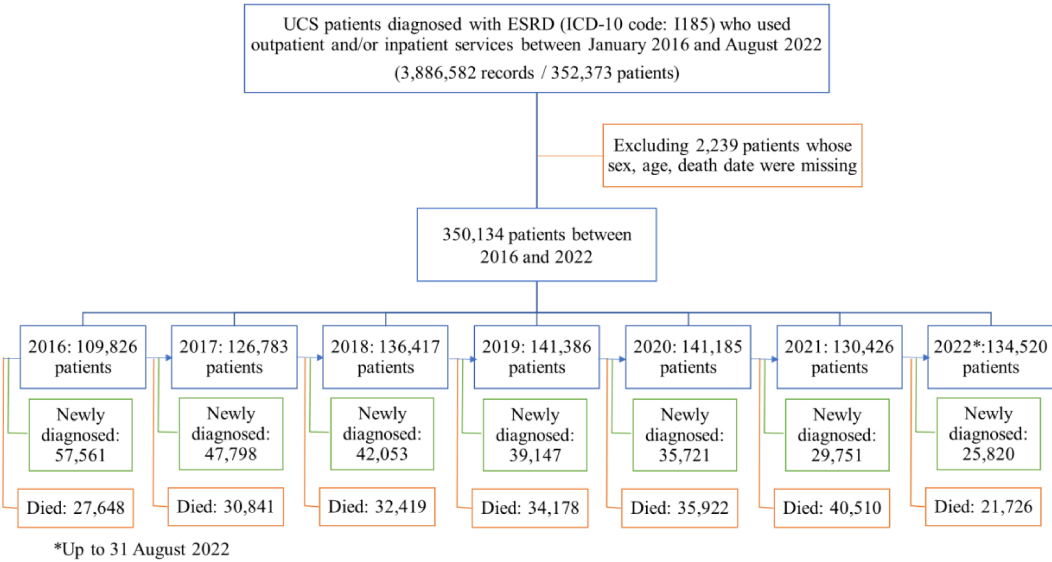


Supplementary file

Figure 1 Population selection flow chart



Box 1 General additive models (GAM)

We used general additive models (GAM) to estimate expected number of deaths based on a negative binomial distribution to account for overdispersion and used the restricted maximum likelihood (REML) method to estimate the smoothing parameters of the model. The equation is:

$$Death_t = \beta_0 + \beta_1 * age_group_t + \beta_2 * sex_t + \log(population_t) + time_t$$

Where t is a given time point in the study period

$Death$ is an expected number of deaths in each time point t

age_group , sex is the factor variable directing a specific number of ESRD populations for each age group and sex in each time point t

We add the logarithm of the number of populations as an offset term and the time variable (integer represents time point t) as the smooth function of time accounting for seasonal fluctuation with a penalized cyclic cubic regression spline for our model.

Our model had an adjusted R^2 of 0.98. The result of the model fitting is shown in the table below

Variable	Coefficient	95% CI
Intercept	-4.68	(-4.79, -4.58)
age group 0-19	ref	-
age group 20-44	0.34	(0.23, 0.44)
age group 45-64	0.73	(0.62, 0.83)
age group 65-74	0.90	(0.8, 1.01)
age group ≥ 75	1.14	(1.04, 1.25)
Sex male	ref	-
Sex female	-0.07	(-0.09, -0.06)

The smooth term *time* had a p-value of less than 0.001 with a k-index 0.96, k` 28.0 and edf equal to 15.6.

Table 1. Positive excess mortality among ESRD patients between March 2020 and August 2022 by age group and sex.

a) Positive excess mortality by age group

Age group	Positive excess death (n)	Proportion
0-19	1	0.00
20-44	30	0.00
45-64	1,188	0.11
65-74	3,343	0.30
75 or more	6,525	0.59
Total	11,087	1.00

b) Positive excess mortality by sex

Age group	Positive excess death (n)	Proportion
Male	3,719	0.40
Female	5,490	0.60
Total	9,209	1.00

Table 2. Monthly excess all-cause mortality among ESRD patients between March 2020 and August 2022 disaggregated by sex

Month	Male				Female			
	Excess deaths (n)	Excess deaths per 100,000 (n)	Relative excess death		Excess deaths (n)	Excess deaths per 100,000 (n)	Relative excess death	
			%	95% CI			%	95% CI
Mar-2020	-238	-371.0	-15.0	-18.7, -11.3	-260	-337.0	-14.0	-17.7, -10.3
Apr-2020	-338	-527.3	-21.5	-25.5, -17.5	-437	-568.1	-23.8	-27.8, -19.8
May-2020	-283	-441.1	-18.6	-22.5, -14.4	-245	-319.2	-13.8	-17.8, -9.8
Jun-2020	-220	-342.0	-15	-18.9, -10.9	-224	-291.6	-13.1	-17.1, -9.3
Jul-2020	-140	-217.1	-9.7	-13.8, -5.6	-88	-114.8	-5.3	-9.4, -1.3
Aug-2020	-79	-122.4	-5.4	-9.3, -1.4	-46	-60.0	-2.7	-6.6, 1.1
Sep-2020	-187	-289.2	-12.6	-16.8, -8.6	-209	-272.6	-12.2	-16.1, -8.1
Oct-2020	-88	-135.5	-5.9	-9.9, -1.9	-3	-3.9	-0.2	-4.2, 3.8
Nov-2020	7	10.8	0.5	-3.4, 4.4	-4	-5.2	-0.2	-4.1, 3.6
Dec-2020	219	338.1	14.9	11, 19.1	169	221.2	10.1	6.1, 14
Jan-2021	288	445.0	20.0	16.1, 23.9	333	437.8	20.3	16.4, 24.1
Feb-2021	-118	-182.2	-8.4	-12.6, -4.4	67	88.3	4.2	0.3, 8.2
Mar-2021	51	78.6	3.8	-0.2, 7.7	129	170.2	8.5	4.5, 12.3
Apr-2021	51	79.0	4.1	0, 7.9	154	204.6	10.6	6.6, 14.4
May-2021	176	273.8	13.9	9.9, 17.9	282	377.1	19.7	15.7, 23.8
Jun-2021	126	196.6	9.9	5.9, 13.8	225	302.8	15.6	11.9, 19.6
Jul-2021	335	526.7	25.7	21.7, 29.8	505	687.9	34.6	30.7, 38.7
Aug-2021	478	758.8	36.3	32.4, 40.2	462	636.3	31.4	27.5, 35.2
Sep-2021	370	591.8	28.0	24.2, 32.1	459	638.4	31.2	27.2, 35.1
Oct-2021	351	565.9	26.8	22.9, 30.8	442	620.7	30.3	26.3, 34.3
Nov-2021	251	407.4	19.3	15.3, 22.9	431	611.9	29.8	25.9, 33.5
Dec-2021	361	592.0	27.7	23.7, 31.7	618	889.9	42.9	38.9, 46.8
Jan-2022	136	222.1	10.3	6.5, 14.1	213	306.1	14.7	10.8, 18.4
Feb-2022	-226	-366.4	-17.3	-21.2, -13.3	-118	-168.8	-8.2	-12.3, -4.5
Mar-2022	114	183.7	9.1	5.2, 13.1	189	269.2	13.7	9.8, 17.7
Apr-2022	282	454.0	23.5	19.4, 27.4	527	753.0	40.2	36.4, 44.1
May-2022	123	197.1	10.4	6.5, 14.6	285	405.5	22.1	18.2, 26.2
Jun-2022	-165	-262.3	-13.7	-17.7, -9.9	-57	-80.6	-4.3	-8.2, -0.5
Jul-2022	-121	-191.3	-9.7	-13.7, -5.7	-7	-9.9	-0.5	-4.6, 3.3
Aug-2022	-232	-365.5	-18.1	-22, -14.2	-110	-154.8	-7.9	-11.9, -4.1
Mar 2020 to Aug 2022	1,284	2,012.1	3.1	-0.8, 7.4	3,682	4,969.2	8.0	3.9, 12.4

Table 3. Monthly excess all-cause mortality among ESRD patients between March 2020 and August 2022 disaggregated by age group

a) Age 0-19 years and 20-44 years

Month	Age 0-19 years				Age 20-44 years			
	Excess deaths (n)	Excess deaths per 100,000 (n)	Relative excess death		Excess deaths (n)	Excess deaths per 100,000 (n)	Relative excess death	
			%	95% CI			%	95% CI
Mar-2020	-9	-809.4	-75.0	-83.3, -58.3	-61	-464.4	-32.1	-36.8, -27.9
Apr-2020	-11	-983.9	-91.7	-100.0, -75.0	-72	-544.3	-37.9	-42.6, -33.7
May-2020	-6	-533.3	-50.0	-50.0, -33.3	-81	-607.2	-43.5	-48.4, -38.7
Jun-2020	-3	-263.6	-27.3	-36.4, -18.2	-31	-230.7	-17.1	-21.5, -12.2
Jul-2020	-5	-435.2	-50.0	-70.0, -50.0	-45	-331.4	-25.1	-30.2, -20.1
Aug-2020	-2	-171.5	-16.7	-16.7, 0.0	-51	-372.3	-28.0	-32.4, -23.6
Sep-2020	-5	-421.6	-41.7	-50.0, -25.0	-69	-498.1	-36.7	-41.5, -31.9
Oct-2020	-7	-585.3	-58.3	-66.7, -41.7	-53	-378.0	-27.6	-32.3, -22.9
Nov-2020	-6	-497.9	-50.0	-58.3, -33.3	-50	-352.6	-25.9	-30.1, -21.8
Dec-2020	1	82.4	8.3	0.0, 25.0	-41	-287.6	-21.4	-25.5, -16.7
Jan-2021	-5	-405.2	-41.7	-50.0, -25.0	-20	-139.0	-10.5	-15.3, -5.8
Feb-2021	-5	-401.9	-41.7	-50.0, -25.0	-61	-421.0	-32.8	-37.6, -28.0
Mar-2021	-7	-555.1	-58.3	-58.3, -41.7	-38	-260.0	-21.2	-26.3, -17.3
Apr-2021	-5	-392.2	-50.0	-70.0, -50.0	-32	-217.7	-18.4	-23.6, -14.4
May-2021	-5	-387.9	-50.0	-70.0, -50.0	-6	-40.7	-3.5	-8.1, 1.2
Jun-2021	-5	-384.3	-41.7	-41.7, -25.0	-45	-303.5	-25.4	-29.9, -20.9
Jul-2021	-7	-528.7	-58.3	-66.7, -41.7	-8	-53.6	-4.4	-8.7, 0.0
Aug-2021	-2	-150.4	-16.7	-25.0, 0.0	30	200.5	16.0	11.2, 19.8
Sep-2021	-5	-372.9	-41.7	-58.3, -25.0	-11	-73.2	-5.8	-9.9, -1.0
Oct-2021	-5	-371.2	-41.7	-58.3, -25.0	-9	-59.6	-4.7	-9.4, -0.5
Nov-2021	-9	-661.3	-75.0	-91.7, -75.0	-35	-230.4	-18.0	-22.2, -13.9
Dec-2021	-3	-220.3	-25.0	-41.7, -25.0	-38	-249.3	-19.3	-23.9, -14.7
Jan-2022	-9	-649.4	-69.2	-76.9, -61.5	-58	-376.7	-29.0	-33.5, -25.0
Feb-2022	-7	-498.2	-53.8	-61.5, -46.2	-76	-488.7	-38.2	-42.2, -33.7
Mar-2022	-8	-560.6	-66.7	-83.3, -66.7	-46	-293.2	-24.0	-28.1, -19.3
Apr-2022	-2	-139.2	-16.7	-25.0, 0.0	-9	-57.2	-4.9	-9.2, -0.5
May-2022	-5	-342.2	-41.7	-50.0, -25.0	-50	-314.5	-27.5	-31.9, -22.5
Jun-2022	-5	-340.1	-41.7	-58.3, -25.0	-75	-466.9	-40.3	-45.2, -36.0
Jul-2022	-5	-339.0	-41.7	-58.3, -41.7	-67	-414.9	-34.7	-39.4, -30.1
Aug-2022	-9	-605.7	-69.2	-84.6, -61.5	-81	-499.3	-40.9	-45.5, -36.4
Overall	-166	-12,779.1	-46.6	-51.7, -39.5	-1,289	-8,781.85	-22.9	-26.3, -19.3

b) Age 45-64 and 65-74 years

Month	Age 45-64 years				Age 65-74 years			
	Excess deaths (n)	Excess deaths per 100,000 (n)	Relative excess death		Excess deaths (n)	Excess deaths per 100,000 (n)	Relative excess death	
			%	95% CI			%	95% CI
Mar-2020	-262	-480.9	-22.5	-26.0, -18.8	-101	-263.0	-10.4	-14.0, -6.7
Apr-2020	-327	-600.0	-28.2	-32.2, -24.3	-218	-569.2	-22.6	-26.6, -18.7
May-2020	-241	-441.5	-21.4	-25.4, -17.4	-140	-366.3	-15.0	-18.9, -11.1
Jun-2020	-237	-431.9	-21.8	-25.6, -17.9	-112	-293.1	-12.5	-16.5, -8.6
Jul-2020	-163	-296.0	-15.2	-19.2, -11.2	-48	-125.8	-5.5	-9.4, -1.5
Aug-2020	-146	-264.0	-13.5	-17.3, -9.6	-20	-52.5	-2.3	-6.1, 1.6
Sep-2020	-227	-408.7	-20.5	-24.4, -16.5	-58	-152.7	-6.5	-10.5, -2.4
Oct-2020	-185	-331.1	-16.4	-20.4, -12.6	35	92.1	3.9	-0.1, 7.8
Nov-2020	-152	-271.1	-13.5	-17.3, -9.7	22	57.9	2.4	-1.4, 6.3
Dec-2020	-50	-89.0	-4.5	-8.4, -0.5	142	375.9	16.0	12.1, 20.1
Jan-2021	24	42.6	2.2	-1.5, 6.0	229	610.3	26.4	22.6, 30.3
Feb-2021	-178	-315.6	-16.7	-20.7, -12.8	-10	-26.7	-1.2	-5.2, 2.7
Mar-2021	-108	-190.6	-10.5	-14.5, -6.7	75	200.7	9.4	5.4, 13.1
Apr-2021	-143	-252.9	-14.4	-18.4, -10.6	132	356.5	17.2	13.3, 21.0
May-2021	32	56.8	3.3	-0.6, 7.3	132	359.0	17.5	13.6, 21.6
Jun-2021	-21	-37.3	-2.1	-5.9, 1.7	128	350.6	16.8	13.1, 20.7
Jul-2021	139	247.9	13.7	9.8, 17.8	347	966.1	45.1	41.2, 49.2
Aug-2021	255	458.2	24.8	21.0, 28.6	311	877.2	40.1	36.2, 43.8
Sep-2021	150	270.7	14.5	10.7, 18.4	303	866.4	39.1	35.4, 43.0
Oct-2021	137	248.5	13.2	9.5, 17.2	260	752.5	33.9	30.0, 37.8
Nov-2021	91	165.8	8.8	5.0, 12.6	255	748.0	33.6	29.6, 37.2
Dec-2021	196	359.7	18.9	14.9, 22.7	279	830.6	36.8	32.8, 40.8
Jan-2022	-36	-65.8	-3.4	-7.2, 0.3	115	341.6	15.0	11.2, 18.7
Feb-2022	-262	-475.7	-25.2	-29.2, -21.4	-51	-150.6	-6.7	-10.6, -2.9
Mar-2022	-21	-37.9	-2.1	-5.9, 1.8	111	325.7	15.2	11.4, 19.2
Apr-2022	133	240.2	13.9	10.0, 17.7	263	773.4	37.8	34.0, 41.6
May-2022	31	55.7	3.3	-0.6, 7.2	184	540.1	27.0	23.2, 30.9
Jun-2022	-209	-373.0	-21.8	-25.7, -18.1	-37	-107.8	-5.3	-9.2, -1.6
Jul-2022	-188	-334.0	-19.0	-22.9, -15.1	20	58.1	2.8	-1.1, 6.8
Aug-2022	-264	-467.1	-25.9	-29.7, -22.2	-49	-141.9	-6.6	-10.4, -2.7
Overall	-2,232	-4,021.9	-7.1	-10.6, -3.4	2,499	6,853.4	10.3	6.2, 14.7

c) Age 75 years or more

Month	Age 75 years or more			
	Excess deaths (n)	Excess deaths per 100,000 (n)	Relative excess death	
			%	95% CI
Mar-2020	-65	-190.2	-5.9	-9.6, -2.4
Apr-2020	-147	-433.8	-13.6	-17.5, -9.7
May-2020	-60	-178.3	-5.8	-9.7, -1.7
Jun-2020	-61	-182.1	-6.1	-9.9, -2.2
Jul-2020	33	99.4	3.4	-0.5, 7.4
Aug-2020	94	285.3	9.7	5.9, 13.5
Sep-2020	-37	-112.9	-3.8	-7.7, 0.1
Oct-2020	119	365.7	12.1	8.2, 15.9
Nov-2020	189	586.5	19.4	15.5, 23.2
Dec-2020	336	1,057.7	35.5	31.6, 39.4
Jan-2021	393	1,253.2	42.8	39.0, 46.5
Feb-2021	203	654.4	23.0	19.1, 27
Mar-2021	258	838.9	30.8	27.0, 34.6
Apr-2021	254	838.4	31.9	28.1, 35.8
May-2021	305	1,020.2	39.2	35.2, 43.1
Jun-2021	294	999.6	37.8	34.1, 41.6
Jul-2021	369	1,282.1	47.2	43.2, 51.2
Aug-2021	346	1,226.5	44.1	40.3, 48
Sep-2021	392	1,416.5	50.4	46.5, 54.2
Oct-2021	410	1,513.2	53.8	49.9, 57.6
Nov-2021	380	1,433.3	50.7	46.8, 54.3
Dec-2021	545	2,116.7	73.8	70.1, 77.8
Jan-2022	337	1,313.9	45.6	41.8, 49.3
Feb-2022	52	202.4	7.1	3.2, 10.9
Mar-2022	267	1,037.7	38.3	34.4, 42.1
Apr-2022	424	1,659.1	64.0	60.2, 67.7
May-2022	248	967.8	38.1	34.3, 42.1
Jun-2022	104	404.1	15.7	12.1, 19.6
Jul-2022	112	434.2	16.4	12.4, 20.2
Aug-2022	61	236.7	8.7	4.9, 12.6
Overall	6,155	20,534.8	24.5	19.8, 29.4

