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USING FINANCIAL MODELLING FOR INTEGRATED HEALTHCARE DATABASES

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See related materials:
A. Botchkarev, P. Andru "Using Financial Modelling for Integrated Healthcare Databases", In Proc. IEEE Canadian Conference on Electrical and Computer Engineering, May 2008. Abstract in IEEE Xplore: http://ieeexplore.ieee.org/Xplore/login.jsp?url=/iel5/4554522/4564482/04564889.pdf?arnumber=4564889

P. Andru, A. Botchkarev "Hospital Case Cost Estimates Modelling - Algorithm Comparison", http://arxiv.org/ftp/arxiv/papers/0802/0802.4126.pdf, 2008.

Business Rationale

Ontario (Canada) Health System stakeholders support the idea and necessity of the integrated source of data that would include both clinical (e.g. diagnosis, intervention, length of stay, case mix group) and financial (e.g. cost per weighted case, cost per diem) characteristics of the Ontario healthcare system activities at the patient-specific level.

Business Rationale (continued)

Sample enquiry scenarios include:

- An analyst in a LHIN wants to know the costs for hip replacement cases across all the facilities performing the procedure in that LHIN, or for all the facilities providing the service to residents of that LHIN.
- An analyst in a LHIN wants to know the range of costs for cardiac cases across all the facilities performing the procedure within the province.
- A ministry analyst wants to know the total costs for kidney transplant, failure, or rejection across facilities and LHINs over the last three years.

LHIN - Local Health Integrated Networks

Problem

- Generally speaking, the actual patient-level case costs in the explicit form are not available in the financial databases.

- Exception is for the cases submitted by the hospitals participating in the Ontario Case Costing Initiative (OCCI). However, only approximately 10% of the Ontario hospitals have been involved in the OCCI.

Terms And Definitions

- Case Cost (CC). Expenditures (direct and indirect) incurred by the health service facility relating to the treatment of a specific (patient-level) case.

- Actual Case Cost (ACC). Case Cost that is considered to be the most trustworthy and most closely reflecting "real-life" hospital expenditures on a specific case is referred to as Actual Case Cost. Actual Case Costs are used as a benchmark for comparing various case costs.

- Case Cost Estimate (CCE). Approximate dollar value of the Case Cost, determined/calculated by employing the Cost Case Model.

Terms And Definitions (2)

- Case Cost Model (CCM). A formal representation of the Case Cost, as a conceptual phenomenon, which involves mathematics, logical expressions, well-defined procedures, computer software, that is constructed with the purpose of producing output – Case Cost Estimate, as a function of one or more clinical and financial parameters. CCM can constitute a single formulae/equation or a set of complex algorithms implemented in a software package.

Case Cost Model

$$CCE(\text{Mod } N) = \mathcal{F}\{ C1, C2,...Cn; F1, F2,...Fn \}$$

Clinical Parameters (C_n)

- PAC_RIW_i – relative intensity of the i-th case. Parameter is available in the DAD database – field PAC_RIW_WT;
- RIW_val_i – relative intensity of the i-th case calculated by the CIHI. Parameter is available in the DAD database – field RIWval;
- LOS_i – Length of Stay for the i-th case. This parameter is available in the DAD database – field TotalL.

Financial Parameters (F_n)

- CpD – cost per diem. Parameter is calculated annually by OCDM for each hospital.
- CPWC – cost per weighted case. Parameter is calculated annually by the OCDM for each hospital.

Case Cost Model

$$CCE(Mod11)_i = \begin{cases} CCE(Mod8)_i, \text{ if } CCE(Mod7)_i \neq minCCE(Mod7)_{cmg_n} \text{ and } CCE(Mod7)_i \neq maxCCE(Mod7)_{cmg_n} \\ \qquad \text{and } CCE(Mod8)_i < maxCCE(Mod7)_{cmg_n} \\ CCE(Mod8)_i, \text{ if } CCE(Mod7)_i = minCCE(Mod7)_{cmg_n} \text{ and } CCE(Mod8)_i < minCCE(Mod7)_{cmg_n} \\ minCCE(Mod7)_{cmg_n}, \text{ if } CCE(Mod7)_i = minCCE(Mod7)_{cmg_n} \text{ and } CCE(Mod8)_i >= minCCE(Mod7)_{cmg_n} \\ maxCCE(Mod7)_{cmg_n}, \text{ if } CCE(Mod7)_i = maxCCE(Mod7)_{cmg_n} \\ [K12*CCE(Mod7)_i + K13*CCE(Mod8)_i] / 2, \text{ if } CCE(Mod8)_i >= maxCCE(Mod7)_{cmg_n} \end{cases}$$

$$\left\{ \sum_{cmg_n} (avgACC_{cmg} * N_{c,\,cmg}) \sum_{cmg_n} \sum_{i=1,\ldots N_{c,\,cmg}} \begin{cases} CCE(Mod8)_i, \text{ if } CCE(Mod7)_i \neq minCCE(Mod7)_{cmg_n} \text{ and } CCE(Mod7)_i \neq maxCCE(Mod7)_{cmg_n} \\ \qquad \text{and } CCE(Mod8)_i < maxCCE(Mod7)_{cmg_n} \\ CCE(Mod8)_i, \text{ if } CCE(Mod7)_i = minCCE(Mod7)_{cmg_n} \text{ and } CCE(Mod8)_i < minCCE(Mod7)_{cmg_n} \\ minCCE(Mod7)_{cmg_n}, \text{ if } CCE(Mod7)_i = minCCE(Mod7)_{cmg_n} \text{ and } CCE(Mod8)_i >= minCCE(Mod7)_{cmg_n} \\ maxCCE(Mod7)_{cmg_n}, \text{ if } CCE(Mod7)_i = maxCCE(Mod7)_{cmg_n} \\ [K12*CCE(Mod7)_i + K13*CCE(Mod8)_i] / 2, \text{ if } CCE(Mod8)_i >= maxCCE(Mod7)_{cmg_n} \end{cases} \right\}$$

$$CCE(Mod7)_i = [\,(LOSac_i - LOSsc_i/24) * K1 + LOSalc_i * K2 + (LOSsc_i/24) * K3\,] * CpD + CPWC * [\,D_i * K8 + I_i * K9\,] + \mu$$

$$CCE(Mod8)_i = CPWC * [\,PAC\_MOD_i + D_i * K6 + I_i * K7\,]$$

$$PAC\_MOD_i = \begin{cases} PAC\_RIW_i, \text{ if } minPAC\_RIW_i \neq maxPAC\_RIW_i \text{ for n-th CMG group} \\ \qquad \text{or } minPAC\_RIW_i = maxPAC\_RIW_i \text{ and } minRIW\_val_i = maxRIW\_val_i \\ \qquad \text{and } minLOS_i = maxLOS_i \text{ for n-th CMG group} \\ RIW\_val_i * \left(\sum_{cmg_n} PAC\_RIW_i \Big/ \sum_{cmg_n} RIW\_val_i \right), \text{ if } minPAC\_RIW_i = maxPAC\_RIW_i \\ \qquad \text{and } minRIW\_val_i \neq maxRIW\_val_i \text{ for n-th CMG group} \\ CCE(Mod7)_i * \left(\sum_{cmg_n} PAC\_RIW_i \Big/ \sum_{cmg_n} CCE(Mod7)_i \right), \text{ if } minPAC\_RIW_i = maxPAC\_RIW_i \text{ and } minRIW\_val_i = maxRIW\_val_i \\ \qquad \text{and } minLOS_i \neq maxLOS_i \text{ for n-th CMG group} \end{cases}$$

PAC Relative Intensity Model – Model 1

$$CCE(Mod1)_i = PAC\_RIW_i * CPWC,$$

where:

PAC_RIW_i – relative intensity of the i-th case. Parameter is available in the DAD database – field PAC_RIW_WT.

CPWC – cost per weighted case. Parameter is calculated annually by OCDM for each hospital.

Cost per Diem Model – Model 4

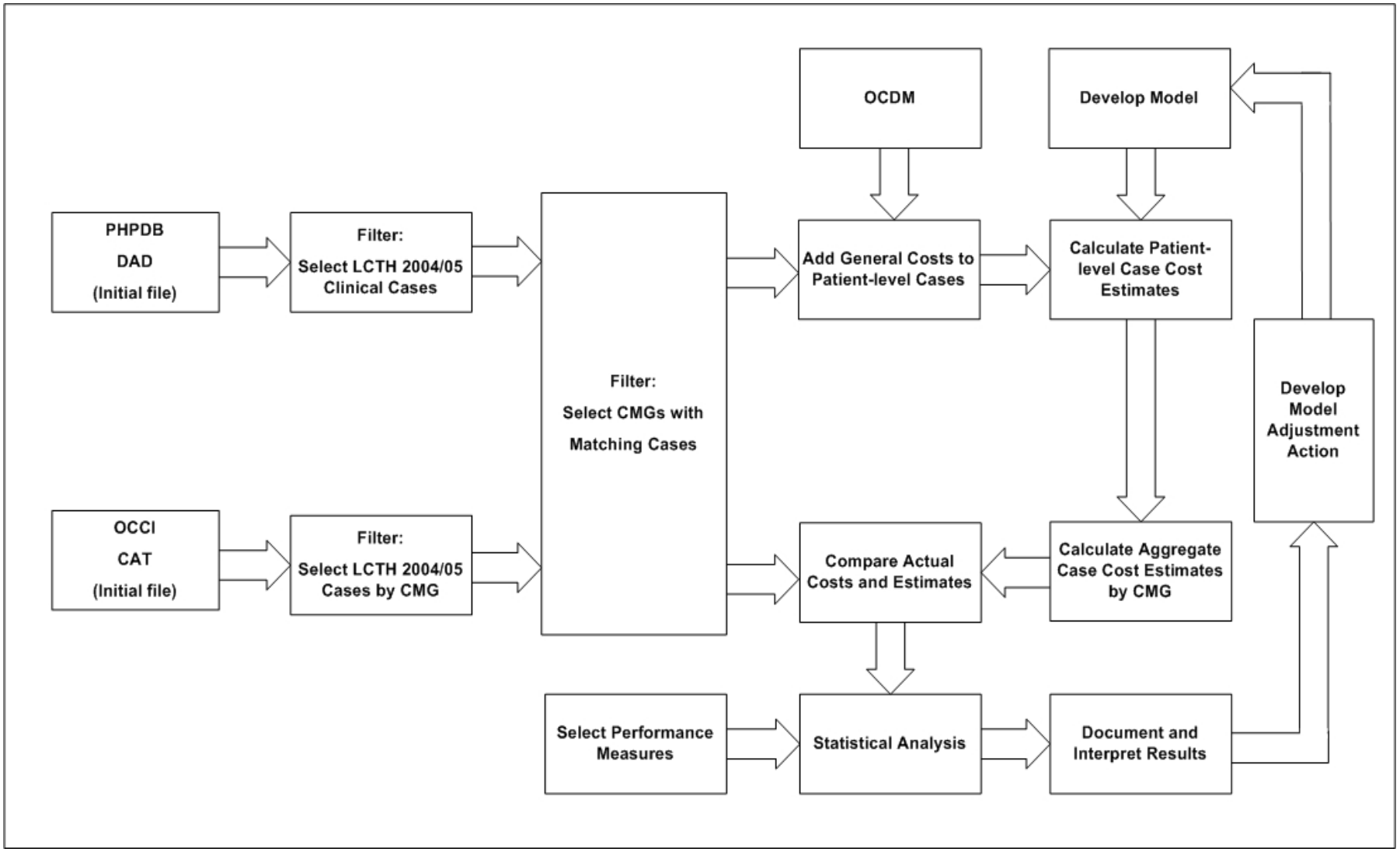
$$CCE(Mod4)_i = LOS_i * CpD$$

where:

LOS_i – Length of Stay for the i-th case. This parameter is available in the DAD database – field TotalL.

CpD – cost per diem. Parameter is calculated annually by OCDM for each hospital.

Experiment Process Logic Diagram



Case Cost Model

$$CCE(Mod11)_i = \begin{cases} CCE(Mod8)_i, \text{ if } CCE(Mod7)_i \neq minCCE(Mod7)_{cmg_n} \text{ and } CCE(Mod7)_i \neq maxCCE(Mod7)_{cmg_n} \\ \qquad \text{and } CCE(Mod8)_i < maxCCE(Mod7)_{cmg_n} \\ CCE(Mod8)_i, \text{ if } CCE(Mod7)_i = minCCE(Mod7)_{cmg_n} \text{ and } CCE(Mod8)_i < minCCE(Mod7)_{cmg_n} \\ minCCE(Mod7)_{cmg_n}, \text{ if } CCE(Mod7)_i = minCCE(Mod7)_{cmg_n} \text{ and } CCE(Mod8)_i >= minCCE(Mod7)_{cmg_n} \\ maxCCE(Mod7)_{cmg_n}, \text{ if } CCE(Mod7)_i = maxCCE(Mod7)_{cmg_n} \\ [K12*CCE(Mod7)_i + K13*CCE(Mod8)_i] / 2, \text{ if } CCE(Mod8)_i >= maxCCE(Mod7)_{cmg_n} \end{cases}$$

$$\left\{ \sum_{cmg_n} (avgACC_{cmg} * N_{c,\,cmg}) \sum_{cmg_n} \sum_{i=1,\ldots N_{c,\,cmg}} \begin{cases} CCE(Mod8)_i, \text{ if } CCE(Mod7)_i \neq minCCE(Mod7)_{cmg_n} \text{ and } CCE(Mod7)_i \neq maxCCE(Mod7)_{cmg_n} \\ \qquad \text{and } CCE(Mod8)_i < maxCCE(Mod7)_{cmg_n} \\ CCE(Mod8)_i, \text{ if } CCE(Mod7)_i = minCCE(Mod7)_{cmg_n} \text{ and } CCE(Mod8)_i < minCCE(Mod7)_{cmg_n} \\ minCCE(Mod7)_{cmg_n}, \text{ if } CCE(Mod7)_i = minCCE(Mod7)_{cmg_n} \text{ and } CCE(Mod8)_i >= minCCE(Mod7)_{cmg_n} \\ maxCCE(Mod7)_{cmg_n}, \text{ if } CCE(Mod7)_i = maxCCE(Mod7)_{cmg_n} \\ [K12*CCE(Mod7)_i + K13*CCE(Mod8)_i] / 2, \text{ if } CCE(Mod8)_i >= maxCCE(Mod7)_{cmg_n} \end{cases} \right\}$$

$$CCE(Mod7)_i = [\,(LOSac_i - LOSsc_i/24) * K1 + LOSalc_i * K2 + (LOSsc_i/24) * K3\,] * CpD + CPWC * [\,D_i * K8 + I_i * K9\,] + \mu$$

$$CCE(Mod8)_i = CPWC * [\,PAC\_MOD_i + D_i * K6 + I_i * K7\,]$$

$$PAC\_MOD_i = \begin{cases} PAC\_RIW_i, \text{ if } minPAC\_RIW_i \neq maxPAC\_RIW_i \text{ for n-th CMG group} \\ \qquad \text{or } minPAC\_RIW_i = maxPAC\_RIW_i \text{ and } minRIW\_val_i = maxRIW\_val_i \\ \qquad \text{and } minLOS_i = maxLOS_i \text{ for n-th CMG group} \\ RIW\_val_i * \left(\sum_{cmg_n} PAC\_RIW_i \Big/ \sum_{cmg_n} RIW\_val_i \right), \text{ if } minPAC\_RIW_i = maxPAC\_RIW_i \\ \qquad \text{and } minRIW\_val_i \neq maxRIW\_val_i \text{ for n-th CMG group} \\ CCE(Mod7)_i * \left(\sum_{cmg_n} PAC\_RIW_i \Big/ \sum_{cmg_n} CCE(Mod7)_i \right), \text{ if } minPAC\_RIW_i = maxPAC\_RIW_i \text{ and } minRIW\_val_i = maxRIW\_val_i \\ \qquad \text{and } minLOS_i \neq maxLOS_i \text{ for n-th CMG group} \end{cases}$$

Data Experiment Results and Conclusions

Financial Model Performance Measures

$\bar{E}(avgCCE_{cmg})$, $	$\bar{E}(minCCE_{cmg})$, $	$\bar{E}(maxCCE_{cmg})$, $
1,852.88	1,097.29	17,013.22
P_{ab}, %	Interval of relative error, %	
	a	b
25%	0	5
15%	5	10
13%	10	15
13%	15	20
21%	20	30
10%	30	50
2%	50	50+

Data Experiment Results and Conclusions

Results of the data experiment show feasibility of the selected approach and correctness of the developed models.

For 66% of the CMG groups, estimated aggregate CMG costs were calculated with a relative error under 20%. Such accuracy could be considered acceptable for practical planning and forecasting purposes. Only for 2% of the CMG groups relative error exceeded 50%.

Data Experiment Results and Conclusions

Next phases of the research will focus on the understanding of the facility-to-facility and year–to-year data variability.

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