Empirical estimation of the optimal time period under potentially protective effect of GP care

Study population

A total of 29 007 individuals were identified with diabetes by 1 July 2009. We then excluded those who died within two-year after the baseline year (2009) (n=2 310, 7.9%) to allow a minimum of two-year follow-up for every individual. Individuals who did not have any hospitalisation and general practitioner encounter in the whole studied period from 1 July 2009 to 30 June 2016 were also excluded (n=95, 0.3 %). Finally, we excluded a small number (n=1 728, 6.0 %) of individuals without details of age, sex, and/or socioeconomic characteristics. A total of 24874 individuals were included in models search for estimation of the optimal time period under GP cover.

The study population were stratified into three cohorts (i) individuals with no complications of diabetes, (ii) those with one or two complications of diabetes and (iii) those with three or more complications of diabetes to account for disease severity levels (1). The data in each complication cohort were constructed in a panel structure with annual measures of the main outcome, predictor and covariate over the period between 2009/2010 to 2015/2016 financial years

Outcome measures

The outcome measure was the number of diabetes related hospitalisations within each financial year, identified using ICD-10-AM codes suggested by the National Health Performance Framework (2) and hospitalisation where diabetes was identified as a significant risk factor (3). The hospitalisations were excluded routine hospitalisations for kidney dialysis and inter-hospital transfers were counted as a single episode of care.

Main predictor: Maximum time interval between GP contacts

For each individual, the date of GP services within a financial year was identified in MBS data. The time between GP visits was determined by number of days: (1) between GP visits within a financial year and; (2) between the date of first GP visit of a financial year and the date of the last GP visit in the previous financial year(s) looking back up to 3 financial years. In the case where a hospitalisation

was observed, time was counted either to the first GP visit post-hospitalisation provided that the GP visit was within 14 days of discharge or from day 14 after hospital discharge date and the next GP visit (4). This rule was based on the previous study which indicates 14 day period after discharge as the period with a low risk of readmission (5). Among multiple time intervals between GP contacts in a financial, the maximum time interval was selected for further analysis.

Other covariates: demographic and socio-demographic characteristics at the baseline and average time interval between GP visits, GP regularity, GP frequency and GP continuity provider index, history of diabetes related hospitalisations, comorbidities at each financial year were included in the analyses.

Threshold effect models

Threshold effect based on random effects negative binomial models were conducted to identify the optimal maximum time interval to GP visit in which the number of diabetes related hospitalisations were minimal for each complication cohort. This approach was proposed by Gannon, Harris (6) and applied previously (1, 7). Briefly, the model searched for subpopulations in which the association between diabetes related hospitalisations and the maximum time interval between GP visits was homogeneous and used information criteria Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) to select the optimal model. The threshold effects models were specified with (1) all the observed covariates; (2) lag1 of GP utilisation including frequency of GP contacts and regularity of GP contact, (3) Mundlak variables, (group means of time-varying variables including frequency of GP contact, regularity of GP contact and comorbidities) to allow for arbitrary correlation between observed and unobserved heterogeneity terms in the model (8, 9) and (4) the initial condition – history of diabetes-related hospitalisations at the baseline year – was also included to allow for any endogeneity arising from the dynamic set-up of the approach (10). The optimal maximum time intervals identified from the threshold effect models in each cohort were presented at the Table 1A and were used to calculate the Cover Index which is defined as the proportion of

time in a financial year people with diabetes were under cover of primary care (via their GP) as previously described above.

Results of threshold effects models

Table 1A shows the results of threshold effect models for each complication cohorts including no complication, one/two complication and three or more complication cohorts. Based on the BIC and the AIC, the preferred models indicated 3 subpopulations for both non-complication and one/two complication cohorts and five sub-populations for three or more complications cohort. The optimal maximum time interval estimated from the threshold effect models was 13 months (Coef. -0.027) for diabetes with no complications, 8 months (Coef. -0.05) for diabetes with 1-2 complications and 6 months (Coef. -0.05) for 3+ complications. Those optimal time intervals were considered as the time interval under GP cover corresponding to individuals' complication level and used to calculate the Cover Index.

Table 1A. Threshold search for the optimal maximum time interval to GP visits by complication cohorts for people aged 45 years and older

Complication cohorts	**No complication**					**1-2 complications**					**3+ complications**					
Models	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Number of subpopulations	**1**	**2**	**3**	**4**	**36**	**1**	**2**	3	**4**	**36**	**1**	**2**	**3**	**4**	5	**36**
AIC	35681.7	35627.9	35603.5	35596.9	35618.1	34824.4	34759.4	34746.5	34742.5	34779.9	70216.6	69935.6	69867.8	69837.5	69832.7	69853.7
BIC	35951.6	35915.7	35900.3	35902.7	36211.7	35084.9	35037.4	35033.1	35037.8	35335.7	70483.6	70220.4	70161.5	70140.1	70144.2	70423.4
Threshold parameters (months)																
τ_1	-	13	1	1	-	-	1	1	1	-	-	1	1	1	1	-
τ_2	-	-	13	6	-	-	-	8	2	-	-	-	2	2	2	-
τ_3	-	-	-	16	-	-	-	-	8	-	-	-	-	20	6	-
τ_4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	20	-
τ_5	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-
Coefficients																
γ_1	-	-0.046**	0.387***	0.288**	-	-	0.445***	0.347***	0.470***	-	-	0.394***	0.690***	0.595***	0.489***	-
γ_2	-	0.068***	-0.027	-0.071**	-	-	-0.003	-0.050*	0.028	-	-	-0.030*	0.146***	0.097***	0.043	-
γ_3	-		0.073***	-0.030	-	-	-	0.021	-0.031	-	-	-	0.013	-0.021	-0.055**	-
γ_4	-		-	0.073***	-	-	-	-	0.028	-	-	-		0.088***	-0.022	-
γ_5	-		-	-	-	-	-	-		-	-	-	-		0.084***	-

*Note: * indicate p-values with * is p-value <0.05; ** is p-value <0.01; *** is p-value <0.001*

The cover index calculation

The Cover Index was calculated for each financial year (ie 1 July to 30 June) ascertained from the number of days within each year that the individual remained alive and not in hospital (i.e., was living in the community and therefore eligible for a GP visit). The annual number of days under GP cover was the number of days following each GP visit that were within the defined optimal maximum time interval with special consideration given to the start of each year and time following a hospitalisation, as follows. For the start of each year the days from the last GP visit in the preceding year that were within the optimal maximum time period and fell within the financial year of interest were counted. Following a hospitalisation, determination of cover re-started on the earliest of either the 15th day post-separation date or the date of the first GP visit.

1. Ha NT, Harris M, Robinson S, Preen D, Moorin R. Stratification strategy for evaluating the influence of diabetes complication severity index on the risk of hospitalization: a record linkage data in Western Australia. J Diabetes Complications. 2017;31(7):1175-80.
2. AIHW. A set of performance indicators across the health and aged care system. Canberra: Australian Institute of Health and Welfare; 2008.
3. Davis WA, Knuiman MW, Hendrie D, Davis TM. Determinants of diabetes-attributable non-blood glucose-lowering medication costs in type 2 diabetes: the Fremantle Diabetes Study. Diabetes Care. 2005;28(2):329-36.
4. Ha NT, Harris M, Preen D, Robinson S, Moorin R. A time-duration measure of continuity of care to optimise utilisation of primary health care: a threshold effects approach among people with diabetes. BMC Health Services Research. 2019;19(1):276.
5. Jackson C, Shahsahebi M, Wedlake T, DuBard CA. Timeliness of outpatient follow-up: an evidence-based approach for planning after hospital discharge. Annals of family medicine. 2015;13(2):115-22.
6. Gannon B, Harris D, Harris M. Threshold effects in nonlinear models with an application to the social capital-retirement health relationship Health Economics. 2014;23(9):1072-83.
7. Gannon B, Harris D, Harris M, Magnusson L, hollingsworth B, Lnder B, et al. New approaches to estimating the child health-patental income relationship Economics Discussion 2015;15-31.
8. Chamberlain G. Multivariate regression models for panel data. Journal of Econometrics. 1982;18(1):5-46.
9. Mundlak Y. On the Pooling of Time Series and Cross Section Data. Econometrica. 1978;46(1):69-85.
10. Wooldridge JM. Simple solutions to the initial conditions problem in dynamic, nonlinear panel data models with unobserved heterogeneity. Journal of Applied Econometrics. 2005;20(1):39-54.