

[研究議題：Assessing the Relationship Between the Variability of Diagnostic Measures and the Risk of Diabetic complications]

1 大綱:

- 1.1 目的
- 1.2 資料來源與疾病定義
- 1.3 資料處理流程
- 1.4 分析方法
- 1.5 分析結果
- 1.6 結論與討論

2 目的: 評估檢驗項目的變異性與糖尿病併發症風險的關係

- 2.1 參考論文: Predictions of diabetes complications and mortality using hba1c variability: a 10-year observational cohort study

3 資料來源與疾病定義:

- 3.1 資料集: 三院臨床資料庫
- 3.2 目標病患: 糖尿病患者
- 3.3 資料區間: 2008-2019
- 3.4 檢樣項目: HbA1c, ALBUMIN, Uric Acid, HDL, LDL, Creatinine
- 3.5 糖尿病相關併發症和共病列表:

類別	疾病名稱
併發症	Eye complications 眼部疾病
	Cardiovascular disease 心血管疾病
	Cerebrovascular disease 腦血管疾病
	Peripheral vascular disease 周邊動脈疾病
	Nephropathy 腎臟病
	Diabetic neuropathy 神經病變
共病 目前 19 種	Essential hypertension 本態性高血壓
	Peripheral enthesopathies and allied syndromes
	外周附著點病變及其相關聯症候群的疾病
	Other ill-defined and unknown causes of morbidity and mortality 定義不明和未知原因的發病和死亡

Disorders of lipid metabolism 脂蛋白的代謝異常
Acute upper respiratory infections of multiple or unspecified sites 多部位或未明確部位的急性上呼吸道感染
Other symptoms involving abdomen and pelvis 腹部和骨盆的其他症狀
Dermatophytosis 真菌引起的皮膚感染
General symptoms 非特定的身體症狀
Symptoms involving respiratory system and other chest symptoms 呼吸系統和其他胸部症狀
Symptoms involving head and neck 頭部和頸部的症狀
Contact dermatitis and other eczema 皮膚疾病
Viral infection in conditions classified elsewhere and of unspecified site 病毒引起的感染
Overweight, obesity and other hyperalimentation 超重, 肥胖及其他過度營養狀態
Other and unspecified disorders of joint 未明確指定的關節疾病
Acute bronchitis and bronchiolitis 呼吸道疾病
Other disorders of soft tissues 其他軟組織的疾病
Nonspecific findings on examination of blood 血液檢查時發現的一些非特定性的異常或發現
Disorders of refraction and accommodation 屈光和調節的疾病
Disorders of conjunctiva 眼球表面覆蓋的結膜的各種疾病

3.6 糖尿病患者發病定義: 一年內有 3 次門診紀錄或 1 次住院紀錄為糖尿病患者

3.6.1 Index Date 定義: 符合條件下的首次看診日

3.7 併發症發病定義: 一年內有 3 次門診紀錄或 1 次住院紀錄

3.8 共病的發病定義: 糖尿病患者 Index_date 前一年內有 3 次門診紀錄或 1 次住院紀錄

3.9 ICD CODE:

3.9.1 糖尿病:

ICD9: 250, 251.8, 357.2, 362.01, 362.02, 366.41, 583.81

ICD10: E08, E09, E10, E11, E12

3.9.2 併發症:

糖尿病相關併發症	ICD CODE	操作定義
Eye complications 眼部疾病	ICD9: 362.01, 362.02, 362.55, 362.11, 365.44, 369, 361, 369.60 ICD10: H33.0, H33.10, H33.11, H33.19, H33.2, H33.3, H33.4, H33.8, E11.31, E11.32, E11.33, E11.34, E11.351, E11.359, H35.03, H35.38, H42, H54.0, H54.1, H54.2, H54.3, H54.8, H54.4, H54.5, H54.6, H54.7	一年內 3 次門診或 1 次住院
Cardiovascular disease 心血管疾病	ICD9: 414.9, 413.9, 411.1, 412, 428, 425, 402 ICD10: I11, I20.0, I20.8, I20.9, I25.2, I25.9, I42, I43, I50.1, I50.2, I50.3, I50.4, I50.9	
Cerebrovascular disease 腦血管疾病	ICD9: 435.9, 434.91, 432.9, 437.1 ICD10: I62.9, I63.50, I63.511, I63.512, I63.519, I63.521, I63.522, I63.529, I63.531, I63.532, I63.539, I63.541, I63.542, I63.549, I63.59, I63.8, I63.9, I67.84, I67.81, I67.82, I67.89, G45.9	
Peripheral vascular disease 周邊動脈疾病	ICD9: 440.2 ICD10: I70.2, I70.92, I75.01, I75.02	
Nephropathy 腎臟病	ICD9: 583, 585, V451 ICD10: E10.21, E11.21, N05.0, N05.1, N05.2, N05.3, N05.4, N05.5, N05.6, N05.7, N05.8, N05.9, N06.0, N06.1, N06.2, N06.3, N06.4, N06.5, N06.6, N06.7, N06.8, N06.9, N07.0, N07.1, N07.2, N07.3, N07.4, N07.5, N07.6, N07.7, N07.8, N07.9, N14, N15.0, N15.8, N15.9, N16, N17.1, N17.2, N18.4, N18.5, N18.6, N18.9	
Diabetic neuropathy 神經病變	ICD9: 357.2, 337.1, 353 ICD10: E08.42, E09.42, E10.40, E10.42, E11.40, E11.42, E13.42, G54, G55, G99.0	

3.9.3 共病:

糖尿病相關共病	ICD CODE	操作定義
Essential hypertension 本態性高血壓	ICD9: 401 ICD10: I10	一年內 3 次門診或 1 次住院
Peripheral enthesopathies and allied syndromes 外周附著點病變及其相關聯症候群的疾病	ICD9: 726 ICD10: M25.70, M25.71, M25.72, M25.73, M25.74, M25.75, M25.76, M25.77, M66.21, M66.81, M70.1, M70.2, M70.3, M70.4, M70.5, M70.6, M70.7, M75.0, M75.10, M75.11, M75.2, M75.3, M75.4, M75.5, M75.8, M75.9, M76, M77	
Other ill-defined and unknown causes of morbidity and mortality 定義不明和未知原因的發病和死亡	ICD9: 799 ICD10: R09.0, R09.2, R41.89, R44.8, R44.9, R45.0, R45.3, R45.4, R45.87, R45.89, R46, R53.81, R64, R68.13, R68.19, R68.82, R68.89, R69	
Disorders of lipid metabolism 脂蛋白的代謝異常	ICD9: 272 ICD10: E71.30, E75.21, E75.22, E75.24, E75.3, E75.5, E75.6, E77, E78.0, E78.1, E78.2, E78.3, E78.4, E78.5, E78.5, E78.6, E78.70, E78.79, E78.8, E78.9, E88.1, E88.2, E88.89	
Acute upper respiratory infections of multiple or unspecified sites 多部位或未明確部位的急性上呼吸道感染	ICD9: 465 ICD10: J06	
Other symptoms involving abdomen and pelvis 腹部和骨盆的其他症狀	ICD9: 724, 789 ICD10: M43.2, M43.8X9 M48.00, M48.04, M48.05, M48.06, M48.07, M48.08, M51.1, M53.2X7, M53.2X8, M53.3, M53.80, M53.84, M53.85, M53.86, M53.87, M53.88, M53.9, M54.03, M54.04, M54.05, M54.06, M54.07, M54.08, M54.09, M54.14, M54.15, M54.16, M54.17, M54.3, M54.4, M54.5, M54.6, M54.89, M54.9, M62.830,	

	M99.22, M99.23, M99.24, M99.25, M99.26, M99.27, M99.28, M99.29, M99.32, M99.33, M99.34, M99.35, M99.36, M99.37, M99.38, M99.39, M99.42, M99.43, M99.44, M99.45, M99.46, M99.47, M99.48, M99.49, M99.52, M99.53, M99.54, M99.55, M99.56, M99.57, M99.58, M99.59, M99.62, M99.63, M99.64, M99.65, M99.66, M99.67, M99.68, M99.69, M99.72, M99.73, M99.74, M99.75, M99.76, M99.77, M99.78, M99.79, R10, R16, R18.8, R19.0, R19.3, R19.8	
Dermatophytosis 真菌引起的皮膚感染	ICD9: 110 ICD9: B35	
General symptoms 非特定的身體症狀	ICD9: 780 ICD10: E03.5, F51.8, G40.909, G47.0, G47.1, G47.20, G47.3, G47.5, G47.61, G47.69, G47.8, G47.9, G93.3, L74.51, L74.52, R40.0, R40.1, R40.20, R40.211, R40.212, R40.221, R40.222, R40.231, R40.232, R40.234, R40.3, R40.4, R41.0, R41.1, R41.2, R41.3, R41.82, R41.89, R41.9, R42, R44.0, R44.2, R44.3, R45.83, R45.84, R50.2, R50.81, R50.9, R52, R53.0, R53.1, R53.8, R55, R56, R61, R68.0, R68.11, R68.12, R68.81, R68.83, R68.89	
Symptoms involving respiratory system and other chest symptoms 呼吸系統和其他胸部症狀	ICD9: 786 ICD10: R04.2, R04.8, R04.9, R05, R06.00, R06.01, R06.02, R06.09, R06.1, R06.2, R06.3, R06.3, R06.4, R06.6, R06.8, R06.9, R07.1, R07.2, R07.8, R07.9, R09.3, R09.89, R22.2, R91.8	
Symptoms involving head and neck 頭部和頸部的症狀	ICD9: 784 ICD10: G44.05, G44.09, G44.1, G44.3, G44.4, G44.52, G44.53, G44.59, G44.81, G44.82, G44.83, G44.84, G44.85, G44.89, R04.0, R04.1, R06.5, R06.7, R07.0, R19.6, R22.0, R22.1, R47.0, R47.1, R47.81, R47.89, R47.9, R48.0, R48.1, R48.2, R48.8, R48.9, R49, R51, R90.0	

Contact dermatitis and other eczema 皮膚疾病	ICD9: 692 ICD10: L23, L24.0, L24.1, L24.2, L24.3, L24.4, L24.5, L24.6, L24.7, L24.8, L24.9, L25, L30.0, L30.2, L30.8, L30.9, L55, L56, L57.1, L57.5, L57.8, L57.9, L58, L59	
Viral infection in conditions classified elsewhere and of unspecified site 病毒引起的感染	ICD9: 79 ICD10: B34.9, E07.81, E79.0, I45.81, N39.0, O28, P09, R03, R09.0, R09.2, R19.5, R29.2, R41.81, R41.89, R44.8, R44.9, R45.0, R45.3, R45.4, R45.87, R45.89, R46, R53.81, R54, R64, R68.13, R68.19, R68.82, R68.89, R69, R70, R71, R73.01, R73.02, R73.09, R73.9, R74, R75, R76, R77, R78, R79.0, R79.1, R79.81, R79.82, R79.89, R79.9, R80.0, R80.1, R80.3, R80.8, R80.9, R81, R82, R83, R84, R85, R86, R87, R88, R89, R90.8, R91.8, R92.0, R92.1, R92.2, R92.8, R93, R94, R97, R99	
Overweight, obesity and other hyperalimentation 超重, 肥胖及其他過度營養 狀態	ICD9: 278 ICD10: E65, E66.0, E66.1, E66.2, E66.8, E66.9, E67, E68	
Other and unspecified disorders of joint 未明確指定的關節疾病	ICD9: 719 ICD10: M12.2, M12.3, M12.4, M25.0, M25.1, M25.4, M25.50, M25.51, M25.52, M25.53, M25.55, M25.56, M25.57, M25.60, M25.61, M25.62, M25.63, M25.64, M25.65, M25.66, M25.67, M25.8, M25.9, M79.643, M79.646, R26.2, R29.4, R29.898	
Acute bronchitis and bronchiolitis 呼吸道疾病	ICD9: 466 ICD10: J20.8, J20.9, J21	
Other disorders of soft tissues 其他軟組織的疾病	ICD9: 729 ICD10: G47.62, M35.6, M54.10, M54.18, M60.8, M60.9, M70.8, M70.9, M72.9, M79, R25.2, R29.898	
Nonspecific findings on examination of blood	ICD9: 790	

血液檢查時發現的一些非特 定性的異常或發現	ICD10: B34.9, E07.81, E79.0, R70, R71, R73.01, R73.02, R73.09, R73.9, R74, R77, R78, R79.0, R79.1, R79.81, R79.82, R79.89, R79.9, R97.2	
Disorders of refraction and accommodation 屈光和調節的疾病	ICD9: 367 ICD10: H52	
Disorders of conjunctiva 眼球表面覆蓋的結膜的各種 疾病	ICD9: 372 ICD10: H10.0, H10.1, H10.2, H10.3, H10.4, H10.5, H10.81, H10.89, H10.9, H11	

4 資料處理流程:

4.1 病歷資料歸入

4.1.1 流程圖:

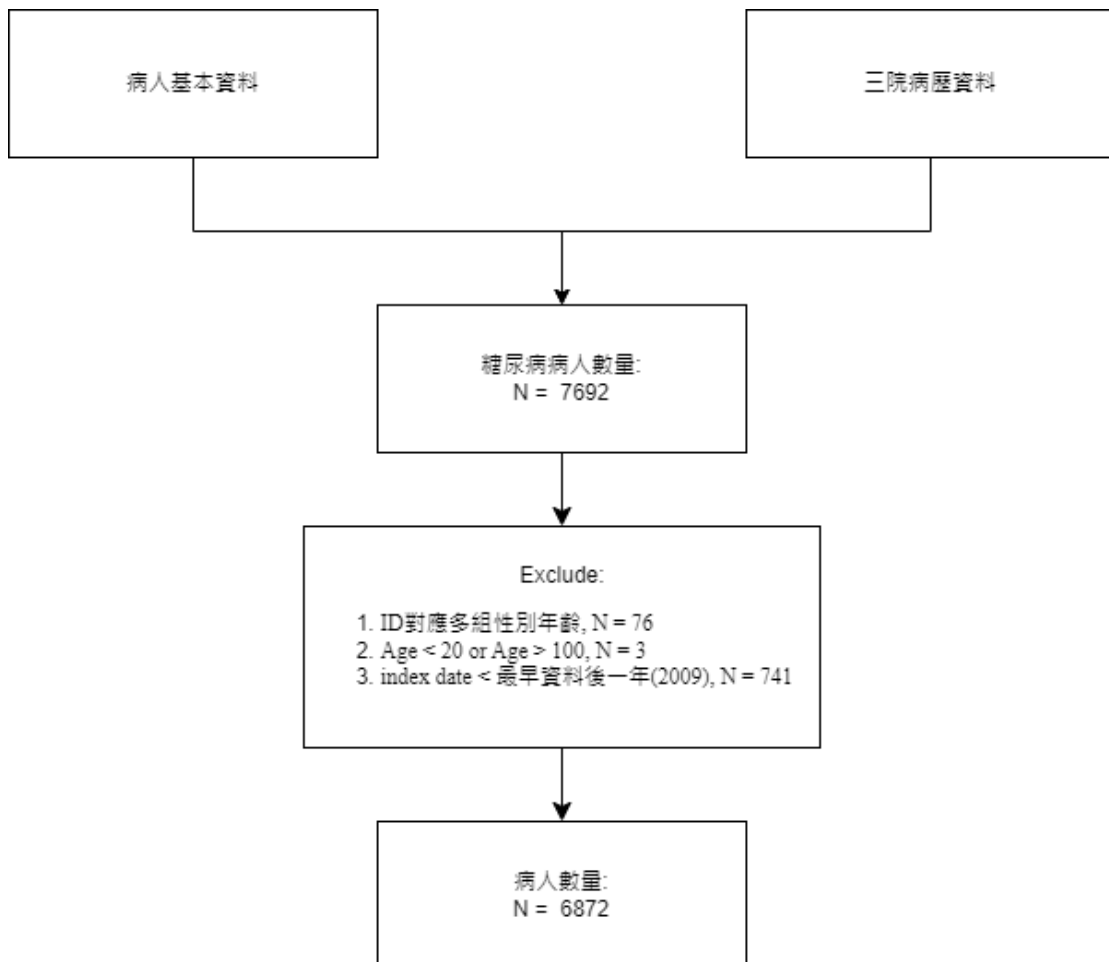


Table1. 糖尿病患者基線特徵分布

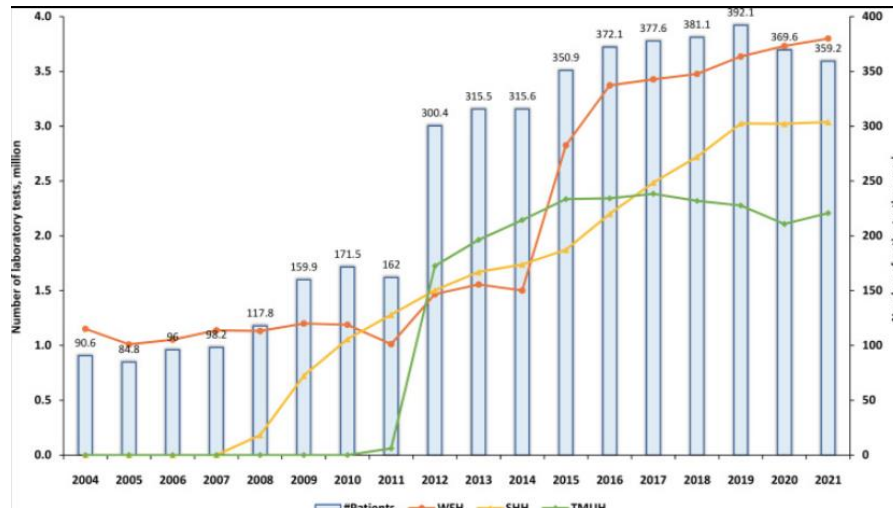
		overall(N=6872)
AGE		
	Mean(SD)	68.23(12.23)
	Median(IQR)	68.35(17.64)
	(Min, Max)	(21.63, 99.25)
AGE_GROUP		
	20-30	17(0.25%)
	30-40	71(1.03%)
	40-50	394(5.73%)
	50-60	1294(18.83%)
	60-70	1974(28.73%)
	70-80	1843(26.82%)
	80-90	1120(16.3%)
	90-100	159(2.31%)
Index_year		
	2009	309(4.5%)
	2010	294(4.28%)
	2011	653(9.5%)
	2012	889(12.94%)
	2013	568(8.27%)
	2014	456(6.64%)
	2015	1399(20.36%)
	2016	1026(14.93%)
	2017	620(9.02%)
	2018	467(6.8%)
	2019	191(2.78%)
SEX_TYPE		
	male	3823(55.63%)
	female	3049(44.37%)

Hypertension_event	1	1143(16.63%)
PeripheralEnthe_event	1	95(1.38%)
UnknownCauses_event	1	7(0.1%)
LipoidMetabDis_event	1	992(14.44%)
AcuteURI_event	1	33(0.48%)
AbdPelvicSymptoms_event	1	135(1.96%)
Dermatophytosis_event	1	102(1.48%)
GenSymptoms_event	1	654(9.52%)
RespChestSymptoms_event	1	196(2.85%)
HeadNeckSymptoms_event	1	96(1.4%)
ContactDermEczema_event	1	103(1.5%)
ViralInfection_event	1	200(2.91%)
ObesityHyperal_event	1	13(0.19%)
JointDisorders_event	1	17(0.25%)
AcuteBronchitis_event	1	35(0.51%)
SoftTissueDis_event	1	191(2.78%)
BloodExamFindings_event	1	82(1.19%)
RefractionDis_event	1	9(0.13%)
ConjunctivaDis_event	1	142(2.07%)

4.1.2 討論:

4.1.2.1 資料問題: 從 Index year 可以看到三院的臨床資料糖尿病患者大多發生在 2015 和 2016, 是否之前分析也有發現相同的情況?

4.1.2.2 資料數從文獻中有看到資料數有隨年分增加的趨勢



Reference:

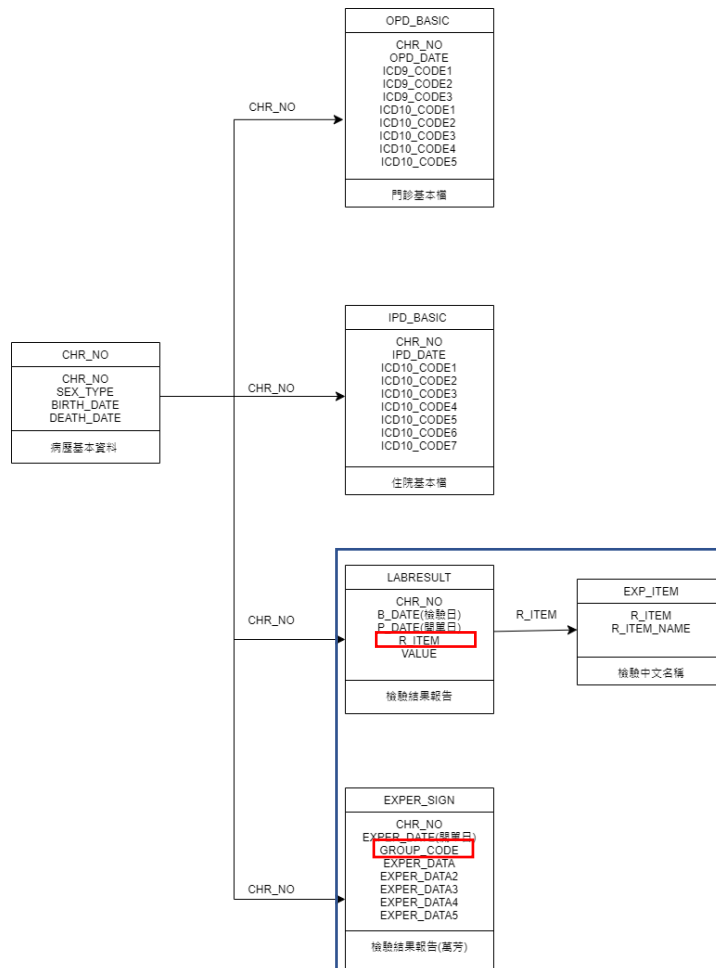
Nguyen, P.-A., Hsu, M.-H., Chang, T.-H., Yang, H.-C., Huang, C.-W., Liao, C.-T., Lu, C. Y., & Hsu, J. C. (2024). Taipei Medical University Clinical Research Database: A Collaborative Hospital Ehr Database aligned with International Common Data Standards. *BMJ Health & Care Informatics*, 31(1). <https://doi.org/10.1136/bmjhci-2023-100890>

4.2 檢驗結果資料整理:

4.2.1 儲存方式: 萬芳與其他兩院分成兩個檢驗結果檔

4.2.2 問題: 檢驗結果皆只有檢驗項目 ID, 需要找對應的檢驗名稱

4.2.3 三院臨床資料庫架構:



4.2.4 資料情況:

醫院	檢驗項目 ID	處理方式
萬芳 exper_sign_w	GROUP_CODE(健保碼)	從萬芳的檢驗資訊查詢系統找檢驗項目的健保碼
北醫, 雙和 Labresult_s(t)	R_ITEM	從 exp_item_s(t)找出對應的 R_ITEM_NAME

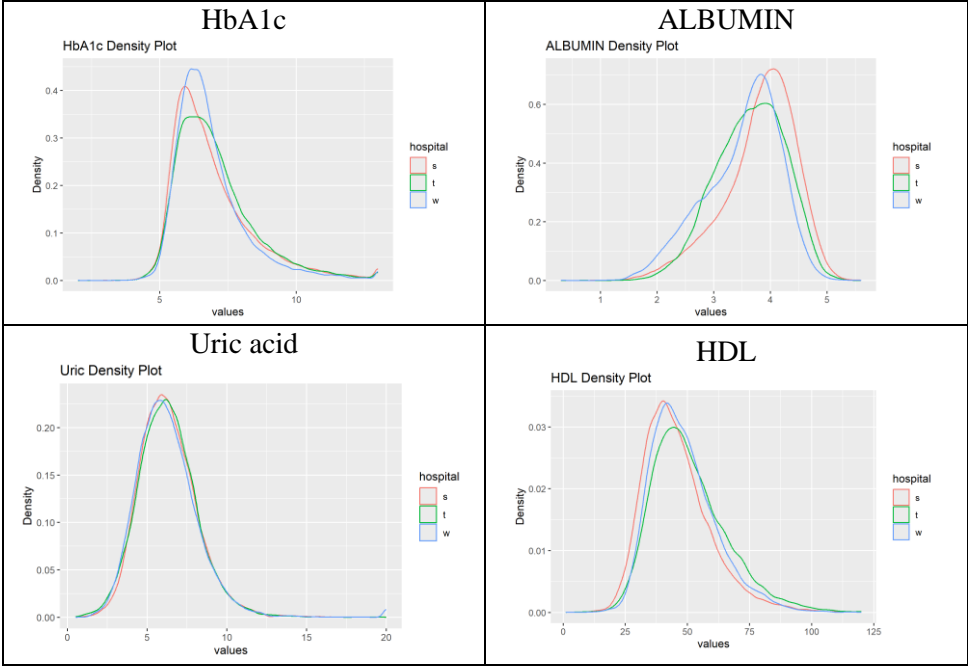
將兩份檢驗結果檔案合併為三院檢驗結果檔(含檢驗項目的中文名稱)

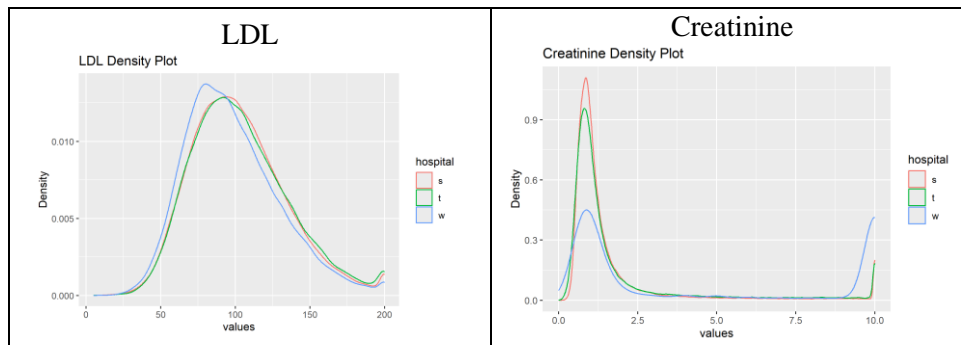
三院檢驗數值分佈狀況: 確認三院分佈情況是否一致

三院各檢驗項目對應 ID:

Test item	Test ID
HbA1c	萬芳: "F09006B" 兩院: "014701"
ALBUMIN	萬芳: "F09038C" 兩院: "010301", "11D101"
Uric Acid	萬芳: "F09013C" 兩院: "011001", "11D801"
HDL	萬芳: "F09043A" 兩院: "011301"
LDL	萬芳: "F09044A" 兩院: "011401"
Creatinine	萬芳: "F09015C" 兩院: "11A201", "010801"

各檢驗項目三院數值分佈圖: (數值是有壓縮過的)





分佈圖顯示 Creatinine 在萬芳的資料分佈與其他不一致可能單位不一致，因此，目前先排除 Creatinine 在萬芳的資料。

Table2. 三院全體檢驗項目數值分佈 (處理 outlier)

Test	min	1%	5%	q1	median	q3	95%	99%	max
HbA1c	2	4.9	5.3	5.9	6.6	7.5	9.9	12.2	19.1
ALBUMIN	0.3	2	2.5	3.3	3.8	4.1	4.6	4.9	5.6
Uric acid	0.5	2.6	3.6	5	6.1	7.4	9.5	11.6	4050
HDL	1	23	29	38	46	55	74	91	153
LDL	5	42	56	78	98	121	161	196	466
Creatinine	0	0.4	0.54	0.8	1.11	2.97	70	120	6320

4.2.5 檢驗結果資料整理流程:

步驟	說明
1	將兩院(雙和、北醫)與萬芳檢驗結果資料做合併
2	保留 Test ID, 檢驗日, 檢驗項目, 檢驗值並重新命名欄位
3	找尋欲分析的檢驗項目
4	將單位分開儲存同時排除無法辨識的資料, ex: <, >, NA
5	分佈狀況不一樣: Creatinine 不考慮萬芳
6	Outlier 存在: 保留 quantile (0.01, 0.99)的資料

三院檢驗項目清整完畢

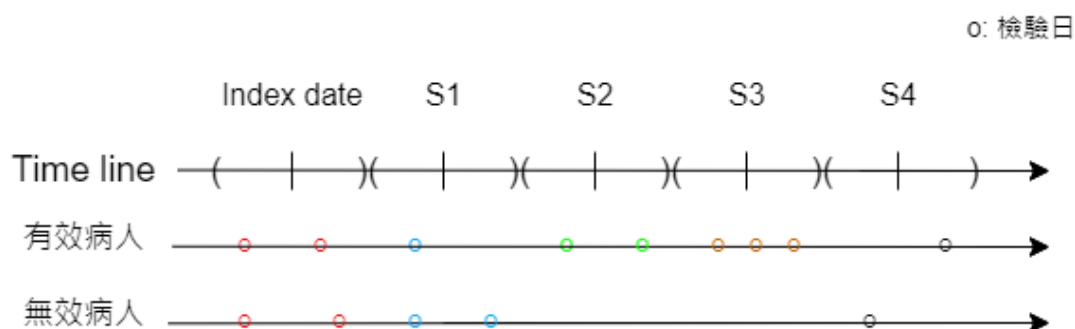
4.3 進一步篩選要分析的糖尿病患者：

4.3.1 目標: 在定義的 Index_date 後的一年內，定期進行指定檢驗項目的患者

4.3.2 Why 一年? 討論變異程度，同一個觀察範圍(一年)下做比較

4.3.3 Why 定期? 避免在計算變異程度時受時間影響

4.3.4 示意圖:



4.3.5 校正方法：從 Index_date 開始，觀察該日期前後 45 天內是否有檢測紀錄，有的話記為 1，沒有則記為 0。接著每隔 90 天進行一次相同的觀察，直到觀察到第 360 天，確認患者整年是否有進行定期檢測。最終，所有觀察期間內都有檢測紀錄的患者作為分析的對象

4.4 符合條件的糖尿病病患檢驗項目各個時間區間下的數值

Table3. 糖尿病目標病患各季度 HbA1c 中位數及檢驗次數(N = 1066)

		Index date	S1	S2	S3	S4
Median	Mean(sd)	7.75(1.52)	7.24(1.21)	7.21(1.22)	7.2(1.19)	7.19(1.19)
	Median(IQR)	7.38(2)	7(1.4)	6.9(1.34)	6.9(1.4)	6.9(1.3)
	(Min, Max)	(5,12.2)	(5,12.2)	(5,12.1)	(5,12.1)	(5.1,12.2)
檢驗次數	Mean(sd)	1.32(0.54)	1.18(0.41)	1.12(0.35)	1.09(0.3)	1.08(0.28)
	Median(IQR)	1(1)	1(0)	1(0)	1(0)	1(0)
	(Min, Max)	(1,4)	(1,4)	(1,3)	(1,3)	(1,3)

Table4. 糖尿病目標病患各季度 ALBUMIN 中位數及檢驗頻率(N = 174)

		Index date	S1	S2	S3	S4
Median	Mean(sd)	3.75(0.53)	3.85(0.48)	3.88(0.5)	3.84(0.52)	3.85(0.49)
	Median(IQR)	3.85(0.74)	3.9(0.6)	3.9(0.6)	3.9(0.6)	3.9(0.65)
	(Min, Max)	(2.3,4.8)	(2.5,4.8)	(2,4.9)	(2.1,4.9)	(2.25,4.8)
檢驗次數	Mean(sd)	2.24(1.47)	2.27(1.25)	2.23(1.24)	2.33(1.48)	2.25(1.33)
	Median(IQR)	2(2)	2(2)	2(2)	2(2)	2(2)
	(Min, Max)	(1,11)	(1,9)	(1,11)	(1,12)	(1,8)

Table5. 糖尿病目標病患各季度 Uric acid 中位數及檢驗頻率 (N = 258)

		Index date	S1	S2	S3	S4
Median	Mean(sd)	6.67(1.77)	6.62(1.69)	6.57(1.72)	6.52(1.71)	6.42(1.61)
	Median(IQR)	6.6(2.5)	6.55(2.37)	6.6(2.5)	6.3(2.37)	6.2(2.4)
	(Min, Max)	(2.8,11.4)	(3,11.6)	(3.1,11.05)	(2.7,11)	(3.1,11)
檢驗次數	Mean(sd)	1.57(0.76)	1.54(0.86)	1.53(0.86)	1.45(0.79)	1.4(0.8)
	Median(IQR)	1(1)	1(1)	1(1)	1(1)	1(0)
	(Min, Max)	(1,4)	(1,5)	(1,5)	(1,5)	(1,6)

Table6. 糖尿病目標病患各季度 HDL 中位數及檢驗頻率(N = 103)

		Index date	S1	S2	S3	S4
Median	Mean(sd)	42.36(12.29)	42.17(10.37)	42.58(11.02)	43.63(12.3)	43.74(12.55)
	Median(IQR)	39.5(13)	39.5(12)	40(13.5)	40(15.5)	40(15)
	(Min, Max)	(26,85)	(24,75)	(24,75)	(26,87)	(25,86)
檢驗次數	Mean(sd)	1.23(0.51)	1.08(0.27)	1.05(0.22)	1.06(0.24)	1.02(0.14)
	Median(IQR)	1(0)	1(0)	1(0)	1(0)	1(0)
	(Min, Max)	(1,3)	(1,2)	(1,2)	(1,2)	(1,2)

Table7. 糖尿病目標病患各季度 LDL 中位數及檢驗頻率 (N = 479)

		Index date	S1	S2	S3	S4
Median	Mean(sd)	104.87(30.47)	99.56(30.93)	98.88(29.98)	97.07(29.67)	96.78(28.27)
	Median(IQR)	104.5(42)	95(44.75)	97(42.5)	93(40.25)	93(38)
	(Min, Max)	(43,196)	(42,195)	(45,190)	(43,196)	(43,178)
檢驗次數	Mean(sd)	1.33(0.56)	1.17(0.38)	1.11(0.34)	1.11(0.32)	1.08(0.3)
	Median(IQR)	1(1)	1(0)	1(0)	1(0)	1(0)
	(Min, Max)	(1,4)	(1,3)	(1,3)	(1,3)	(1,4)

Table8. 糖尿病目標病患各季度 Creatinine 中位數及檢驗頻率 (N = 865)

		Index date	S1	S2	S3	S4
Median	Mean(sd)	1.92(2.08)	1.98(2.16)	2.06(2.26)	2.13(2.33)	2.18(2.4)
	Median(IQR)	1.19(1.02)	1.2(1.03)	1.24(1.08)	1.23(1.12)	1.21(1.2)
	(Min, Max)	(0.4,11.6)	(0.4,11.95)	(0.4,12.1)	(0.4,11.62)	(0.4,11.8)
檢驗次數	Mean(sd)	2.68(2.41)	2.19(2.1)	2.12(2.17)	2.14(2.57)	2.12(2.66)
	Median(IQR)	2(2)	1(2)	1(1)	1(1)	1(1)
	(Min, Max)	(1,20)	(1,19)	(1,30)	(1,34)	(1,31)

4.5 併發症整理流程:

4.5.1 Exclude :

4.5.1.1 index date 前有發生併發症

4.5.1.2 index date 後一年內發生併發症

Table9: 糖尿病患者相關併發症情況

test	Outcome	Event	Total person years	N	Incidence rate (Per 100 person-years)
HbA1c	Eye complications	64	5676.915	989	1.127
	Cardiovascular disease	247	3796.921	744	6.505
	Cerebrovascular disease	136	5495.063	907	2.475
	Peripheral vascular disease	10	6482.808	1062	0.154
	Nephropathy	118	5628.518	975	2.096
	Diabetic neuropathy	71	5693.493	971	1.247

ALBUMIN	Eye complications	9	745.011	151	1.208
	Cardiovascular disease	36	404.8822	93	8.891
	Cerebrovascular disease	22	783.2247	150	2.809
	Peripheral vascular disease	4	926.5945	173	0.432
	Nephropathy	16	158.6192	43	10.087
	Diabetic neuropathy	8	857.8575	161	0.933
Uric acid	Eye complications	9	1177.901	234	0.764
	Cardiovascular disease	62	528.4521	132	11.732
	Cerebrovascular disease	27	1175.386	221	2.297
	Peripheral vascular disease	4	1370.707	256	0.292
	Nephropathy	25	633.7123	137	3.945
	Diabetic neuropathy	13	1259.515	240	1.032
HDL	Eye complications	2	482.2356	98	0.415
	Cardiovascular disease	12	225.4932	49	5.322
	Cerebrovascular disease	12	435.3041	90	2.757
	Peripheral vascular disease	0	514.189	102	0
	Nephropathy	6	402.4219	82	1.491
	Diabetic neuropathy	4	461.3562	94	0.867
LDL	Eye complications	18	2326.603	447	0.774
	Cardiovascular disease	105	1527.485	326	6.874
	Cerebrovascular disease	49	2158.455	389	2.27
	Peripheral vascular disease	2	2611.321	478	0.077
	Nephropathy	38	2306.959	434	1.647
	Diabetic neuropathy	23	2374.389	447	0.969
Creatinine	Eye complications	32	4187.726	789	0.764
	Cardiovascular disease	176	2597.178	541	6.777
	Cerebrovascular disease	109	4020.027	727	2.711
	Peripheral vascular disease	7	4766.362	854	0.147
	Nephropathy	110	3139.51	633	3.504
	Diabetic neuropathy	41	4222.186	785	0.971

以上檢驗項目及糖尿病相關併發症清楚結果和發病情況的摘要

5 資料分析:

5.1 變數處理:

5.1.1 控制變數: SEX, Index year, AGE_GROUP, Baseline mean, 共病是否發生

變數名稱	描述
Baseline mean	Index Date 區間下的檢驗值平均
共病是否發生	Essential hypertension 本態性高血壓
	Peripheral enthesopathies and allied syndromes 外周附著點病變及其相關聯症候群的疾病
	Other ill-defined and unknown causes of morbidity and mortality 定義不明和未知原因的發病和死亡
	Disorders of lipid metabolism 脂蛋白的代謝異常
	Acute upper respiratory infections of multiple or unspecified sites 多部位或未明確部位的急性上呼吸道感染
	Other symptoms involving abdomen and pelvis 腹部和骨盆的其他症狀
	Dermatophytosis 真菌引起的皮膚感染
	General symptoms 非特定的身體症狀
	Symptoms involving respiratory system and other chest symptoms 呼吸系統和其他胸部症狀
	Symptoms involving head and neck 頭部和頸部的症狀
	Contact dermatitis and other eczema 皮膚疾病
	Viral infection in conditions classified elsewhere and of unspecified site 病毒引起的感染
	Overweight, obesity and other hyperalimentation 超重, 肥胖及其他過度營養狀態
	Other and unspecified disorders of joint 未明確指定的關節疾病
	Acute bronchitis and bronchiolitis 呼吸道疾病
	Other disorders of soft tissues 其他軟組織的疾病
	Nonspecific findings on examination of blood 血液檢查時發現的一些非特定性的異常或發現
	Disorders of refraction and accommodation 屈光和調節的疾病
	Disorders of conjunctiva 眼球表面覆蓋的結膜的各種疾病

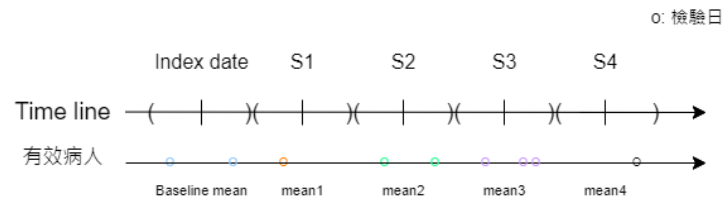
5.2 其他變數組合: 不同檢驗項目的變異程度指標: SD, CV, RMS

5.2.1 計算方式: 為了避免有病患在特定季節集中做檢驗

5.2.1.1 對各病患計算每一季的檢測項目平均值: Index Date, S1, S2, S3, S4

5.2.1.2 針對這些平均值, 計算標準差, 變異係數以及均方根

5.2.1.3 圖例:



5.2.2 標準差(SD) 計算方式:

$$\sigma = \sqrt{\frac{1}{N} \sum_{i=1}^N (x_i - \mu)^2}$$

5.2.3 變異係數(CV) 計算方式:

$$c_v = \frac{\sigma}{\mu}$$

5.2.4 均方根(RMS) 計算方式:

$$M = \sqrt{\frac{\sum_{i=1}^n x_i^2}{n}}$$

5.3 反應變數: 病患追蹤日期, 是否有發生併發症

5.4 模型: cox model

5.5 模型指標: HR (Hazard ratios), 95% CI, P-value

6 分析結果: (以 HbA1c 為主, 以及其他檢驗項目變異程度有顯著的結果)

6.1 P-value: ∴ p < 0.1, *: p < 0.05, **: p < 0.01, ***: p < 0.001

Table10: Eye complications 與 HbA1c 檢驗結果分析 (N = 989)

Models	Variables	HR	95%CI	P-value
Model1	Baseline	1.188	1.012, 1.396	*
Model2	Baseline	1.085	0.857, 1.375	
	SD	1.448	0.719, 2.916	
Model3	Baseline	1.142	0.922, 1.413	
	CV	4.408	0.026, 738.134	
Model4	Baseline	0.915	0.703, 1.19	
	RMS	1.604	1.138, 2.26	**

Table11: Cardiovascular disease 與 HbA1c 檢驗結果分析 (N = 744)

Models	Variables	HR	95%CI	P-value
Model1	Baseline	0.981	0.9, 1.07	
Model2	Baseline	0.997	0.884, 1.123	
	SD	0.932	0.647, 1.342	
Model3	Baseline	1	0.898, 1.115	
	CV	0.443	0.03, 6.555	
Model4	Baseline	0.943	0.822, 1.081	
	RMS	1.074	0.889, 1.299	

Table12: Cerebrovascular disease 與 HbA1c 檢驗結果分析 (N = 907)

Models	Variables	HR	95%CI	P-value
Model1	Baseline	1.011	0.904, 1.131	
Model2	Baseline	1.078	0.924, 1.256	
	SD	0.742	0.452, 1.216	
Model3	Baseline	1.061	0.925, 1.218	
	CV	0.117	0.003, 4.342	
Model4	Baseline	0.935	0.782, 1.118	
	RMS	1.147	0.903, 1.456	

Table13: Peripheral vascular disease 與 HbA1c 檢驗結果分析 (N = 1062) (發生很少)

Models	Variables	HR	95%CI	P-value
Model1	Baseline	0.912	0.589, 1.414	
Model2	Baseline	0.696	0.468, 1.036	.
	SD	3.342	1.211, 9.219	*
Model3	Baseline	0.716	0.481, 1.068	
	CV	9836.151	4.079, 23720382.232	*
Model4	Baseline	0.928	0.6, 1.437	
	RMS	0.966	0.501, 1.86	

Table14: Nephropathy 與 HbA1c 檢驗結果分析 (N = 975)

Models	Variables	HR	95%CI	P-value
Model1	Baseline	1.094	0.969, 1.235	
Model2	Baseline	1.084	0.908, 1.294	
	SD	1.039	0.607, 1.778	
Model3	Baseline	1.098	0.936, 1.287	
	CV	0.867	0.017, 44.407	
Model4	Baseline	1.013	0.837, 1.225	
	RMS	1.153	0.885, 1.501	

Table15: Diabetic neuropathy 與 HbA1c 檢驗結果分析 (N = 971)

Models	Variables	HR	95%CI	P-value
Model1	Baseline	0.941	0.797, 1.112	
Model2	Baseline	0.997	0.791, 1.258	
	SD	0.769	0.37, 1.6	
Model3	Baseline	1.002	0.812, 1.235	
	CV	0.074	0, 15.706	
Model4	Baseline	0.74	0.569, 0.961	*
	RMS	1.533	1.104, 2.131	*

Table16: Nephropathy 與 HDL 檢驗結果分析 (N = 82)

Models	Variables	HR	95%CI	P-value
Model1	Baseline	1.193	1.109,1.283	***
Model2	Baseline	1.309	1.218,1.407	***
	SD	2.555	2.108,3.098	***
Model3	Baseline	1.513	1.402,1.633	***
	CV	Inf	Inf ,Inf	***
Model4	Baseline	Inf	0.652,Inf	.
	RMS	0	0,8.621	.

Table17: Diabetic neuropathy 與 uric acid 檢驗結果分析 (N = 240)

Models	Variables	HR	95%CI	P-value
Model1	Baseline	0.896	0.645, 1.246	
Model2	Baseline	0.786	0.573, 1.077	
	SD	2.353	1.036, 5.341	*
Model3	Baseline	0.843	0.614, 1.159	
	CV	105.966	0.359, 31276.269	
Model4	Baseline	0.743	0.531, 1.041	.
	RMS	1.333	0.889, 2	

Table18: Eye complications 與 Creatinine 檢驗結果分析 (N = 789)

Models	Variables	HR	95%CI	P-value
Model1	Baseline	1.091	0.941, 1.265	
Model2	Baseline	0.955	0.779, 1.171	
	SD	2.609	1.108, 6.141	*
Model3	Baseline	1.091	0.94, 1.265	
	CV	11.082	0.396, 309.897	
Model4	Baseline	0.425	0.232, 0.78	**
	RMS	2.498	1.489, 4.191	***

Table19: Nephropathy 與 Creatinine 檢驗結果分析 (N = 633)

Models	Variables	HR	95% CI	P-value
Model1	Baseline	2.554	2.113, 3.087	***
Model2	Baseline	2.464	1.928, 3.15	***
	SD	1.179	0.579, 2.401	
Model3	Baseline	2.515	2.068, 3.06	***
	CV	1.737	0.268, 11.258	
Model4	Baseline	1.29	0.737, 2.259	
	RMS	1.865	1.164, 2.989	**

結論:

- 1 模型顯示 HbA1c 的變異程度對於 Eye complications, Nephropathy, Diabetic neuropathy 等併發症為重要因子, 符合文獻結果

- 2 其他顯著的檢驗項目:

併發症	檢驗項目	變異程度指標
Eye complications	Creatinine	SD, RMS
Nephropathy	HDL	SD
Nephropathy	Creatinine	RMS
Diabetic neuropathy	Uric acid	SD, CV

- 3 資料不顯著可能的原因: 人數太少, 每季只考慮平均值會損失部分訊息, 資料本身是以中風的條件下去篩選的

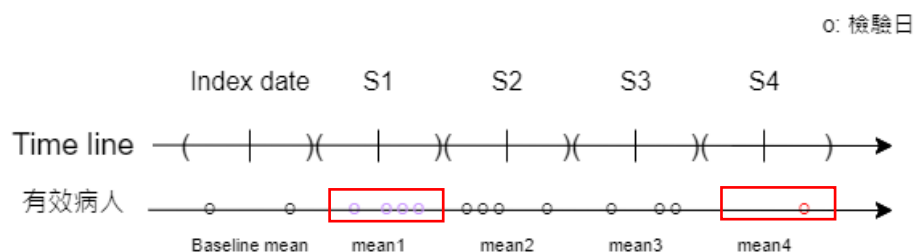
- 4 後續可以做的研究方向:

$$4.1 \quad \text{考慮其他的變異性指標, ex: HVS} = \frac{\sum_{i=1}^n I(|\Delta HbA1c_i| > 0.5\%) \times 100\%}{n},$$

$$\text{其中, } \Delta HbA1c_i = HbA1c_i - HbA1c_{i-1}$$

- 4.2 Outlier 定義

- 4.3 多考慮各個時間區間內的變異: weighted SD



- 4.4 控制各季的平均數 $\text{mean}(\text{mean1}, \text{mean2}, \text{mean3}, \text{mean4})$, 來確保變異程度指標在模型的合理性

- 5 目前已驗證的方法可行性, 可以進行與心血管相關的分析方法

心血管 (cardiovascular disease)相關主題:

心血管相關檢測項目：

- 血壓變異性（如日間和夜間的血壓波動）
- 血糖變異性（如血糖的日間波動）
- 血脂變異性（如 LDL 和 HDL 的波動）
- Heart rate

心血管相關併發症：

- 運動功能障礙: Motor Function Impairment
- 語言障礙: Speech Impairment
- 認知障礙: Cognitive Impairment
- 情緒和心理問題: Emotional and Psychological Problems
- 吞嚥困難: Dysphagia
- 褥瘡: Pressure Ulcers

共病:

- 高脂血症（Hyperlipidemia）
- 冠心病（Coronary Artery Disease）
- 慢性腎病（Chronic Kidney Disease）
- 慢性阻塞性肺病（Chronic Obstructive Pulmonary Disease, COPD）
- 心房顫動（Atrial Fibrillation）
- 周邊動脈疾病（Peripheral Artery Disease）
- 肥胖（Obesity）
- 代謝綜合徵（Metabolic Syndrome）
- 睡眠呼吸暫停綜合徵（Sleep Apnea Syndrome）
- 甲狀腺疾病（Thyroid Disorders）
- 腦外傷史（History of Traumatic Brain Injury）
- 抑鬱症（Depression）
- 焦慮症（Anxiety Disorders）
- 酒精使用障礙（Alcohol Use Disorder）
- 藥物濫用（Substance Abuse）
- 缺乏運動（Physical Inactivity）
- 不良飲食習慣（Unhealthy Dietary Habits）
- 家族中風史（Family History of Stroke）

- 高血壓
- 糖尿病