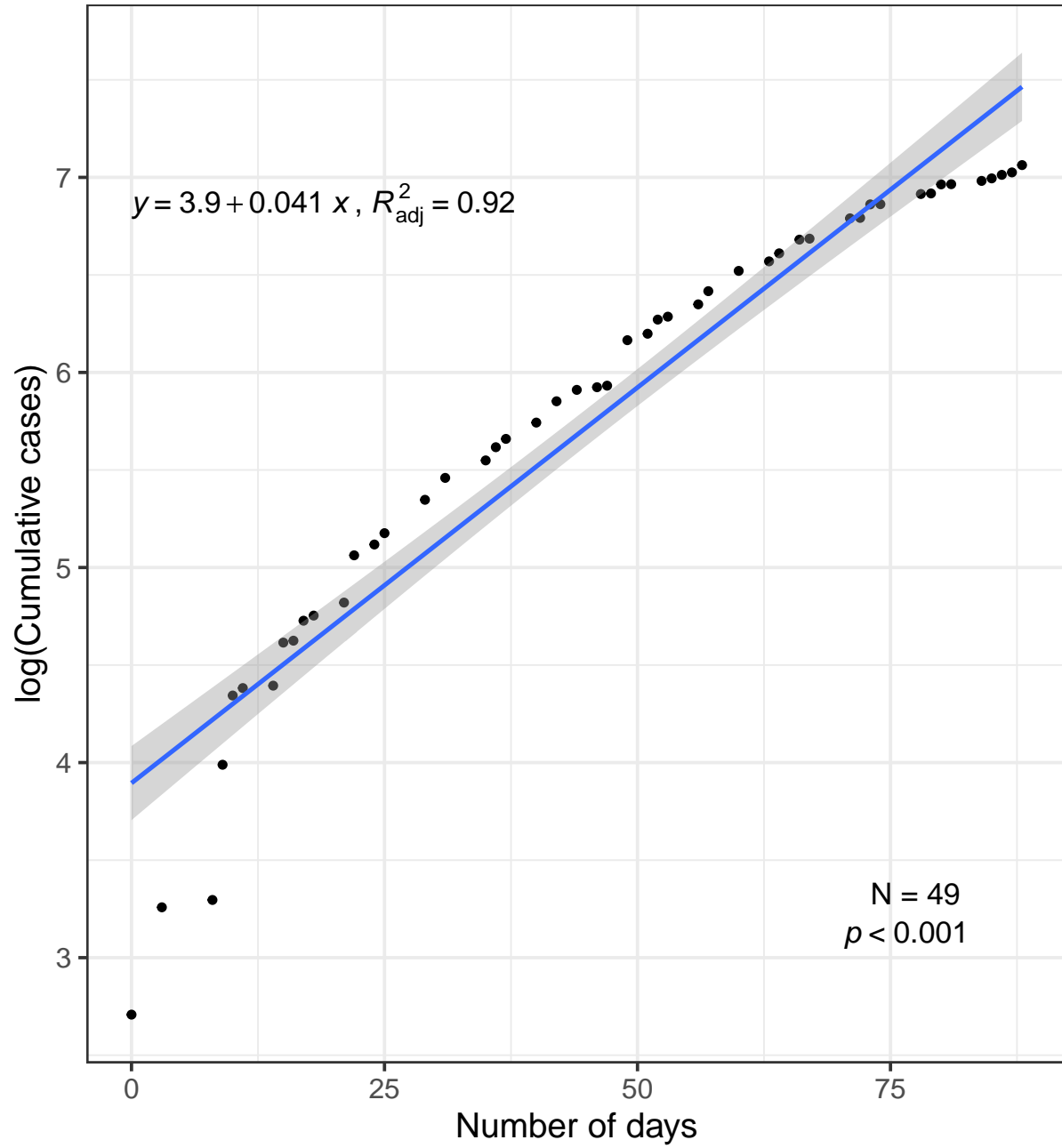
Belgium



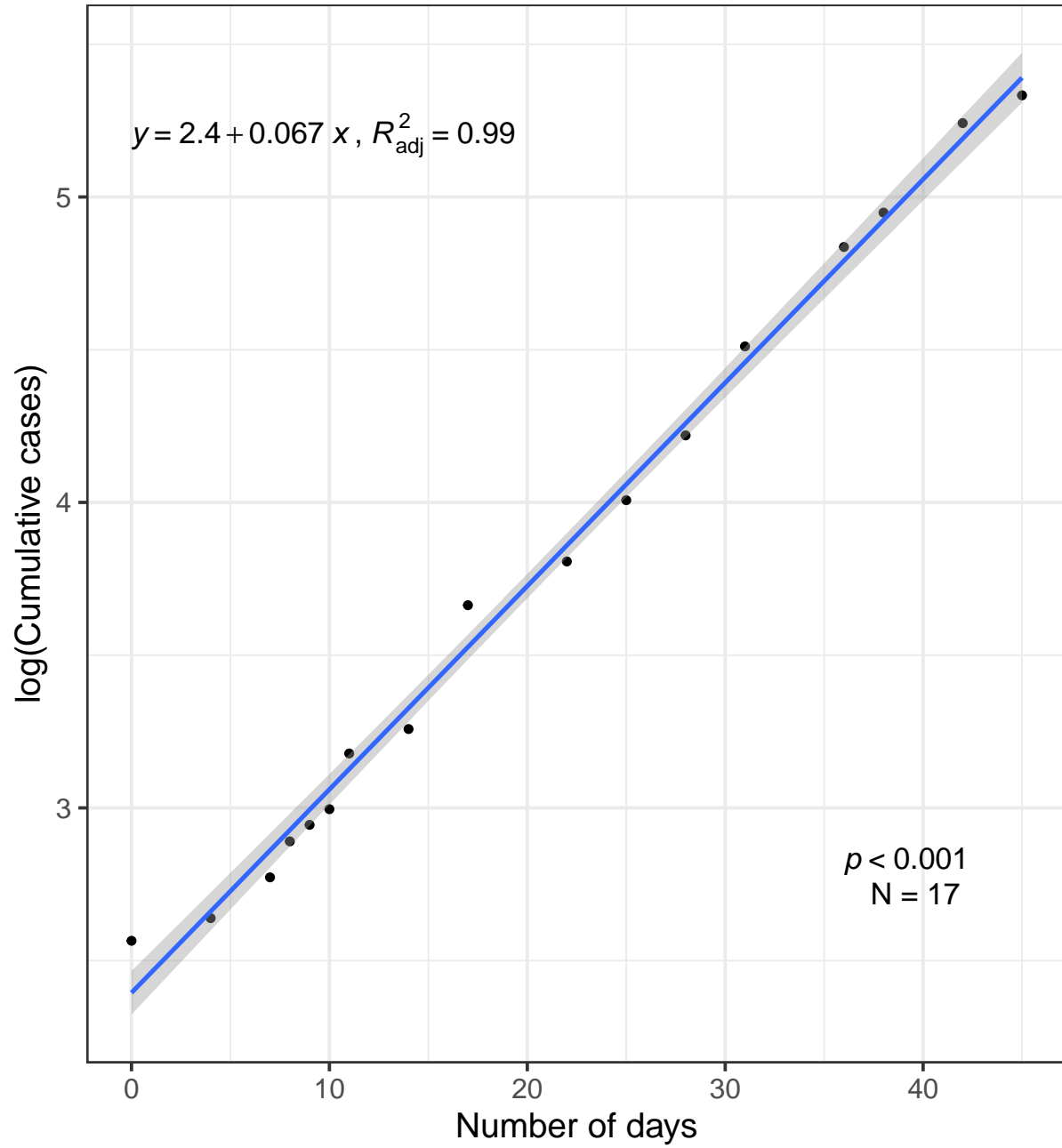
Brazil



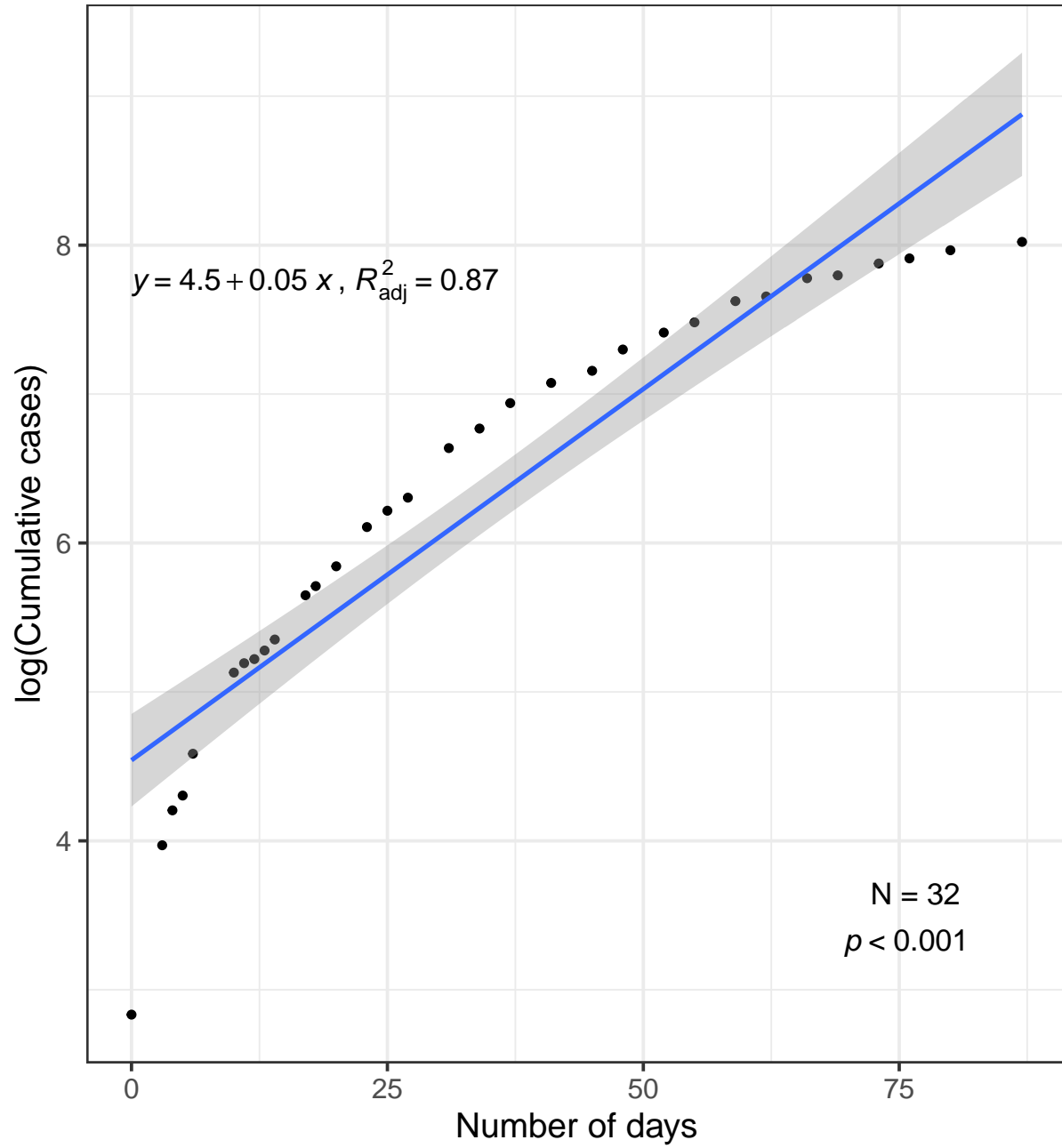
Canada



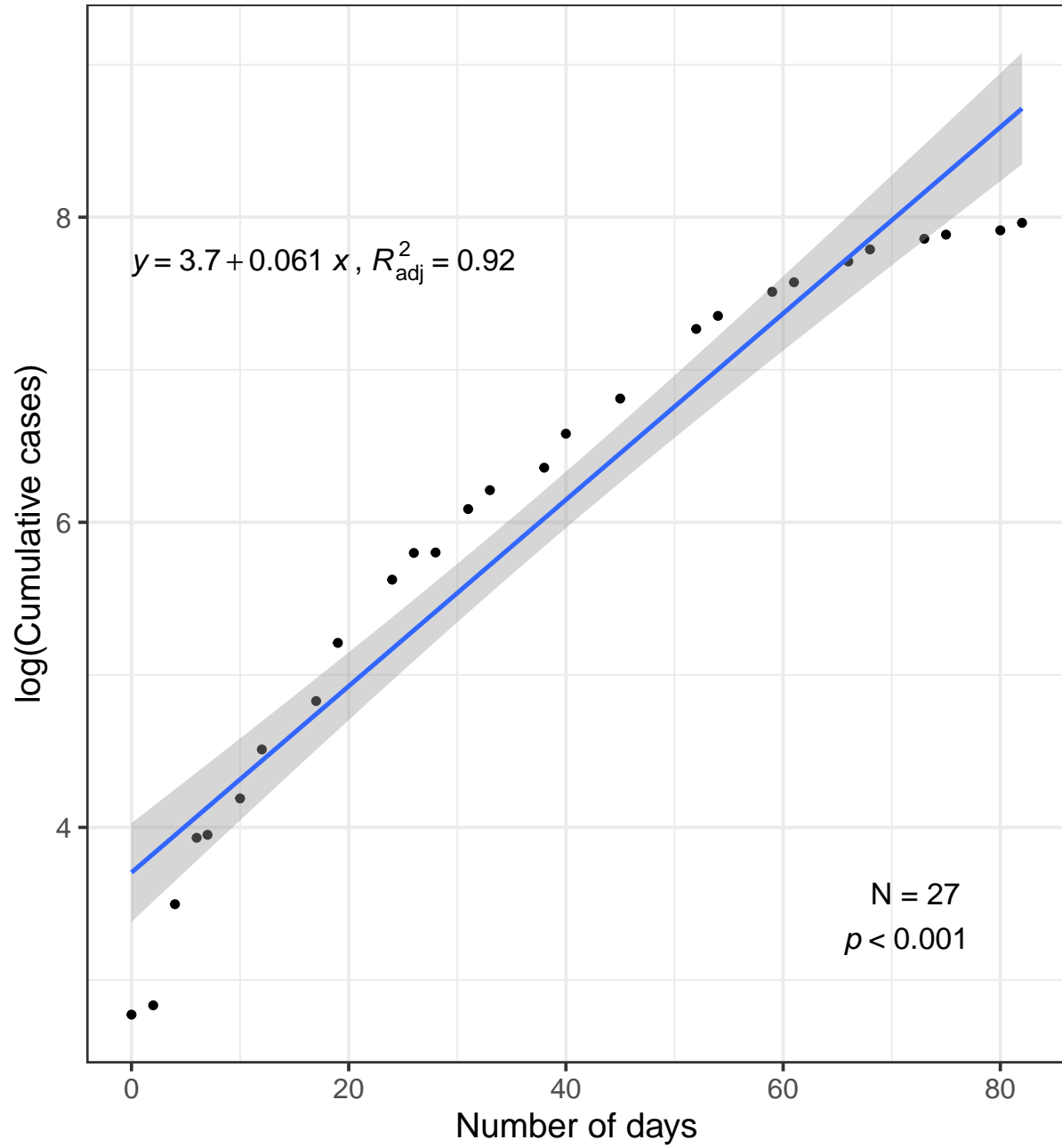
Chile



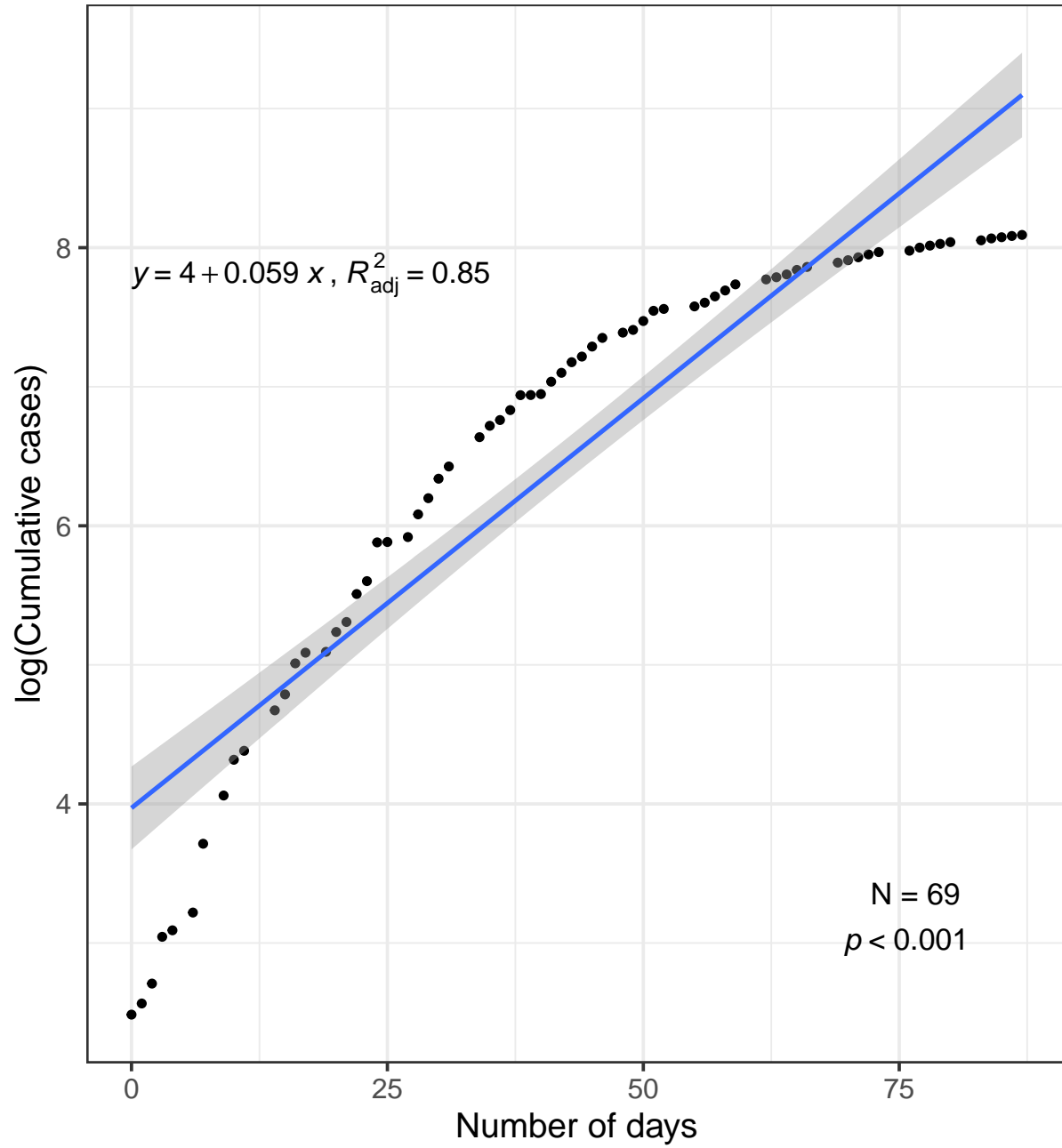
England



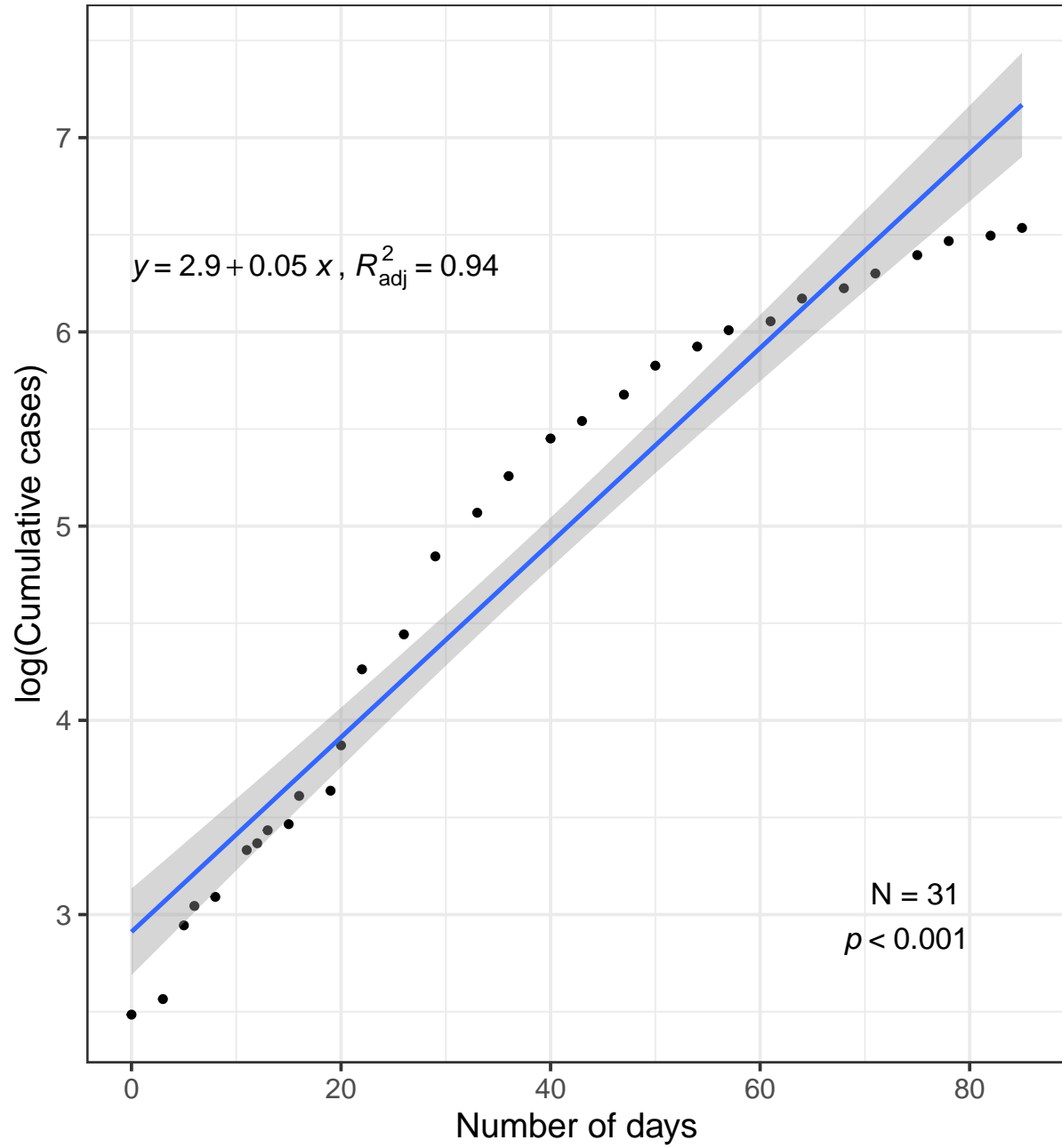
France



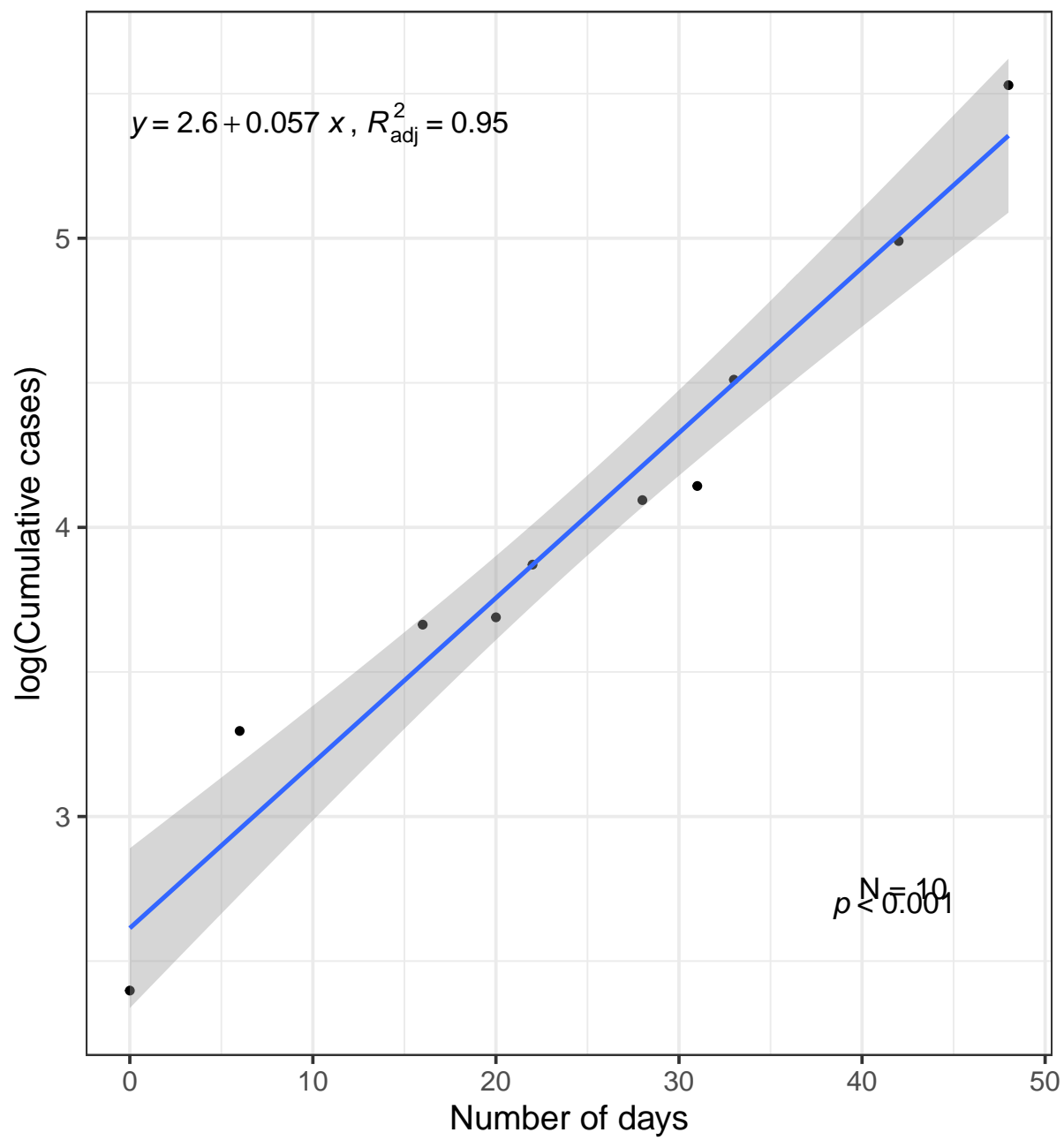
Germany



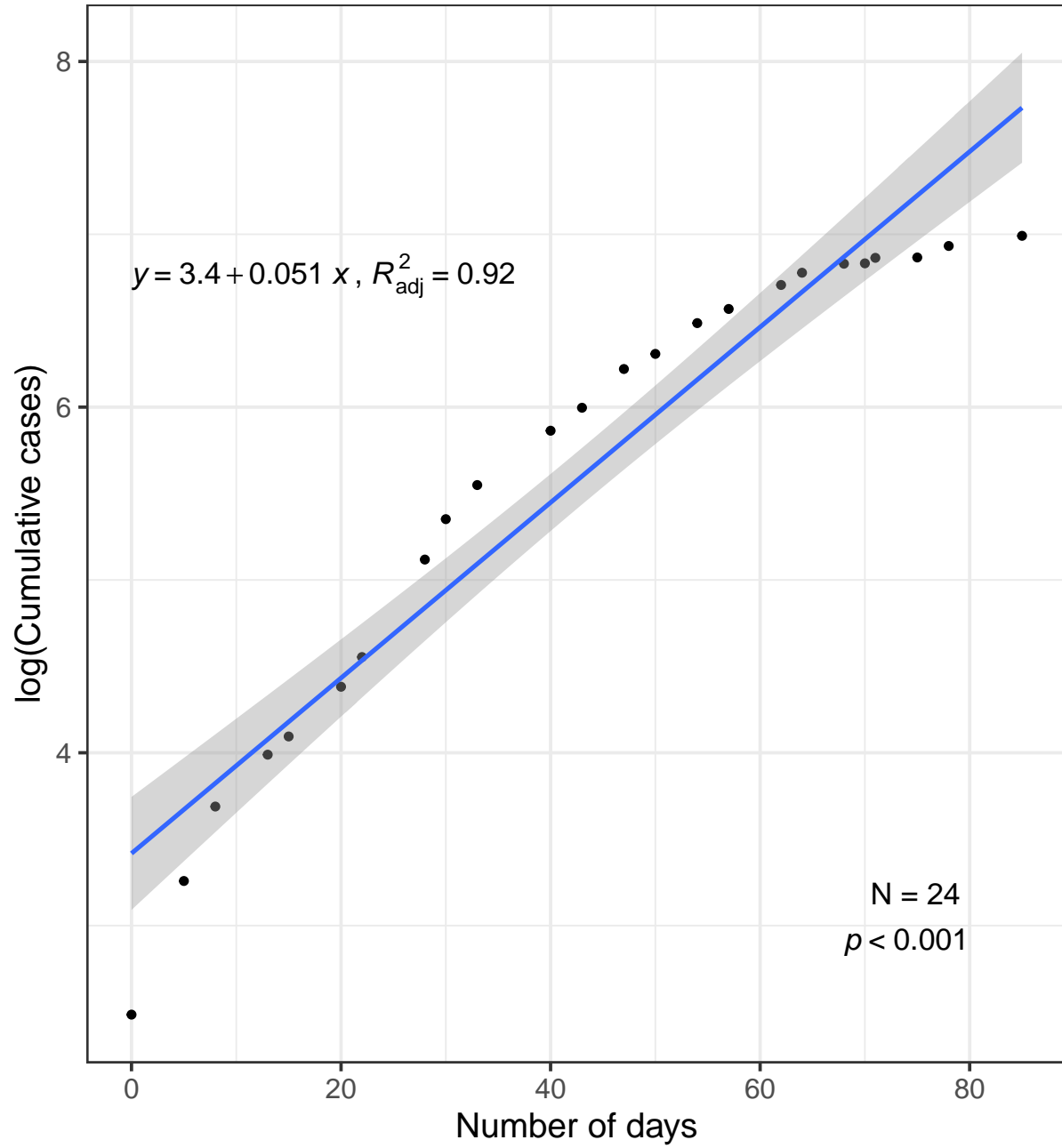
Italy



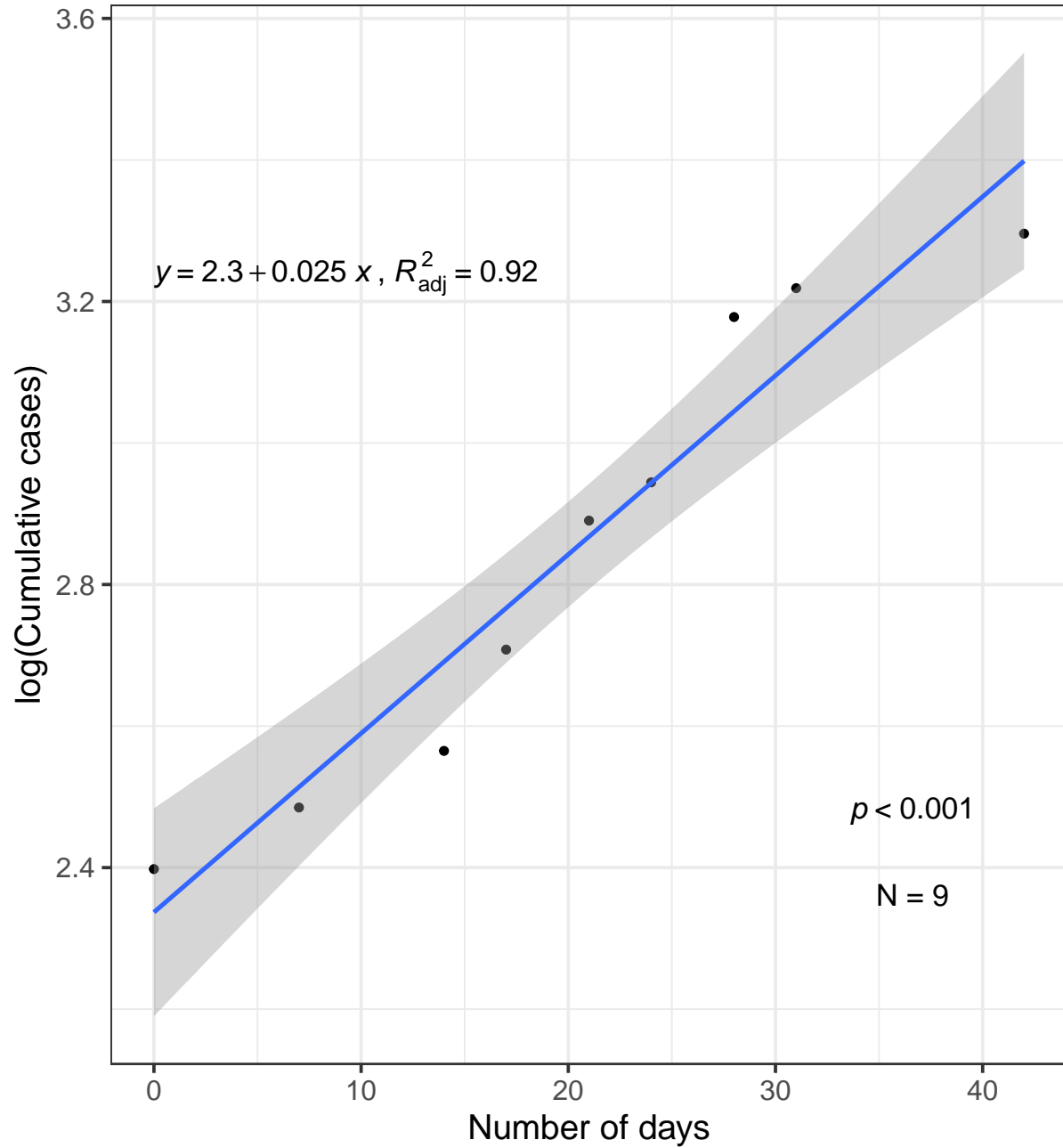
Mexico



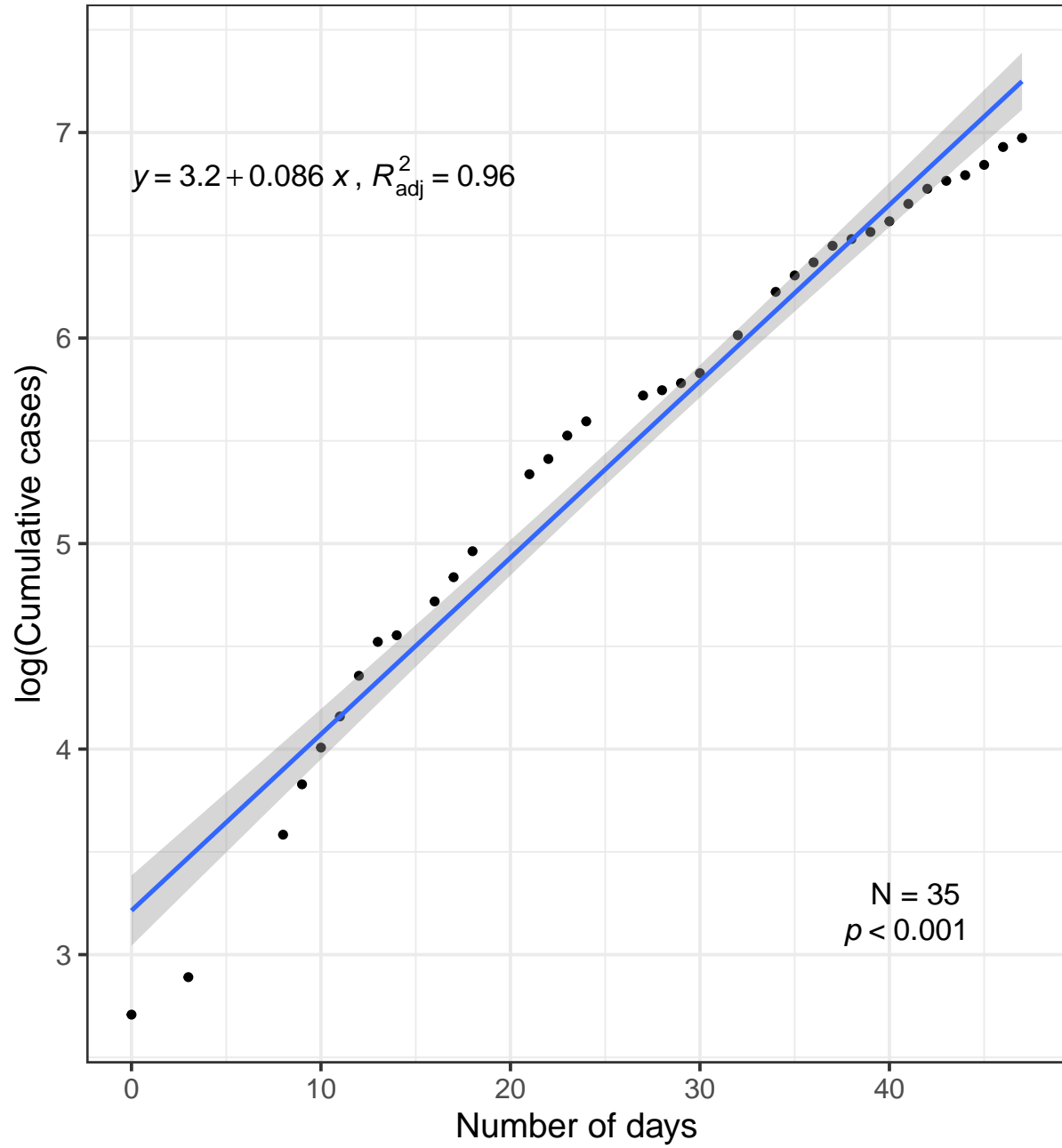
Netherlands



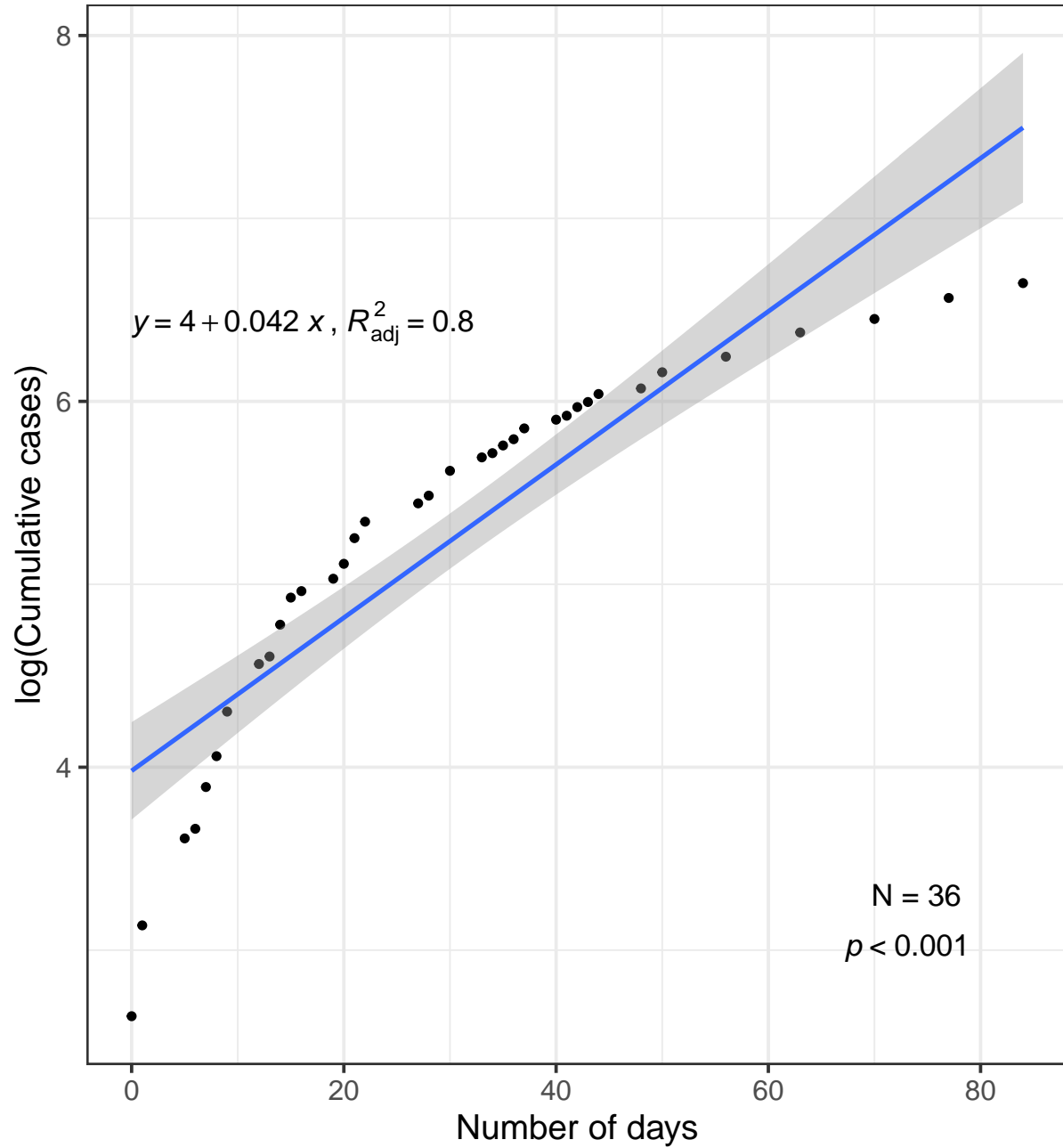
Northern Ireland



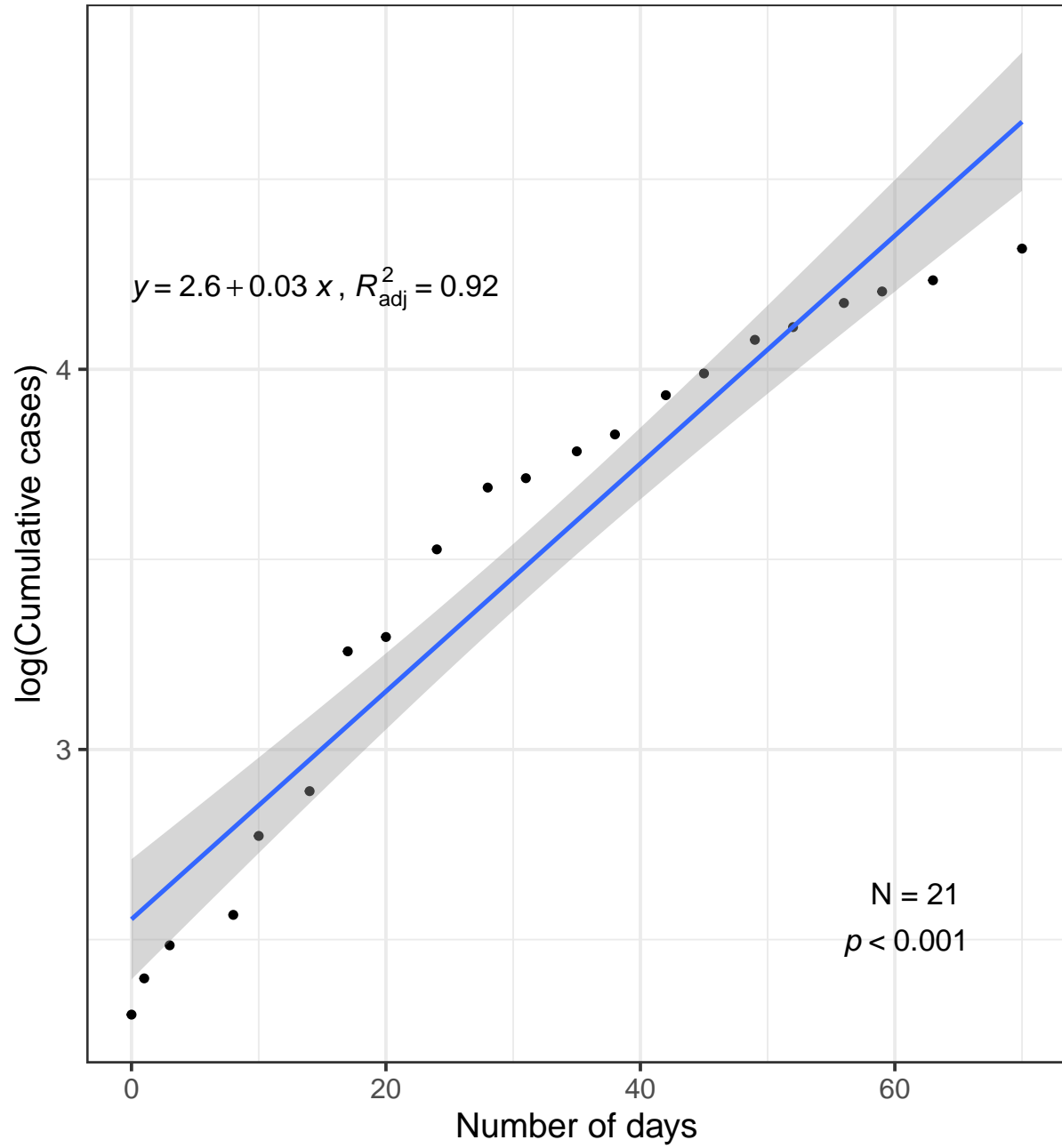
Peru



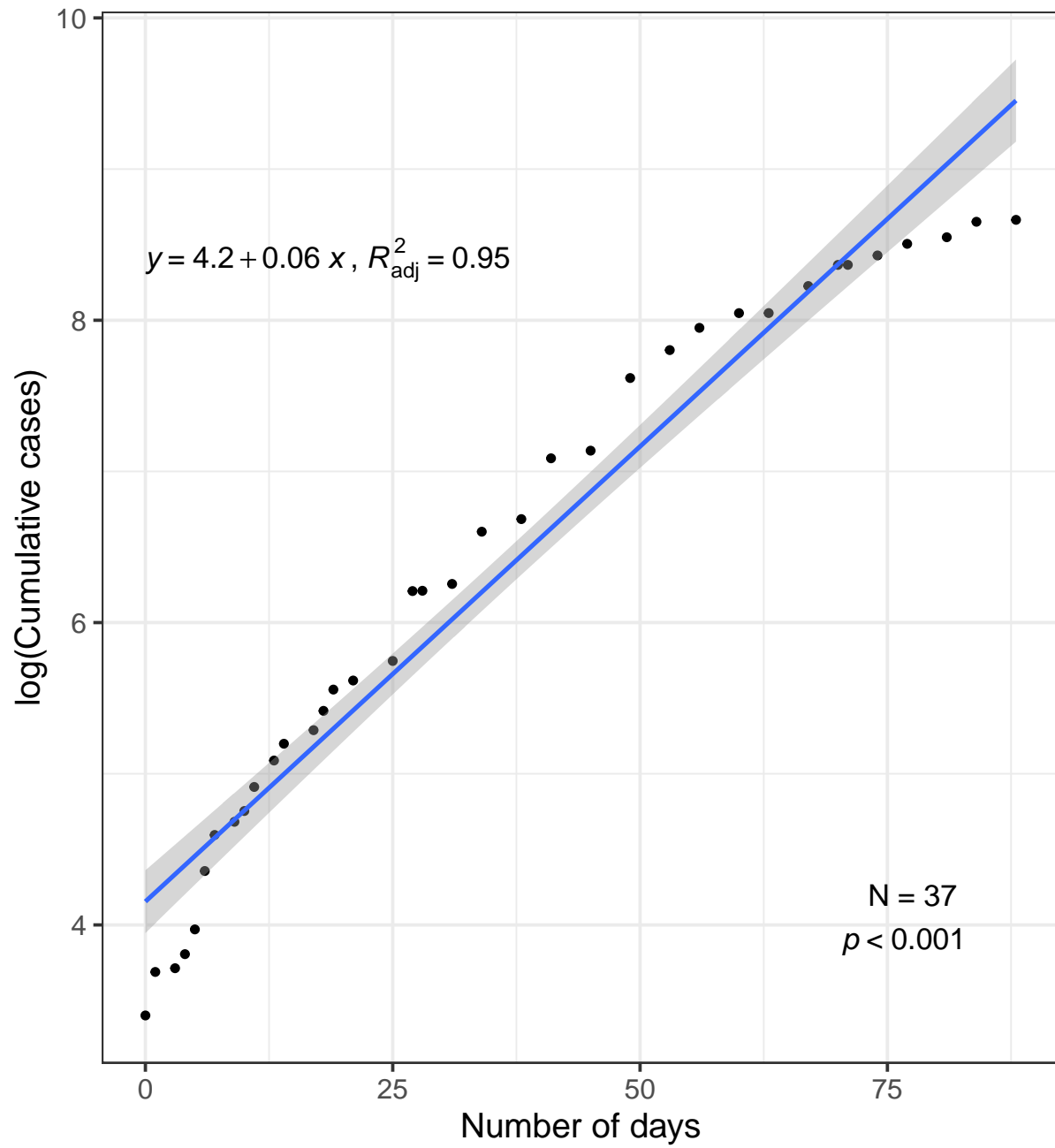
Portugal



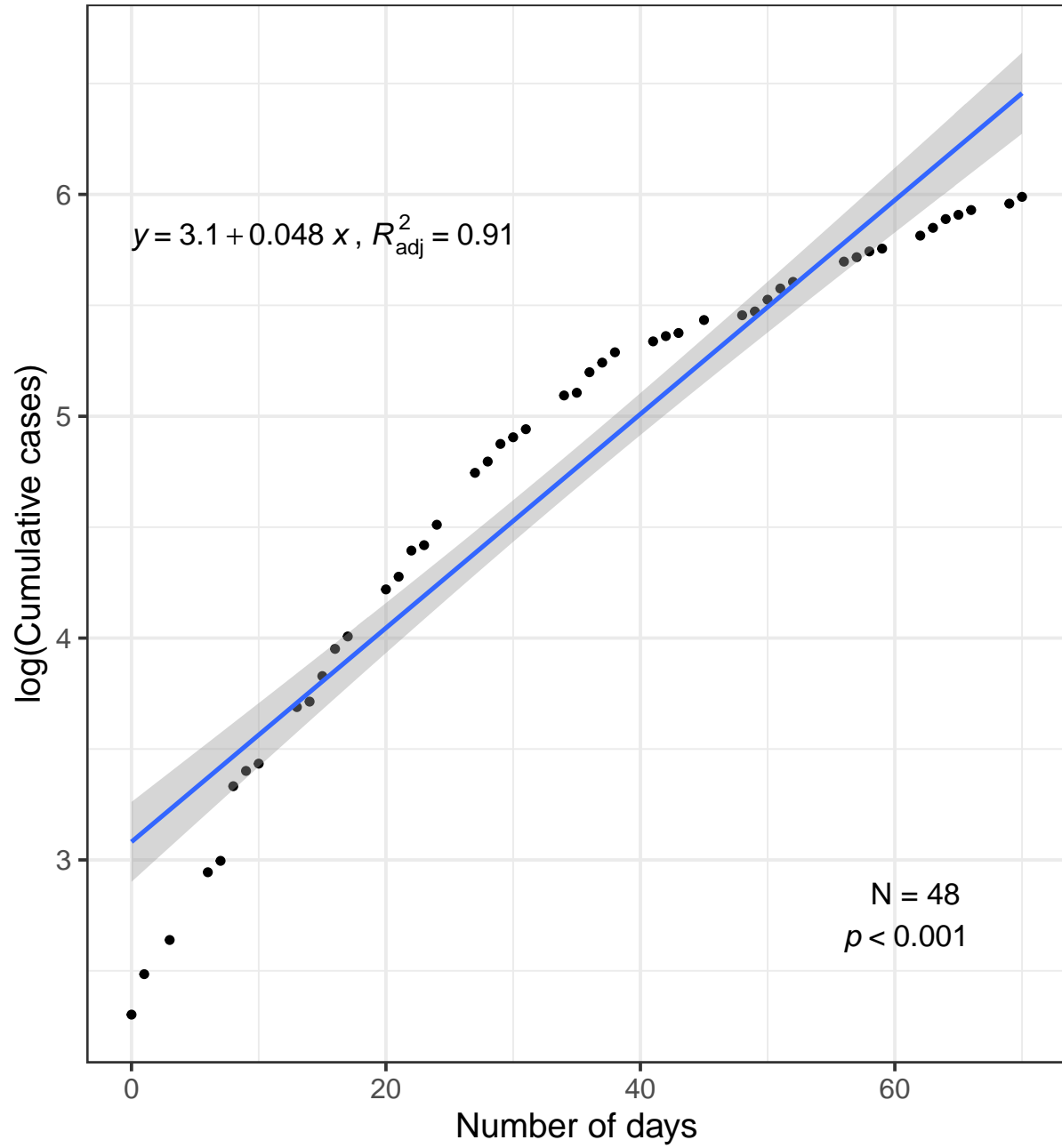
Scotland



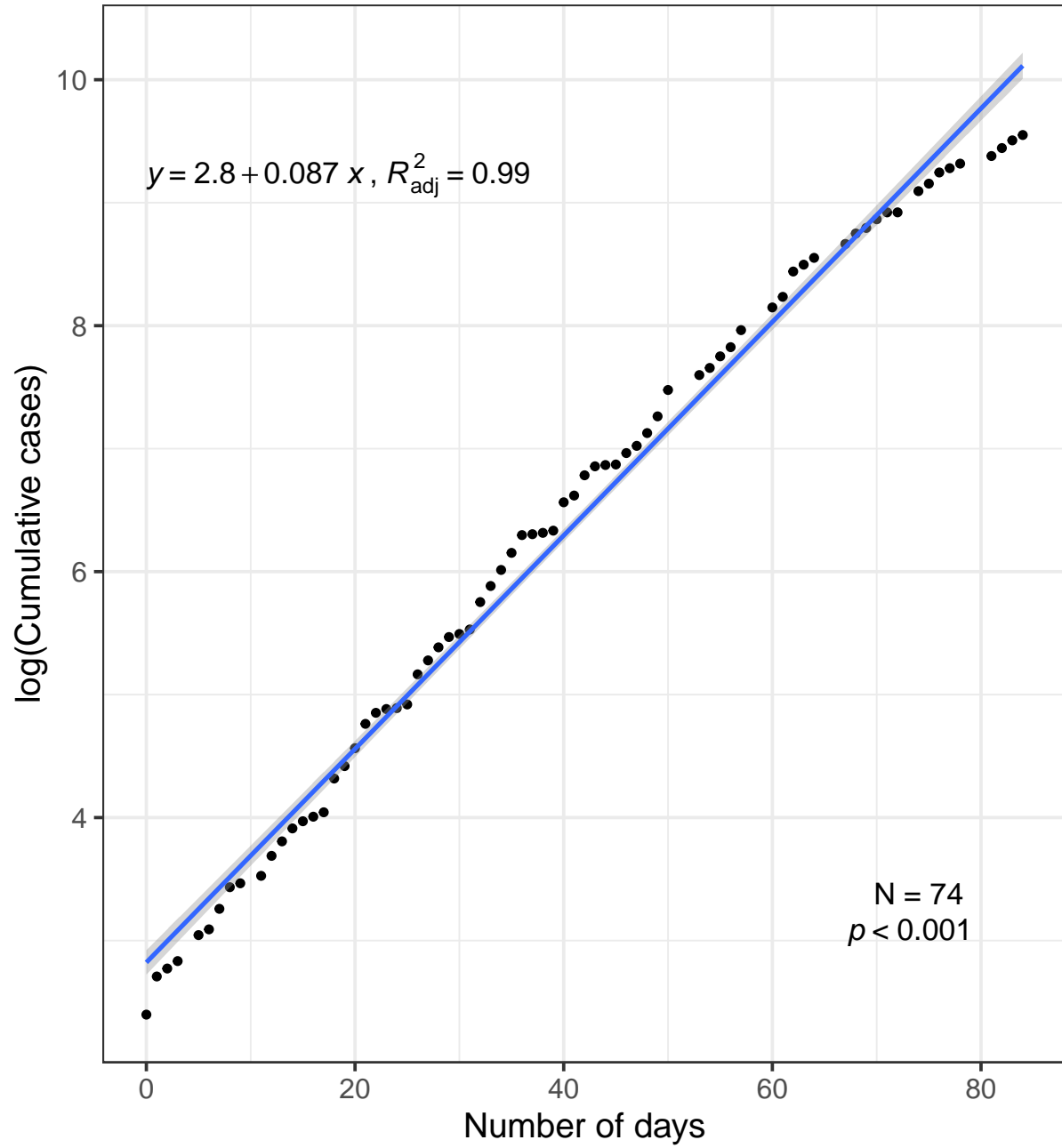
Spain



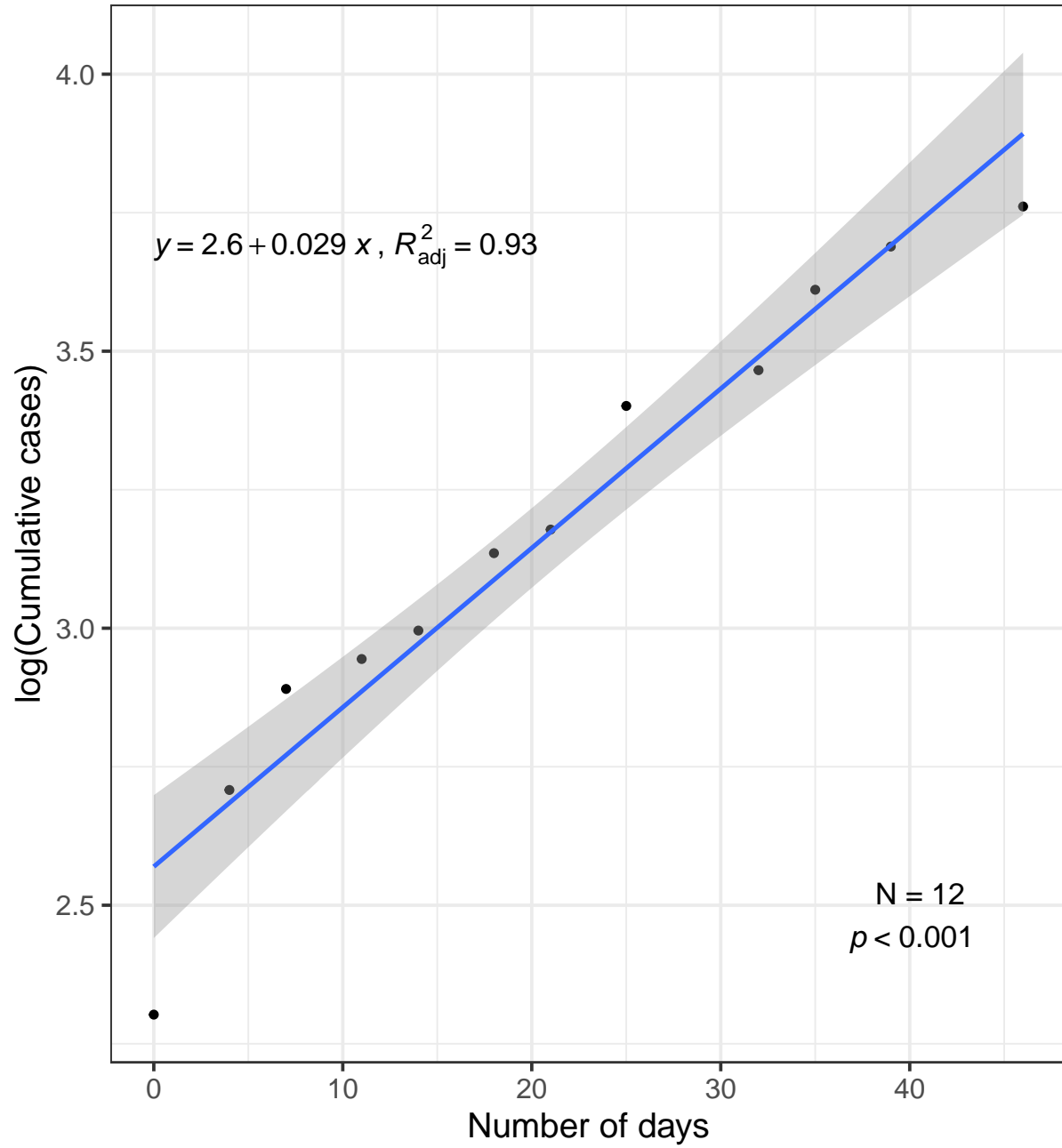
Switzerland



United States



Wales



B Estimation of the duplication time

Given two cumulative counts: C_1 , C_2 , obtained at two different times: t_1 , t_2 , their ratio Q is defined as follows:

$$Q = \frac{C_2}{C_1} = \frac{\alpha e^{(\gamma \log \beta) t_2}}{\alpha e^{(\gamma \log \beta) t_1}} = \alpha e^{(\gamma \log \beta)(t_2 - t_1)} \quad (4)$$

When $Q = 2$, then the difference $(t_2 - t_1)$ is defined as the duplication time T_d : the time it takes for the count to double in size with respect to an initial value.

Using that definition, and employing Equation 3:

$$\log Q = \log \frac{C_2}{C_1} \quad (5)$$

$$= \log C_2 - \log C_1 \quad (6)$$

$$= (A + Bt_2) - (A + Bt_1) \quad (7)$$

$$= B(t_2 - t_1) \quad (8)$$

$$= B(T_d) \quad (9)$$

Finally we can define T_d in terms of the slope (B), if $Q = 2$, then:

$$T_d = \frac{\log 2}{B} \quad (10)$$

Using the regression results of the slope and its standard error, we can calculate T_d and its C.I., obtaining:

Table 3: Duplication time estimates for selected countries

Country	N° Obs. ¹	Slope	S.E. _{slope}	95% CI _{slope}	\hat{T}_d	95% CI _{\hat{T}_d}
<i>Brazil</i>	51	0.0948	0.0031	[0.0887 - 0.1009]	7.3107	[6.8682 - 7.8141]
<i>United States</i>	74	0.0868	0.0011	[0.0847 - 0.0889]	7.9850	[7.7979 - 8.1813]
<i>Peru</i>	35	0.0859	0.0028	[0.0804 - 0.0914]	8.0737	[7.5874 - 8.6265]
<i>Chile</i>	17	0.0666	0.0014	[0.0639 - 0.0692]	10.4119	[10.0102 - 10.8472]
<i>France</i>	27	0.0611	0.0035	[0.0543 - 0.0678]	11.3487	[10.2172 - 12.7621]
<i>Spain</i>	37	0.0602	0.0023	[0.0558 - 0.0647]	11.5111	[10.7195 - 12.4289]
<i>Germany</i>	69	0.0589	0.0030	[0.0531 - 0.0648]	11.7623	[10.6958 - 13.0650]
<i>Mexico</i>	10	0.0571	0.0042	[0.0488 - 0.0654]	12.1380	[10.6040 - 14.1909]
<i>Belgium</i>	14	0.0509	0.0034	[0.0443 - 0.0576]	13.6151	[12.0404 - 15.6636]
<i>Netherlands</i>	24	0.0508	0.0032	[0.0446 - 0.0569]	13.6548	[12.1718 - 15.5492]
<i>Italy</i>	31	0.0501	0.0024	[0.0454 - 0.0548]	13.8356	[12.6466 - 15.2712]
<i>England</i>	32	0.0498	0.0035	[0.0430 - 0.0567]	13.9047	[12.2222 - 16.1244]
<i>Switzerland</i>	48	0.0482	0.0022	[0.0439 - 0.0526]	14.3764	[13.1856 - 15.8037]
<i>Austria</i>	16	0.0466	0.0031	[0.0406 - 0.0527]	14.8628	[13.1637 - 17.0656]
<i>Portugal</i>	36	0.0419	0.0035	[0.0350 - 0.0487]	16.5596	[14.2205 - 19.8199]
<i>Canada</i>	49	0.0406	0.0018	[0.0371 - 0.0440]	17.0891	[15.7449 - 18.6842]
<i>Scotland</i>	21	0.0300	0.0020	[0.0261 - 0.0339]	23.1295	[20.4743 - 26.5758]
<i>Wales</i>	12	0.0288	0.0023	[0.0243 - 0.0332]	24.1057	[20.8500 - 28.5662]
<i>Northern Ireland</i>	9	0.0253	0.0026	[0.0201 - 0.0304]	27.4195	[22.7908 - 34.4076]

¹ Number of days with reports of confirmed cases in the date range

C Estimation of the effective reproduction number

According to (Bonifazi et al. 2021) there is a functional relation between the effective reproduction number (R_t), and the duplication time, of the form:

$$\widehat{R}_t = e^{(g \log 2)/\widehat{T}_d} \quad (11)$$

where: g is the generation time, and \widehat{T}_d is the estimate of the duplication time.

Combining Equation 10 and Equation 11, we can derive

$$\widehat{R}_t = e^{(g \log 2)/(\log 2/B)} = e^{gB} \quad (12)$$

A recent article (Guzzetta et al. 2022), gives an early estimate for the generation time of the current MPXV outbreak of 12.5 days (95% CI: [7.5 - 17.3]). Using Equation 12, along with our estimate for the slope (B) and the published estimate for g with its 95% CI, we can compute a possible value of R_t :

Table 4: Estimates of R_t for selected countries

Country	Slope	$R_t(\text{mean})^1$	$R_t(\text{lower})^2$	$R_t(\text{upper})^3$
<i>Brazil</i>	0.095	3.271	2.036	5.157
<i>United States</i>	0.087	2.960	1.918	4.489
<i>Peru</i>	0.086	2.925	1.904	4.416
<i>Chile</i>	0.067	2.298	1.648	3.164
<i>France</i>	0.061	2.146	1.581	2.877
<i>Spain</i>	0.060	2.123	1.571	2.834
<i>Germany</i>	0.059	2.089	1.556	2.772
<i>Mexico</i>	0.057	2.042	1.535	2.686
<i>Belgium</i>	0.051	1.890	1.465	2.413
<i>Netherlands</i>	0.051	1.886	1.463	2.407
<i>Italy</i>	0.050	1.871	1.456	2.379
<i>England</i>	0.050	1.865	1.453	2.369
<i>Switzerland</i>	0.048	1.827	1.436	2.303
<i>Austria</i>	0.047	1.791	1.419	2.241
<i>Portugal</i>	0.042	1.687	1.369	2.063
<i>Canada</i>	0.041	1.660	1.356	2.017
<i>Scotland</i>	0.030	1.454	1.252	1.679
<i>Wales</i>	0.029	1.433	1.241	1.645
<i>Northern Ireland</i>	0.025	1.372	1.209	1.549

¹ Using the mean estimate of 12.5 days

² Using the lower estimate of 7.5 days

³ Using the higher estimate of 17.3 days

D Cumulative incidence for all countries with confirmed cases

In the following two tables, we show the cumulative incidence up to the most current complete epidemiological week (2022W33), separating those countries with 10 or more confirmed cases in total, from those with less than 10 cases.

Table 5: Cumulative incidence per million for countries at least 10 confirmed cases

Country	Date of first confirmed case ¹³	Total cases ¹³	Population (2022) ⁴	Incidence (per million) ³
<u>Africa</u>				
<i>Democratic Republic Of The Congo</i>	2022-05-08	163	99,010,212	1.646
<i>Ghana</i>	2022-06-08	47	33,475,870	1.404
<i>Nigeria</i>	2022-01-31 ²	172	218,541,212	0.787
<u>Asia</u>				
<i>Israel</i>	2022-05-21	194	9,038,309	21.464
<i>Singapore</i>	2022-06-20	15	5,975,689	2.510
<i>United Arab Emirates</i>	2022-05-24	16	9,441,129	1.695
<i>India</i>	2022-07-14	10	1,417,173,173	0.007
<u>Europe</u>				
<i>Spain</i>	2022-05-18	5,792	47,558,630	121.787
<i>Portugal</i>	2022-05-17	770	10,270,865	74.969
<i>Luxembourg</i>	2022-06-16	45	647,599	69.487
<i>Netherlands</i>	2022-05-20	1,087	17,564,014	61.888
<i>Malta</i>	2022-05-28	31	533,286	58.130
<i>Belgium</i>	2022-05-19	624	11,655,930	53.535
<i>Switzerland</i>	2022-05-21	399	8,740,472	45.650
<i>England</i>	2022-05-06	3,050	67,508,936	45.179
<i>France</i>	2022-05-19	2,873	64,626,628	44.455
<i>Germany</i>	2022-05-19	3,266	83,369,843	39.175
<i>Iceland</i>	2022-06-15	12	372,899	32.180
<i>Denmark</i>	2022-05-23	163	5,882,261	27.710
<i>Austria</i>	2022-05-23	217	8,939,617	24.274
<i>Ireland</i>	2022-05-27	113	5,023,109	22.496
<i>Slovenia</i>	2022-05-24	43	2,119,844	20.285
<i>Norway</i>	2022-05-31	76	5,434,319	13.985
<i>Sweden</i>	2022-05-19	139	10,549,347	13.176
<i>Italy</i>	2022-05-19	689	59,037,474	11.671
<i>Hungary</i>	2022-05-31	62	9,967,308	6.220
<i>Greece</i>	2022-06-08	50	10,384,971	4.815

Table 5: Cumulative incidence per million for countries at least 10 confirmed cases (*continued*)

Country	Date of first confirmed case ¹³	Total cases ¹³	Population (2022) ⁴	Incidence (per million) ³
<i>Serbia</i>	2022-06-17	31	7,221,365	4.293
<i>Croatia</i>	2022-06-23	17	4,030,358	4.218
<i>Finland</i>	2022-05-27	22	5,540,745	3.971
<i>Czech Republic</i>	2022-05-24	36	10,493,986	3.431
<i>Poland</i>	2022-06-10	104	39,857,145	2.609
<i>Slovakia</i>	2022-07-07	10	5,643,453	1.772
<i>Romania</i>	2022-06-13	33	19,659,267	1.679
<i>Scotland</i>	2022-05-23	75	67,508,936	1.111
<i>Wales</i>	2022-05-26	43	67,508,936	0.637
<i>Northern Ireland</i>	2022-05-26	27	67,508,936	0.400
<u>Latin America and the Caribbean</u>				
<i>Peru</i>	2022-06-26	1,068	34,049,588	31.366
<i>Puerto Rico</i>	2022-06-29	66	3,252,407	20.293
<i>Brazil</i>	2022-06-08	3,756	215,313,498	17.444
<i>Chile</i>	2022-06-17	207	19,603,733	10.559
<i>Bolivia</i>	2022-08-01	42	12,224,110	3.436
<i>Colombia</i>	2022-06-23	164	51,874,024	3.162
<i>Mexico</i>	2022-05-28	252	127,504,125	1.976
<i>Argentina</i>	2022-05-27	72	45,510,318	1.582
<i>Ecuador</i>	2022-07-06	20	18,001,000	1.111
<u>Northern America</u>				
<i>United States</i>	2022-05-18	14,050	338,289,857	41.532
<i>Canada</i>	2022-05-19	1,168	38,454,327	30.374
<u>Oceania</u>				
<i>Australia</i>	2022-05-20	90	26,177,413	3.438

¹ Source: Global.health Monkeypox data repository² Reports earlier than May 2022 are from endemic areas³ As of complete epidemiological week #33 of 2022.⁴ Source: UN 2022 Revision of World Population Prospects

Table 6: Cumulative incidence per million for countries with less than 10 confirmed cases

Country	Date of first confirmed case ¹³	Total cases ¹³	Population (2022) ⁴	Incidence (per million) ³
<u>Africa</u>				
<i>Central African Republic</i>	2022-03-04 ²	8	5,579,144	1.434
<i>Republic of Congo</i>	2022-04-12 ²	3	5,970,424	0.502
<i>Liberia</i>	2022-07-23	2	5,302,681	0.377
<i>Cameroon</i>	2022-02-17 ²	7	27,914,536	0.251
<i>Benin</i>	2022-06-14	3	13,352,864	0.225
<i>South Africa</i>	2022-06-22	5	59,893,885	0.083
<i>Sudan</i>	2022-07-31	2	46,874,204	0.043
<i>Morocco</i>	2022-06-02	1	37,457,971	0.027
<u>Asia</u>				
<i>Cyprus</i>	2022-08-02	4	1,251,488	3.196
<i>Qatar</i>	2022-07-20	3	2,695,122	1.113
<i>Lebanon</i>	2022-06-20	6	5,489,739	1.093
<i>Georgia</i>	2022-06-15	2	3,744,385	0.534
<i>Saudi Arabia</i>	2022-07-14	6	36,408,820	0.165
<i>Taiwan</i>	2022-06-24	3	23,893,394	0.126
<i>Thailand</i>	2022-07-21	5	71,697,030	0.070
<i>Turkey</i>	2022-06-30	5	85,341,241	0.059
<i>Japan</i>	2022-07-25	4	123,951,692	0.032
<i>Philippines</i>	2022-07-28	3	115,559,009	0.026
<i>South Korea</i>	2022-06-22	1	51,815,810	0.019
<i>Iran</i>	2022-08-16	1	88,550,570	0.011
<i>Indonesia</i>	2022-08-19	1	275,501,339	0.004
<u>Europe</u>				
<i>Gibraltar</i>	2022-06-01	6	32,649	183.773
<i>Monaco</i>	2022-07-21	3	36,469	82.262
<i>Andorra</i>	2022-07-25	4	79,824	50.110
<i>Estonia</i>	2022-06-28	9	1,326,062	6.787
<i>Latvia</i>	2022-06-03	4	1,850,651	2.161
<i>Lithuania</i>	2022-08-03	5	2,750,055	1.818
<i>Montenegro</i>	2022-08-01	1	627,082	1.595
<i>Bosnia And Herzegovina</i>	2022-07-13	3	3,233,526	0.928
<i>Moldova</i>	2022-08-08	2	3,272,996	0.611
<i>Bulgaria</i>	2022-06-23	4	6,781,953	0.590
<i>Martinique</i>	2022-07-15	2	64,626,628	0.031

Table 6: Cumulative incidence per million for countries with less than 10 confirmed cases
(continued)

Country	Date of first confirmed case ¹³	Total cases ¹³	Population (2022) ⁴	Incidence (per million) ³
<i>Guadeloupe</i>	2022-07-25	1	64,626,628	0.015
<i>Russia</i>	2022-07-12	1	144,713,314	0.007
Latin America and the Caribbean				
<i>Saint Martin (French part)</i>	2022-08-01	1	31,791	31.455
<i>Barbados</i>	2022-07-16	1	281,635	3.551
<i>Panama</i>	2022-07-05	7	4,408,581	1.588
<i>Jamaica</i>	2022-07-06	4	2,827,377	1.415
<i>Uruguay</i>	2022-07-29	2	3,422,794	0.584
<i>Costa Rica</i>	2022-07-20	3	5,180,829	0.579
<i>Dominican Republic</i>	2022-07-06	6	11,228,821	0.534
<i>Honduras</i>	2022-08-13	3	10,432,860	0.288
<i>Guatemala</i>	2022-08-03	3	17,843,908	0.168
<i>Venezuela</i>	2022-06-12	1	28,301,696	0.035
Northern America				
<i>Greenland</i>	2022-08-09	2	56,466	35.420
<i>Bermuda</i>	2022-07-21	1	64,184	15.580
Oceania				
<i>New Caledonia</i>	2022-07-12	1	289,950	3.449
<i>New Zealand</i>	2022-07-09	4	5,185,288	0.771

¹ Source: Global.health Monkeypox data repository

² Reports earlier than May 2022 are from endemic areas

³ As of complete epidemiological week #33 of 2022.

⁴ Source: UN 2022 Revision of World Population Prospects

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