Title: Population-level impact of diabetes integrated care on payments for inpatient care among people with type 2 diabetes in Cambridgeshire

Authors: Dahai Yu [1,2], Wei Yang [1,3] , Yamei Cai [1], Zhanzheng Zhao [1*], David Simmons [4*]

1. Department of Nephrology, the First Affiliated Hospital, Zhengzhou University, Zhengzhou 450052, China

2. Arthritis Research UK Primary Care Centre, Research Institute for Primary Care & Health Sciences, Keele University, Keele ST5 5BG, UK

3. School of Medicine, Washington University in St Louis, 660 S Euclid Ave, St. Louis, MO 63110, United States

4. Western Sydney University, Campbelltown, Sydney NSW 2751, Australia

***Correspondence 1 (China):**
Professor Zhanzheng Zhao, Department of Nephrology, The First Affiliated Hospital
Zhengzhou University, Zhengzhou 450052, CHINA
Email: zhanzhengzhao@zzu.edu.cn
TEL:+86 139 3852 5666
FAX:+86 371 6698 8753

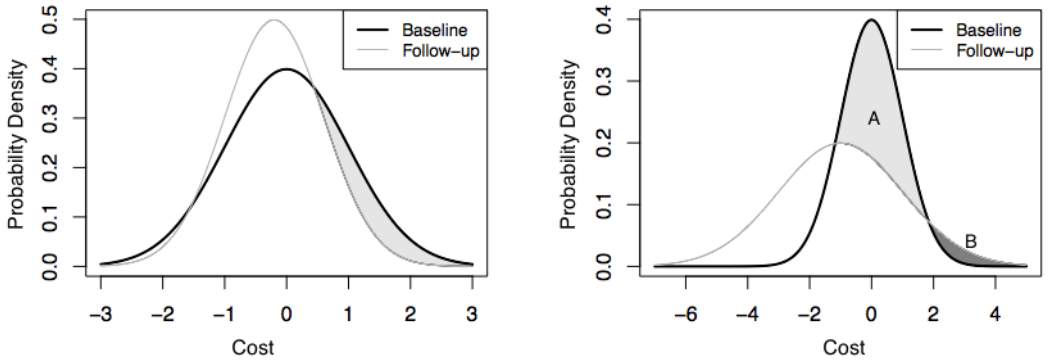
***Correspondence 2 (Australia):**
Professor David Simmons, Macarthur Clinical School, School of Medicine, Western Sydney University, Locked Bag 1797, Campbelltown NSW 2751, AUSTRALIA
Email: dsworkster@gmail.com
TEL: (61+2) 4620 3899
FAX: (61+2) 4620 3890

Online supplemental Technical Appendix

Estimating intervention impact, and confidence interval estimation

Sarkadi et. al. described a method to assess the population-level impact of interventions using normal distributions to approximate the actual data. After estimating the mean and standard deviation for the normal distributions before and after intervention, the "health gain" is defined as the area between the two distribution curves on the right side, where the distribution density after intervention is lower (the shaded area in supplemental Figure 1 below).

Online supplemental Figure 1. Normal distribution curves.



To estimate the confidence interval, Sarkadi et. al. proposed to start from estimating the confidence intervals of mean and standard deviation for the two normal distributions. The point estimation of the mean for the baseline is μ_1, and the lower and higher bounds of the confidence interval at a certain level (for example, 95% confidence interval) are μ_{1min} and μ_{1max}, respectively; the estimation of standard deviation at baseline is σ_1, and the two bounds of confidence interval are σ_{1min} and σ_{1max}. Similarly, for the follow-up data, point estimations are μ_2 and σ_2, and the confidence bounds for them as μ_{2min}, μ_{2max}, and σ_{2min}, σ_{2max}. Denote the health gain as a function of the parameters for the two normal distributions as F (μ_1, σ_1,,μ_2,σ_2). Sarkadi et. al. get the lower and higher bounds of confidence interval for the health gain as MIN(F (μ_{1min}, σ_{1max},,μ_2,σ_2), F (μ_1, σ_1,,μ_{2min},σ_{2max})), and MAX(F (μ_{1max}, σ_{1min},,μ_2,σ_2), F (μ_1, σ_1,,μ_{2max},σ_{2min})).

Modification of the impact estimation

There are a few situations where the original estimation algorithm is ambiguous.

When using real data to estimate parameters for the two normal distributions, it is unlikely that the two curves have the same standard deviation. In this case, the two curves will have to crossover points.

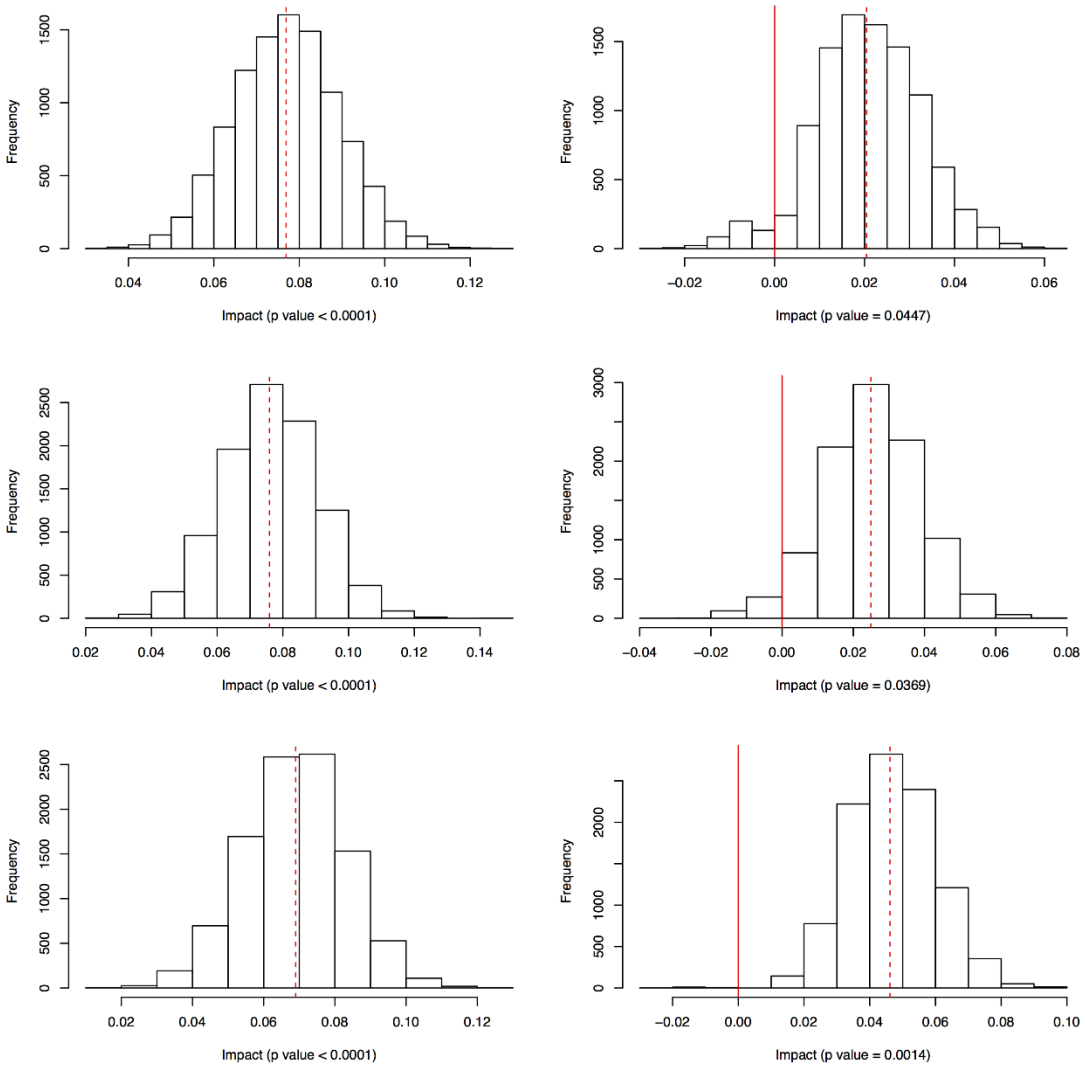
(1) If the two distributions are shown as in the left graph in Supplemental Figure 1, where the density of the follow-up is always lower compared to the baseline when observed data is larger than the larger of the two crossover points, it is easy to get the health gain estimation as the shaded area.

(2) However, if the situation is as in the right graph in Supplemental Figure 1, where the density of follow-up is only lower compared to the baseline in the region between the two crossover points, the original method has failed to make a clear definition of the health gain. Here, we will define it as the difference of the two shaded areas A and B.
(3) The original method only discussed the case where the estimated mean after intervention is no larger than that of the baseline. We need to define health gain estimation even though this is not true, so that we can have negative estimations when calculating confidence intervals. If the estimated mean after intervention increases, we switch the places of the two curves to estimate a positive health gain as previously, and then put a negative sign to this value and take it as the negative health gain.

Online supplemental Figure 2. The health gain (impact) distribution

The health gain (impact) was defined as percentage of people with type 2 diabetes and hospital admission having reduced inpatient payment after the 3 year integrated care at population level. Distributions of the impact were approximated by bootstrapping. Subjects and their associated inpatient payment were selected by random resampling with replacement from the original data for 10000 times, and the impact was calculated in each resampled dataset. Dashed red line shows the impact in original data. Bootstrap p value was calculated by comparing the impact estimated in the resampled data to 0 (indicated by the solid red line; null hypothesis H0: impact<=0, and alternative hypothesis H1: impact>0; P = [Percentage with impact <= 0]).

Left top: East Cambridge and Fenland, <70 years; right top: East Cambridge and Fenland, ≥70 years;
Left middle: Great Cambridge, <70 years; right middle: Great Cambridge, ≥70 years;
Left bottom: Huntingdonshire, <70 years; right bottom: Huntingdonshire, ≥70 years.



Online supplemental Table 1. Goodness-of-fit statistics for Normal, Gamma, and log-normal distribution

		Normal distribution (log transformed inpatient payment)	Gamma distribution	Log Normal distribution	Normal distribution
		AIC			
East Cambridge and Fenland, 2008-2009	< 70 years	4138.08	4649.35	4413.18	5757.95
	≥70 years	4792.04	5639.68	5494.05	6648.18
East Cambridge and Fenland, 2011-2012	< 70 years	5125.91	5195.19	4799.82	6792.39
	≥70 years	6555.80	7541.19	7287.31	9014.41
Huntingdonshire, 2008-2009	< 70 years	3088.09	3592.87	3350.03	4603.81
	≥70 years	3063.47	3475.19	3319.11	4247.04
Huntingdonshire, 2011-2012	< 70 years	3910.41	4434.23	4070.55	5843.54
	≥70 years	4335.50	4634.40	4371.58	5835.11
Greater Cambridge, 2008-2009	< 70 years	2987.32	3506.21	3376.34	4203.61
	≥70 years	3739.02	4733.66	4663.78	5406.49
Greater Cambridge, 2011-2012	< 70 years	3647.87	4031.53	3784.87	5082.50
	≥70 years	4398.30	5438.64	5317.42	6307.03
		BIC			
East Cambridge and Fenland, 2008-2009	< 70 years	4149.13	4660.40	4424.23	5769.00
	≥70 years	4803.20	5650.85	5505.21	6659.34
East Cambridge and Fenland, 2011-2012	< 70 years	5137.38	5206.66	4811.29	6803.86
	≥70 years	6567.57	7552.96	7299.08	9026.18
Huntingdonshire, 2008-2009	< 70 years	3398.76	3603.54	3360.70	4614.48
	≥70 years	3073.81	3485.52	3329.44	4257.37
Huntingdonshire, 2011-2012	< 70 years	3921.50	4445.39	4081.71	5854.70
	≥70 years	4346.46	4645.37	4382.55	5846.08
Greater Cambridge, 2008-2009	< 70 years	2997.81	3516.70	3386.83	4214.09
	≥70 years	3749.75	4744.38	4674.50	5417.21
Greater Cambridge, 2011-2012	< 70 years	3658.76	4042.44	3795.77	5093.41
	≥70 years	4409.37	5449.71	5328.49	6318.10

		Log likelihood			
Overall					
East Cambridge and Fenland, 2008-2009	< 70 years	-2067.04	-2322.67	-2204.59	-2876.97
	≥70 years	-2394.02	-2817.84	-2745.02	-3322.09
East Cambridge and Fenland, 2011-2012	< 70 years	-2560.95	-2595.59	-2397.91	-3394.19
	≥70 years	-3275.90	-3768.59	-3641.66	-4505.20
Huntingdonshire, 2008-2009	< 70 years	-1692.05	-1794.44	-1673.01	-2299.90
	≥70 years	-1529.74	-1735.59	-1657.55	-2121.52
Huntingdonshire, 2011-2012	< 70 years	-1953.21	-2215.12	-2033.28	-2919.77
	≥70 years	-2165.75	-2315.20	-2183.79	-2915.56
Greater Cambridge, 2008-2009	< 70 years	-1491.66	-1751.11	-1686.17	-2099.80
	≥70 years	-1867.51	-2364.83	-2329.89	-2701.24
Greater Cambridge, 2011-2012	< 70 years	-1821.93	-2013.77	-1890.43	-2539.25
	≥70 years	-2197.15	-2717.32	-2656.71	-3151.51

AIC, Akaike information criterion; *BIC,* Bayesian information criterion.

Online supplemental Table 2. The estimated absolute 'health gain (impact)' after the intervention by age and region: estimation based on Normal-distribution

		Impact, %	95% confidence interval, %	P value (bootstrapping)
East Cambridge and Fenland	< 70 years	1.58	(-1.91, 4.88)	0.051948
	≥70 years	2.74	(1.29 , 5.81)	0.014985
Huntingdonshire	< 70 years	1.83	(-2.44, 5.87)	0.220779
	≥70 years	-2.06	(-5.54, 3.79)	0.737263
Greater Cambridge	< 70 years	3.20	(1.77, 7.20)	0.004995
	≥70 years	4.14	(2.27, 7.86)	0.000999

The health gain (impact) was defined as percentage of people with type 2 diabetes and hospital admission having reduced inpatient payment after the integrated care at population level.