healthcare

Supplementary Materials: Regional Disparities in Registered Autism Spectrum Disorder Cases and Child Psychiatry Workforce Capacity in Kazakhstan, 2015–2025: A Nationwide Registry-Based Study

Table S1. Registered ASD cases by region and year, 2015–2025 (raw administrative units).

Region	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Abai	0	0	0	0	0	0	0	0	49	76	96
Akmola	6	19	13	14	27	23	82	81	149	222	265
Aktobe	1	0	28	32	40	40	47	72	71	80	156
Almaty city	32	40	39	30	67	82	142	173	170	246	298
Almaty region	10	13	19	27	39	48	79	132	118	165	210
Astana	51	63	82	106	171	163	296	316	563	903	1123
Atyrau	0	9	5	7	10	23	46	43	118	143	299
East Kazakhstan	35	32	37	43	56	70	86	176	166	163	128
Karaganda	3	4	1	2	2	9	47	58	47	72	57
Kostanay	9	23	46	35	36	51	81	100	183	205	191
Kyzylorda	3	6	4	7	11	8	18	24	13	13	176
Mangystau	1	9	11	23	35	36	49	34	75	133	127
North Kazakhstan	29	29	33	35	26	33	39	30	50	78	66
Pavlodar	0	0	26	28	29	30	40	123	134	152	182
Shymkent	0	0	0	0	24	32	21	46	49	100	228
South Kazakhstan (pre-2018, historical)	3	3	10	14	0	0	0	0	0	0	0
Turkestan	0	0	0	0	10	12	15	16	56	116	204
Ulytau	0	0	0	0	0	0	0	0	21	17	51
West Kazakhstan	14	12	15	16	19	29	40	67	78	123	222
Zhambyl	10	8	19	49	36	58	52	113	140	135	215
Zhetysu	0	0	0	0	0	0	0	0	44	58	92

Table S2a reports the national ASD case count, national child population aged 0–17, and the coefficient of variation (CV) and Gini coefficient of the regional raw count distribution, by year, underlying the descriptive statistics reported in the main text.

Table S2a. National ASD case counts, child population, and regional concentration statistics (raw counts) by year, 2015–2025.

Year	Total ASD cases	Child population aged 0–17 (n)	Coefficient of variation (%)	Gini coefficient
2015	207	5,296,464	143.3	0.686
2016	270	5,459,254	125.3	0.626
2017	388	5,623,557	108.8	0.562
2018	468	5,783,129	108.3	0.537
2019	638	5,942,753	120.0	0.536
2020	747	6,108,161	102.6	0.505
2021	1180	6,292,916	113.7	0.515
2022	1604	6,616,984	99.0	0.513
2023	2294	6,737,957	104.9	0.455
2024	3200	6,841,445	118.0	0.457
2025	4386	6,902,492	105.1	0.411

Table S2b reports registered ASD case counts by year for the historical-boundary (16-unit) regional classification used in Section 2.4 and Table 3 of the main text, in which post-2022 regions (Abai, Zhetysu, Ulytau) and the pre-2018 Turkestan/Shymkent split are merged back into their historical parent regions for consistent year-on-year comparison.

Table S2b. Registered ASD cases by historical-boundary region and year, 2015–2025.

Region	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Astana	51	63	82	106	171	163	296	316	563	903	1123
Almaty city	32	40	39	30	67	82	142	173	170	246	298
East Kazakhstan (incl. Abai)	35	32	37	43	56	70	86	176	215	239	224
Almaty region (incl. Zhetysu)	10	13	19	27	39	48	79	132	162	223	302
Kostanay	9	23	46	35	36	51	81	100	183	205	191
Southern macro-region (Turkestan+Shymkent+ex-South Kaz.)	3	3	10	14	34	44	36	62	105	216	432
Akmola	6	19	13	14	27	23	82	81	149	222	265
Zhambyl	10	8	19	49	36	58	52	113	140	135	215
Pavlodar	0	0	26	28	29	30	40	123	134	152	182
Atyrau	0	9	5	7	10	23	46	43	118	143	299
West Kazakhstan	14	12	15	16	19	29	40	67	78	123	222
Aktobe	1	0	28	32	40	40	47	72	71	80	156
Mangystau	1	9	11	23	35	36	49	34	75	133	127
North Kazakhstan	29	29	33	35	26	33	39	30	50	78	66
Karaganda (incl. Ulytau)	3	4	1	2	2	9	47	58	68	89	108
Kyzylorda	3	6	4	7	11	8	18	24	13	13	176

Table S2c reports the child population aged 0–17 by historical-boundary region and year. For 2015–2022, figures are obtained directly from Bureau of National Statistics compilations for the 17 pre-2022 administrative regions. For 2023–2025, the population of East Kazakhstan, Almaty region, and Karaganda includes an added estimate for Abai, Zhetysu, and Ulytau respectively, calculated as each new region's published total population multiplied by its parent region's child-to-total population ratio (Section 2.5); this estimation step is a secondary approximation specific to these three regions in these three years. A residual discrepancy between the summed regional population and the independently compiled national total (7–9% for 2015–2022) remains unresolved (Section 4.1).

Table S2c. Child population aged 0–17 by historical-boundary region and year, 2015–2025 (2023–2025 figures for East Kazakhstan, Almaty region, and Karaganda include an estimated addition for Abai, Zhetysu, and Ulytau respectively).

Region	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Astana	242,425	259,252	299,031	322,892	346,832	374,619	398,837	427,481	444,505	472,084	507,173
Akmola	196,154	199,423	196,759	201,352	203,884	205,125	205,939	223,606	223,954	223,499	221,710
Atyrau	204,720	212,728	220,855	228,934	237,136	244,687	253,283	262,387	269,592	274,688	275,839
West Kazakhstan	174,076	178,701	182,744	188,016	193,417	198,489	203,832	211,751	215,129	217,427	218,247
Kostanay	203,129	205,186	205,494	206,051	206,478	206,389	206,880	209,313	208,302	206,584	203,474
Pavlodar	185,539	189,295	191,550	193,774	196,224	198,907	201,454	205,518	205,745	205,031	202,589
East Kazakhstan (incl. Abai)	165,117	168,336	170,581	173,072	174,811	176,132	178,571	183,222	337,197	337,448	337,265
North Kazakhstan	136,007	136,439	136,182	136,242	135,770	134,947	134,423	129,590	128,365	126,424	123,384
Kyzylorda	275,506	282,442	287,125	293,591	300,180	306,131	315,067	323,035	330,718	335,399	335,907
Aktobe	244,105	252,771	261,126	270,050	278,974	288,907	299,767	318,565	325,473	330,877	334,587
Zhambyl	396,043	406,912	414,340	419,563	426,916	432,092	441,252	457,058	463,618	465,492	462,102
Almaty city	385,194	406,460	425,280	446,498	470,604	499,484	527,670	638,452	647,261	665,429	679,872
Mangystau	224,639	235,958	245,403	256,048	266,698	278,407	291,181	310,483	320,939	329,617	335,760
Almaty region (incl. Zhetysu)	407,541	422,417	448,453	469,584	485,569	502,146	518,587	530,364	789,969	803,726	815,033
Southern macro-region	1,108,460	1,140,731	1,167,606	1,197,137	1,230,118	1,263,812	1,305,923	1,368,309	1,400,508	1,424,132	1,436,857
Karaganda (incl. Ulytau)	291,378	296,542	299,316	301,779	304,083	307,360	311,262	316,473	379,697	378,788	376,202

Table S2d reports the population-standardized registered ASD rate per 100,000 children (Table S2b divided by Table S2c, ×100,000) by historical-boundary region and year, underlying Table 2, Table 3, Figure 2, and Figure 3 of the main text. Rates for East Kazakhstan, Almaty region, and Karaganda in 2023–2025 rely on the estimated population addition described in Table S2c and should be interpreted with the corresponding caution.

Table S2d. Population-standardized registered ASD rate per 100,000 children by historical-boundary region and year, 2015–2025.

Region	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Astana	21.0	24.3	27.4	32.8	49.3	43.5	74.2	73.9	126.7	191.3	221.4
Akmola	3.1	9.5	6.6	7.0	13.2	11.2	39.8	36.2	66.5	99.3	119.5
Atyrau	0.0	4.2	2.3	3.1	4.2	9.4	18.2	16.4	43.8	52.1	108.4
West Kazakhstan	8.0	6.7	8.2	8.5	9.8	14.6	19.6	31.6	36.3	56.6	101.7
Kostanay	4.4	11.2	22.4	17.0	17.4	24.7	39.2	47.8	87.9	99.2	93.9
Pavlodar	0.0	0.0	13.6	14.4	14.8	15.1	19.9	59.8	65.1	74.1	89.8
East Kazakhstan (incl. Abai)	21.2	19.0	21.7	24.8	32.0	39.7	48.2	96.1	63.8	70.8	66.4
North Kazakhstan	21.3	21.3	24.2	25.7	19.2	24.5	29.0	23.1	39.0	61.7	53.5
Kyzylorda	1.1	2.1	1.4	2.4	3.7	2.6	5.7	7.4	3.9	3.9	52.4
Aktobe	0.4	0.0	10.7	11.8	14.3	13.8	15.7	22.6	21.8	24.2	46.6
Zhambyl	2.5	2.0	4.6	11.7	8.4	13.4	11.8	24.7	30.2	29.0	46.5
Almaty city	8.3	9.8	9.2	6.7	14.2	16.4	26.9	27.1	26.3	37.0	43.8
Mangystau	0.4	3.8	4.5	9.0	13.1	12.9	16.8	11.0	23.4	40.3	37.8
Almaty region (incl. Zhetysu)	2.5	3.1	4.2	5.7	8.0	9.6	15.2	24.9	20.5	27.7	37.1
Southern macro-region	0.3	0.3	0.9	1.2	2.8	3.5	2.8	4.5	7.5	15.2	30.1
Karaganda (incl. Ulytau)	1.0	1.3	0.3	0.7	0.7	2.9	15.1	18.3	17.9	23.5	28.7

Table S2e summarizes how the administrative units in use during 2015–2025 were combined into the 16 historical-boundary analytical units used for all longitudinal regional analyses (Section 2.4).

Table S2e. Crosswalk between administrative units and the 16 historical-boundary analytical units used for regional analyses, 2015–2025.

Historical-boundary analytical unit (2015–2025)	Administrative units included	Change during the study period
East Kazakhstan (incl. Abai)	East Kazakhstan region; Abai region	Abai region separated from East Kazakhstan region in 2022
Almaty region (incl. Zhetysu)	Almaty region; Zhetysu region	Zhetysu region separated from Almaty region in 2022
Karaganda (incl. Ulytau)	Karaganda region; Ulytau region	Ulytau region separated from Karaganda region in 2022
Southern macro-region	Former South Kazakhstan region; Turkestan region; Shymkent city	South Kazakhstan region reorganized into Turkestan region and Shymkent city in 2018
Astana; Almaty city; Akmola; Aktobe; Atyrau; West Kazakhstan; Zhambyl; Kostanay; Kyzylorda; Mangystau; Pavlodar; North Kazakhstan (12 units)	Unchanged	None

ASD cases for Abai, Zhetysu and Ulytau are recorded separately in Form 10-f from 2023 onward (2022 counts were zero) and were added to their parent units. For 2023–2025, the child populations of these three regions were estimated and added to the parent unit denominators (Section 2.5).

Table S3 reports the diagnostics of the negative binomial model for the national trend (Sections 2.7 and 3.1).

Table S3. Diagnostics of the negative binomial model for the national trend in newly registered ASD cases (F84.0+F84.1+F84.5) among children aged 0–17 years, Kazakhstan, 2015–2025 (n = 11 annual observations).

Diagnostic	Result
Dispersion parameter (NB2, alpha)	0.0038 (SE 0.0022)
Likelihood-ratio test, negative binomial vs. Poisson	$\chi^2 = 18.2$, $p < 0.001$

Pearson χ^2/df, Poisson model	5.13
Pearson χ^2/df, negative binomial model	1.17
Deviance/df, negative binomial model	1.22
Pearson residuals, range	−2.29 (2020) to 1.21 (2017)
Residual autocorrelation, lag 1	r = 0.37
Ljung–Box test, lags 1 / 2 / 3	p = 0.19 / 0.24 / 0.13
Rate ratio, model-based SE (95% CI)	1.324 (1.305–1.343)
Rate ratio, Newey–West HAC SE, lag 1 (95% CI)	1.324 (1.305–1.343)
Poisson model, rate ratio with robust (sandwich) SE (95% CI)	1.340 (1.322–1.358)
Leave-one-year-out rate ratio, range	1.317–1.330
Largest Cook's distance	0.55 (2025)
Quadratic year term: likelihood-ratio test	$\chi^2 = 11.3$, $p < 0.001$
Log-likelihood, linear model	−61.60
AIC, linear vs. quadratic model	129.2 vs. 119.9
Implied annual rate ratio, quadratic model	≈1.24 (2015–2016) to 1.40 (2024–2025)

Model: annual case count regressed on calendar year (centered at 2020) with log child population (0–17 years) as offset, fitted by maximum likelihood (Python, statsmodels). HAC, heteroscedasticity- and autocorrelation-consistent; AIC, Akaike information criterion. Given n = 11, diagnostic tests have limited power and are interpreted descriptively.

Table S4 reports region-specific compound annual growth rates as a descriptive supplementary measure (Section 3.4).

Table S4. Compound annual growth rate (CAGR) of registered ASD rates per 100,000 children aged 0–17 years by historical-boundary region, 2015–2025 (descriptive only).

Region (historical boundaries)	2015 cases (n)	2015 rate	2025 rate	CAGR 2015–2025 (%/yr)	Interpretable
Astana	51	21.0	221.4	26.5	Yes
Akmola	6	3.1	119.5	44.3	Yes
Atyrau	0	0.0	108.4	NA	No (zero baseline)
West Kazakhstan	14	8.0	101.7	28.9	Yes
Kostanay	9	4.4	93.9	35.7	Yes
Pavlodar	0	0.0	89.8	NA	No (zero baseline)
East Kazakhstan (incl. Abai)	35	21.2	66.4	12.1	Yes
North Kazakhstan	29	21.3	53.5	9.6	Yes
Kyzylorda	3	1.1	52.4	47.3	No (<5 cases)
Aktobe	1	0.4	46.6	60.6	No (<5 cases)
Zhambyl	10	2.5	46.5	33.8	Yes
Almaty city	32	8.3	43.8	18.1	Yes
Mangystau	1	0.4	37.8	55.9	No (<5 cases)
Almaty region (incl. Zhetysu)	10	2.5	37.1	31.2	Yes
Southern macro-region (Turkestan+Shymkent+ex-South Kaz.)	3	0.3	30.1	60.2	No (<5 cases)
Karaganda (incl. Ulytau)	3	1.0	28.7	39.5	No (<5 cases)

CAGR = (rate2025/rate2015)^(1/10) − 1. CAGR is not interpreted for regions with fewer than 5 registered cases in 2015, because a single additional baseline case substantially changes the estimate, and cannot be calculated for regions with no registrations in 2015 (NA).

Table S5 reports the sensitivity of regional inequality measures and Astana's rank to alternative population-denominator assumptions (Sections 2.7 and 3.5).

Table S5. Sensitivity of regional inequality measures and Astana's rank to alternative population-denominator assumptions, 2015–2025.

Year	Shortfall (%)	Gini: main	Gini: B	Gini: C (range)	CV (%): main	CV (%): B	CV (%): C (range)	Astana rank: main / B / C
2015	8.6	0.635	0.638	0.629–0.653	129.1	129.6	129.1–138.1	3 / 2 / 2–5
2016	8.5	0.547	0.548	0.521–0.569	103.0	105.3	97.8–110.1	1 / 1 / 1–6
2017	8.4	0.473	0.479	0.454–0.497	86.5	88.6	83.1–92.7	1 / 1 / 1–6
2018	8.3	0.437	0.435	0.399–0.463	80.3	81.6	72.2–86.3	1 / 1 / 1–5
2019	8.2	0.413	0.398	0.344–0.442	83.4	84.5	62.8–90.5	1 / 1 / 1–2
2020	8.0	0.372	0.356	0.329–0.402	71.2	68.2	62.4–77.3	1 / 1 / 1–4

2021	7.9	0.363	0.366	0.306–0.393	70.3	72.9	55.1–76.8	1 / 1 / 1–4
2022	7.6	0.385	0.358	0.334–0.419	73.9	65.3	63.1–79.3	2 / 1 / 1–5
2023	0.7	0.391	0.391	0.381–0.396	73.8	73.8	70.4–75.3	1 / 1 / 1–1
2024	0.7	0.395	0.395	0.385–0.399	78.0	78.0	73.9–79.5	1 / 1 / 1–1
2025	0.5	0.321	0.321	0.313–0.326	64.8	64.8	61.8–66.1	1 / 1 / 1–1

Shortfall: difference between the national child population (0–17 years) and the sum of the 16 regional denominators, as a percentage of the national total. Main: denominators as in Table S2c. Scenario A (proportional scaling of all regional denominators to the national total) yields Gini coefficients, coefficients of variation and ranks identical to the main analysis and is therefore not shown separately. B: shortfall allocated to East Kazakhstan, Almaty region and Karaganda in proportion to the estimated 2023 child populations of Abai (153,975), Zhetysu (259,605) and Ulytau (63,224). C: entire shortfall allocated to each of the 16 regions in turn; ranges across the 16 allocations are shown. In scenario C, Astana ranked below first in 2016–2021 only when the shortfall was allocated to Astana itself. CV, coefficient of variation (population standard deviation/mean × 100).

Figure S1 shows a sample of the Form 10-f report used as the data source of this study (Section 2.1 of the main text). In its current version (Appendix 13 to Order of the Minister of Health of the Republic of Kazakhstan No. ҚР ДСМ-313/2020 of 22 December 2020, as amended by Order No. ҚР ДСМ-144 of 30 November 2022), the form carries the index 13-PPR. The study used the rows of Table 1000 reporting patients with childhood autism (F84.0), atypical autism (F84.1) and Asperger syndrome (F84.5) diagnosed for the first time in life; an English translation of these rows is given below the figure.

(a)

Сноска. Форма – в редакции приказа и.о. Министра здравоохранения РК от 30.11.2022 № ҚР ДСМ-144 (вводится в действие по истечении десяти календарных дней после дня его первого официального опубликования).

Форма, предназначенная для сбора административных данных Представляется: Министерство здравоохранения Республики Казахстан Форма административных данных размещена на интернет ресурсе: dsm.gov.kz Отчет о заболеваниях и контингентах больных психическими и поведенческими расстройствами Отчетный период за 20____ год Индекс: 13-ППР Периодичность: годовая Круг лиц, представляющих: организации здравоохранения районов, областей, города республиканского значения и столицы Срок представления: один раз в год, 10 февраля, следующего за отчетным периодом БИН

□□□□□□□□□□□□

1000 Распределение больных с впервые в жизни установленным диагнозом по полу и возрасту, всего

Наименование		№ строки	Шифр по МКБ Х-пересмотра	Всего	в том числе у больных в возрасте, лет							
					0-4	5-9	10-14	15-19	20-24	25-28	29-34	35-39
А	Б	В	Г	1	2	3	4	5	6	7	8	9

(b)

Нарушение психологического развития	всего	21	F80-F89									
	женщины	22										
из них: детский аутизм;	всего	23	F84.0									
	женщины	24										
атипичный аутизм;	всего	25	F84.1									
	женщины	26										
синдром Аспергера	всего	27	F84.5									
	женщины	28										

Figure S1. Sample of Form 10-f (current index 13-PPR), "Report on diseases and contingents of patients with mental and behavioral disorders" (original in Russian). (a) Title section of the form and header of Table 1000, "Distribution of patients with a diagnosis established for the first time in life, by sex and age, total"; (b) rows 21–28 of Table 1000 used in this study. Source: Appendix 13 to Order of the Minister of Health of the Republic of Kazakhstan No. ҚР ДСМ-313/2020 (as amended by Order No. ҚР ДСМ-144 of 30 November 2022).

English translation of the rows of Table 1000 used in this study:

Name (English translation)	Original (Russian)	Row No.	ICD-10 code	Breakdown
Disorders of psychological development	Нарушение психологического развития	21 (total); 22 (women)	F80–F89	Total and by age group

of which: childhood autism	из них: детский аутизм	23 (total); 24 (women)	F84.0	Total and by age group
atypical autism	атипичный аутизм	25 (total); 26 (women)	F84.1	Total and by age group
Asperger syndrome	синдром Аспергера	27 (total); 28 (women)	F84.5	Total and by age group

Age groups in Table 1000 of the current version of the form: 0–4, 5–9, 10–14, 15–19, 20–24, 25–28, 29–34, 35–39, 40–44, 45–49, 50–54, 55–59, 60–64, 65–69, 70–74, 75–79, 80–84 and ≥85 years, and 14–28 years inclusive. The data for children aged 0–17 years used in this study were provided by the Republican Center for Electronic Health Care of the Ministry of Health of the Republic of Kazakhstan. Table 1001 of the form reports the same rows for the rural population. Rows 22, 24, 26 and 28 report women; the study used the totals (rows 23, 25 and 27; row 21 for context).