

Supplementary Material

The treatment gap for deep brain stimulation in Parkinson's disease: a comparative analysis of cost and utilisation in high-income countries

Athena Stein^{A,B,*} (PhD, MPH, FHEA, Postdoctoral Researcher), *Nathan Higgins*^C (BSc, PhD Candidate), *Mehul Gajwani*^C (MD, PhD Candidate) and *Christian A. Gericke*^{A,D} (MD, PhD, MPH (Cantab), MSc, MBA FRACP, FAFPHM, Conjoint Professor of Medicine, Neurologist, Honorary Professor of Public Health)

^ASchool of Public Health, The University of Queensland, Herston, Qld, Australia

^BThe University of Queensland Child Health Research Centre, South Brisbane, Qld, Australia

^CThe Turner Institute for Brain and Mental Health and Monash Biomedical Imaging, Monash University, Clayton, Vic, Australia

^DSchool of Medicine and Public Health, The University of Newcastle, Callaghan, NSW, Australia

*Correspondence to: Email: a.stein@uq.edu.au

Supplementary Methods

Supplementary Table S1: Sources of cost data and regulatory information

Country	Reference	Hardware cost source	Hardware manufacturer & model	FDA approval date for use in PD
Germany	Meissner et al. (2005) ¹	Manufacturer price list 2004	Medtronic Kinetra® (7428) primary cell (PC) dual program neurostimulator	December 2003 (PMA P960009 S027)
Australia	MSAC application 1092 (2006) ²	Manufacturer price list 2006		
Canada	Ng (2013) ³	Manufacturer price list 2012		
France	Perez et al. (2017) ⁴	Official French National Price List 2012 ¹	Medtronic Activa® PC (37601) primary cell dual program neurostimulator	April 2009 (PMA P960009 S052)
United Kingdom	Eggington et al. (2014) ⁵	Manufacturer price list 2010		
United States	Hitti et al. (2019) ⁶	Cost incurred per patient by the treating Hospital between 2011 - 2014 ²		
Spain	Valdeoriola et al. (2013) ⁷	Manufacturer price list 2010		
Hong Kong	Zhu et al. (2014) ⁸	Cost incurred per patient by the treating Hospital between 2009 - 2011 ³	Not specified	
Japan	Kawamoto et al. (2016) ⁹	Costs incurred per patient by the public healthcare system in 2014		
Korea	Moon et al. (2017) ¹⁰	Manufacturer price list 2016		

1. Via (Australian Medical Services Advisory Committee (MSAC))
2. The Official National Price List in France is a comprehensive list of prices set by the French government for various goods and services. This list is used as a reference for pricing and is updated regularly to reflect changes in the market and the cost of goods and services. The list includes prices for a wide range of products, including but not limited to prescription drugs, medical devices, and other healthcare products.

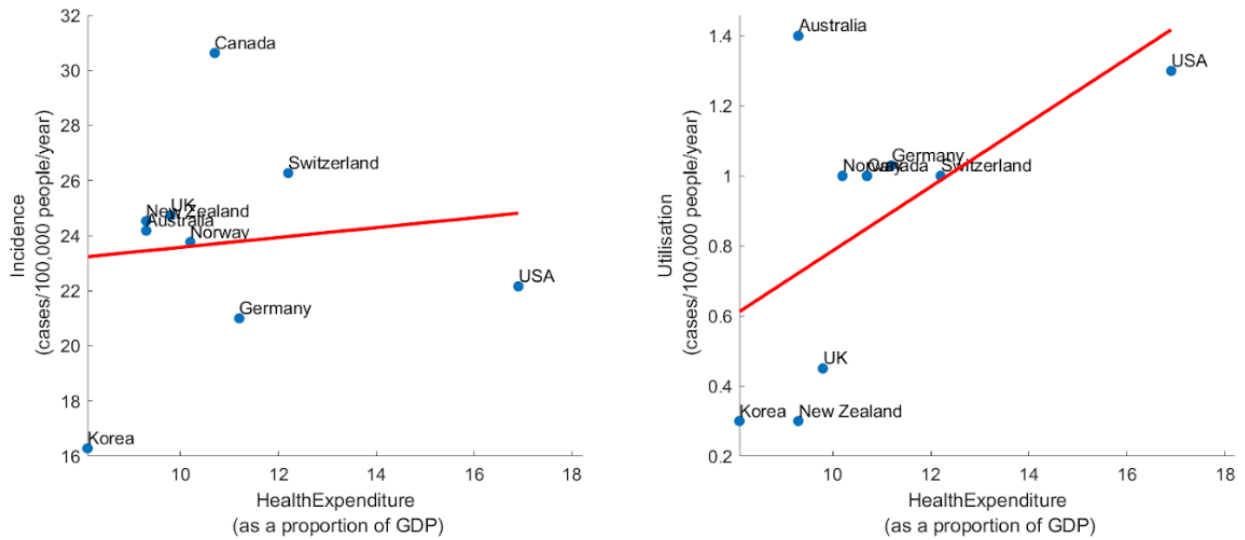
3. Prince of Wales Hospital, Chinese University of Hong Kong, Hong Kong Department of Neurosurgery, Pennsylvania Hospital, University of Pennsylvania

Supplementary Table S2. Summary of data used in analysis

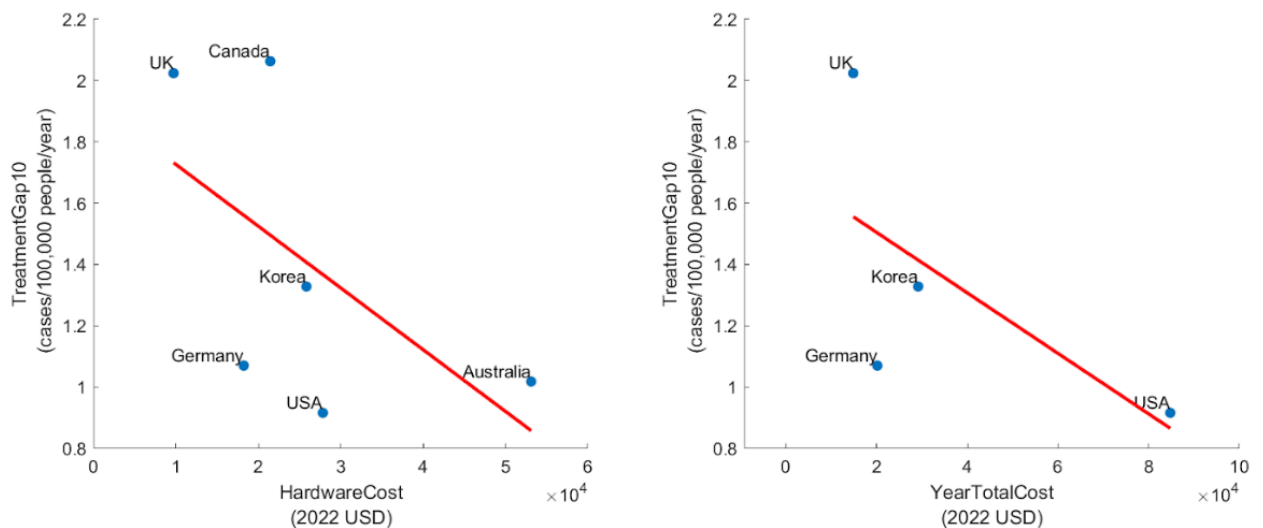
Country	Incidence (new cases/100,000 population/year)	Utilisation rate (DBS surgeries/100,000 population/year)	Uptake Rate (DBS surgeries/new case)*	Treatment Gap (if 10% eligible)	Hardware Cost (2022 USD\$ equivalent)	Year Total Cost (2022 USD\$ equivalent)	Health Expenditure (% of GDP)
Australia	24.18	1.4 ¹¹	5.78990902	1.018	53122.61082		9.27
Canada	30.63	1 ¹²	3.2647731	2.063	21461.93677		10.84
France					14061.93215	59715.72729	11.33
Germany	21	1.03 ¹³	4.9047619	1.07	18242.8804	20156.6574	11.33
Hong Kong					27510.666	23517.88101	
Japan					32194.94049	47341.12732	10.66
Korea	16.28	0.3 ¹⁴	1.84275184	1.328	25840.83025	29159.69237	7.11
Netherlands					21347.73623	44960.21462	10.11
New Zealand	24.53	0.3 ¹⁵	1.22299225	2.153			9.02
Norway	23.77	1 ¹⁶	4.20698359	1.377			10.32
Spain					20728.46412		8.96
Switzerland	26.27	1 ¹⁷	3.80662352	1.627			11.48
UK	24.74	0.45 ¹⁸	1.81891673	2.024	9717.507688	14846.20162	9.81
USA	22.16	1.3 ¹⁹	5.86642599	0.916	27841.22705	84756.00157	16.81

* Reflects the ratio of utilization of DBS to incidence of PD

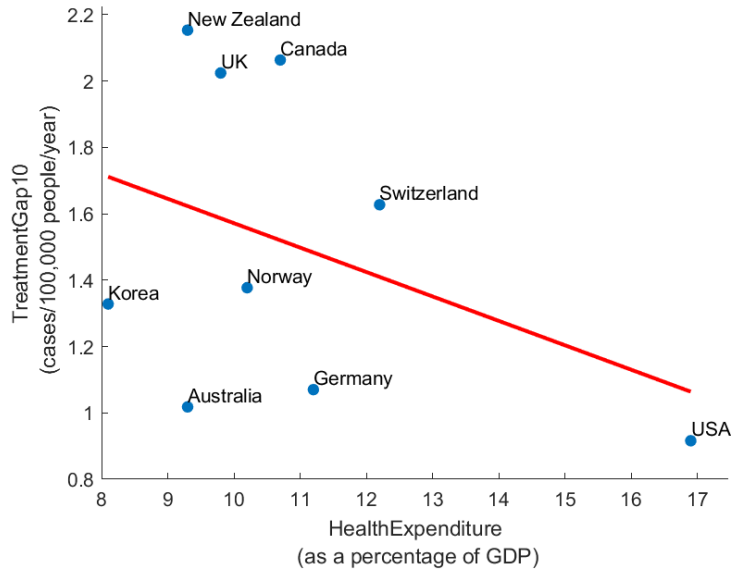
Supplementary Results



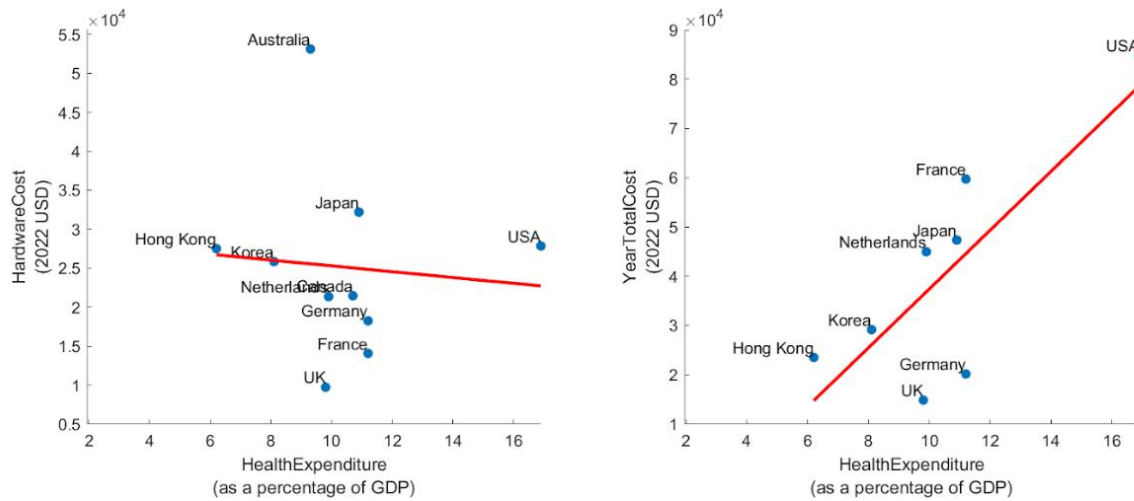
Supplementary Figure S1. The relationship between PD incidence and health expenditure in nine high-income countries. (A) The relationship between incidence of PD and health expenditure as a proportion of GDP. The solid line shows the mean trend across the nine countries ($r^2 = 0.03$). (B) The relationship between utilisation of DBS for PD and health expenditure as a proportion of GDP ($r^2 = 0.38$).



Supplementary Figure S2. Treatment gap for DBS is negatively correlated with cost. (A) The relationship between treatment gap and cost of DBS hardware. The solid line shows the mean trend ($r^2 = 0.33$). (B) The relationship between treatment gap and cost of DBS hardware ($r^2 = 0.42$).



Supplementary Figure S3. Treatment gap of DBS for PD is negatively correlated with national healthcare expenditure. The solid line shows the mean trend across the nine countries ($r^2 = 0.14$).



Supplementary Figure S4. The relationship between national healthcare expenditure and cost of DBS. (A) Hardware cost ($r^2 = 0.00$). (B) Total surgical cost after 1 year ($r^2 = 0.58$).

Supplementary References

1. Meissner W, Schreiter D, Volkmann J, et al. Deep brain stimulation in late stage Parkinson's disease: A retrospective cost analysis in Germany. *J Neurol* 2005; 252: 218-223. DOI: 10.1007/s00415-005-0640-3.
2. Medical Services Advisory Committee. Deep brain stimulation for the symptoms of Parkinson's disease. In: Department of Health and Ageing, (ed.). Canberra: Commonwealth of Australia, 2006.
3. Dahm J, Wong D and Ponsford J. Validity of the Depression Anxiety Stress Scales in assessing depression and anxiety following traumatic brain injury. *Journal of Affective Disorders* 2013; 151: 392-396.
4. Perez J, Gonzalez V, Cif L, et al. Rechargeable or nonrechargeable deep brain stimulation in dystonia: A cost analysis. *Neuromodulation* 2017; 20: 243-247.
5. Eggington S, Valldeoriola F, Chaudhuri KR, et al. The cost-effectiveness of deep brain stimulation in combination with best medical therapy, versus best medical therapy alone, in advanced Parkinson's disease. *J Neurol* 2014; 261: 106-116.
6. Hitti FL, Ramayya AG, McShane BJ, et al. Long-term outcomes following deep brain stimulation for Parkinson's disease. *J Neurosurg* 2019; 132: 205-210.
7. Valldeoriola F, Puig-Junoy J, Puig-Peiró R and study WotS. Cost analysis of the treatments for patients with advanced Parkinson's disease: SCOPE study. *Journal of medical economics* 2013; 16: 191-201.
8. Zhu X, Chan DT, Lau CK, et al. Cost-effectiveness of subthalamic nucleus deep brain stimulation for the treatment of advanced Parkinson disease in Hong Kong: A prospective study. *World Neurosurg* 2014; 82: 987-993.
9. Kawamoto Y, Mouri M, Taira T, et al. Cost-effectiveness analysis of deep brain stimulation in patients with Parkinson's disease in Japan. *World Neurosurg* 2016; 89: 628-635.
10. Moon W, Kim SN, Park S, et al. The cost-effectiveness of deep brain stimulation for patients with treatment-resistant obsessive-compulsive disorder. *Medicine* 2017; 96.
11. Poortvliet P, Silburn PA, Coyne T and Chenery H. Deep brain stimulation for Parkinson's disease in Australia: Current scientific and clinical status. *Intern Med J* 2015; 45: 134-139.
12. Honey CM, Malhotra AK, Tamber MS, et al. Canadian assessment of deep brain stimulation access: The Canada study. *Can J Neurol Sci* 2018; 45: 553-558.
13. Richter D, Bartig D, Jost W, et al. Dynamics of device-based treatments for Parkinson's disease in Germany from 2010 to 2017: application of continuous subcutaneous apomorphine, levodopa-carbidopa intestinal gel, and deep brain stimulation. *Journal of Neural Transmission* 2019; 126: 879-888.
14. Lee J-I. The current status of deep brain stimulation for the treatment of Parkinson's disease in the Republic of Korea. *J Mov Disord* 2015; 8: 115.
15. New Zealand Ministry of Health. Assessment of the Business Case for a Deep Brain Stimulation Neurosurgical Programme for Movement Disorders. In: (NZ) MoH, (ed.). Wellington, New Zealand 2008.
16. Ezat B, Pihlstrøm L, Aasly J, et al. Use of advanced therapies for Parkinson's disease in Norway. *Tidsskrift for den Norske laegeforening: tidsskrift for praktisk medicin, ny raeke* 2017; 137: 619-623.
17. Christen M and Müller S. Current status and future challenges of deep brain stimulation in Switzerland. *Swiss Med Wkly* 2012; 142.

18. DeSouza R, Akram H, Low H, et al. The timing of deep brain stimulation for Parkinson's disease in the UK from 1997 to 2012. *Eur J Neurol* 2015; 22: 1415-1417.
19. Pilitsis JG, Burrows A, Peters ML, et al. Changing practice patterns of deep brain stimulation in Parkinson's disease and essential tremor in the USA. *Stereotact Funct Neurosurg* 2012; 90: 25-29.