In the matter of the Public Inquiry into the Safety and Security of Residents in the Long-Term Care Homes System, pursuant to the Order in Council 1549/2017 and the *Public Inquiries Act, 2009*

Affidavit of Dr. Michael Hillmer

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Affidavit of Dr. Michael Hillmer

I, Dr. Michael Hillmer, of the City of Toronto, in the Province of Ontario, SOLEMNLY AFFIRM AND SAY:

1. I am the Executive Director of Information Management, Data and Analytics ("IMDA") within the Health System Information Management Division (the "HSIM Division") of the Ministry of Health and Long-term Care (the "Ministry"). I affirm this Affidavit as part of my evidence to the Public Inquiry into the Safety and Security of Residents in the Long-Term Care Homes System (the "Inquiry") on the work of the HSIM Division after Elizabeth Wettlaufer confessed to the Offences. I have knowledge of the information contained in this Affidavit.

My Training and Experience

2. I obtained a PhD from the University of Toronto in 2007 with a specialization in clinical epidemiology. I have worked for the Ministry since that time. A copy of my curriculum vitae (LTCI00072898) is attached as **Exhibit "A"**.

3. I was initially employed as the Manager of the Chronic Disease Unit, which was a policy role wherein I was tasked with creating a chronic disease strategy. After five years, I was promoted to Director of the System Policy and Strategy Branch and, after a short duration, was transferred to become the Director of the Research, Analysis and Evaluation Branch. In that role, which I held for two and a half years, my responsibilities included conducting economic analyses, program evaluations, literature reviews, and funding research studies.

4. I have held my present position as Executive Director of Information Management, Data and Analytics within the HSIM Division since March 2016.

Structure and Function of the HSIM Division

5. The purpose of the HSIM Division is to obtain and analyze health data to improve decision making. The HSIM Division is not tasked with implementing or executing on its analysis – generally, research or projects are undertaken with a partner (for example, another department within government), which implements the results of the work.

6. The HSIM Division has recently undergone a structural change, and is now comprised of four branches:

(a) Health Data Branch, which collects, standardizes and distributes data and reports to a range of entities (ex. Ministry users, hospitals, long-term care homes ("LTC Homes"), provincial agencies, researchers, media, police, regulatory colleges, etc);

(b) Health Analytics and Insights Branch (formerly called the Health Analytics Branch), which is tasked with helping to describe the health status of the population, patient journeys, care utilization patterns, cost of healthcare services, and the performance of the healthcare system. This information is used for planning, system design, and operational, accountability and/or performance monitoring purposes;

(c) Information Management, Strategy and Policy Branch, which is tasked with overseeing the Province's health privacy legislation (*Personal Health Information*

Protection Act) and providing privacy and information management advice and consultation for the Ministry; and

(d) Health Data Sciences Branch (which is a new entity), which is tasked with developing models and machine learning / artificial intelligence applications to predict, simulate and forecast, with the goal of producing actionable insights and automating routine processes.

Health Data Utilized by the HSIM Division

7. The health data used by the HSIM Division are collected from several sources, including:

(a) information on physician services obtained via claims physicians submit to the Ministry directly for payment (i.e. through the Ontario Health Insurance Plan ("OHIP") billing system);

(b) information on medications obtained via claims for filled prescriptions submitted by pharmacies to the Ministry for payment;

(c) Canadian Institute for Health Information ("CIHI" – described below); and

(d) the Registered Persons Database, which contains demographic information of each individual eligible for healthcare services in the Province and their OHIP number.

8. CIHI is a federal agency that obtains data from hospitals (including mental health and rehabilitation hospitals), LTC Homes, and complex continuing care facilities on a weekly basis. The HSIM Division then obtains quarterly compilations of that data. CIHI has established national standards for institutional data collection to be used by those health entities, which is

then made available to stakeholders at the organizational level (for quality improvement activities, program planning and resource allocation), as well as at the systems level (to analyze and compare health data across regions and provinces).

9. From LTC Homes, the information supplied to CIHI is generally obtained through the completion of the interRAI clinical assessment instruments (the Resident Assessment Instrument – Minimum Data Set) ("RAI-MDS instruments") by care providers at the LTC Home. Standardized assessment instruments, such as those created by interRAI, enable the structured recording of information about an individual, which can be aggregated to show changes in the status of both individuals and larger populations over time.

10. InterRAI is a global non-profit network of researchers and practitioners in over 35 countries that creates and continually researches the validity of its clinical assessment instruments. The main purpose of the interRAI assessment instruments is as clinical tools, which depict an individual's functional status and can be used to generate a care plan for that resident. The routine and ongoing use of the interRAI assessment instruments permits the aggregation of data from routine clinical practice, which can in turn be utilized by policy makers and service providers for research, planning and policy purposes. InterRAI assessment instruments have been developed for numerous care settings, including: acute care, post-acute care, community health, home (community) care, LTC Homes, and assisted living, among others.

11. In Ontario, implementation of the interRAI RAI-MDS instruments in LTC Homes was initiated in June 2005, with the goal of improving care to residents in LTC Homes by standardizing the assessment and care planning process. The Ministry enters into Performance Agreements with the Local Health Integration Networks ("LHINs"), known as the Ministry-

LHIN Performance Agreement, to establish their respective performance obligations. These include the requirements that:

(a) the Ministry develop, maintain and support health data standards, and communicate health data reporting requirements and standards to the LHIN and health service providers; and

(b) the LHIN require health service providers (such as LTC Homes) to submit data and information as required by the Ministry, CIHI, and other third parties.

By way of example, the Ministry and South West LHIN Performance Agreement, 2013-2015, dated April 1, 2013 (LTCI00055181) [1] is attached as **Exhibit "B"**.

12. The LHINs, in turn, enter into Long-Term Care Home Service Accountability Agreements ("LSAAs") with LTC Homes, which require the LTC Homes to conduct the RAI-MDS assessments of residents and submit the information to CIHI at least quarterly. By way of example, the South West LHIN and Caressant Care Woodstock LSAA, April 1, 2013-March 31, 2016 (LTCI00055279) [2] is attached as **Exhibit "C"**.

13. Generally, my understanding is that the RAI-MDS instruments are to be completed for residents of LTC Homes upon admission, quarterly, and upon significant change of clinical status (ex. functional, clinical, weight loss, new symptoms such as pain or depression, etc).

14. The HSIM Division also obtains some information from the Office of the Chief Coroner in respect of death investigations conducted, pursuant to a data sharing agreement completed in

[1] Exhibit 9, Ministry OR, Vol. 2(b), Tab 47.
[2] Exhibit 9, Ministry OR, Vol. 2(b), Tab 47. Other examples such as the Hamilton Niagara Haldimand Brant Local Health Integration Network (LHIN) and Revera Long Term Care Inc. LSAA in respect of Telfer Place, April 1, 2013-March 31, 2016 (LTCI00055151) and South West LHIN and Meadow Park (London) Inc. LSAA, April 1, 2013-March 31, 2016, (LTCI00055305).

October 2016 (LTCI00072899) and amended in May 2018 (LTCI00072900). Copies of these agreements are attached as **Exhibits "D"** and **"E"**, respectively. The value of this data to the HSIM Division is where it provides information that only the investigating coroner could assess, such as cause of death and some of the antecedent circumstances leading up to death. In addition, it provides data about deaths that occur in a non-health care setting.

The General Methodology for IMDA Projects

15. As outlined above, the Health Analytics and Insights Branch ("HAIB") and the Health Data Sciences Branch ("HDSB") of the Division are tasked with obtaining and describing the aspects of the health care system, for purposes including planning, system design, and operational, accountability and/or performance monitoring purposes.

16. When these branches are asked to consider and analyze an issue, the first step is to review methodologies published in the public domain to see if the project has been attempted or considered previously. These sources include published academic literature and grey literature (which is materials and research produced by organizations or individuals that have not undergone traditional academic peer review and publication). The CIHI, the Institute for Clinical Evaluative Sciences, and Statistics Canada are frequent publishers of healthcare reports which include detailed methodology. These organizations often provide a starting point for any IMDA investigation.

17. If a similar project has been attempted or considered before, the next step is to consider whether it could be replicated in Ontario, based on the available data sources. The branches will then validate the selected approach or methodology with subject matter experts.

Assessing Mortality in Long-term Care Homes: Initiation and Overview of the Project

18. In December 2016, the Associate Deputy Minister of Policy and Transformation of the Ministry called a meeting that included myself, the Assistant Deputy Minister of the Long-term Care Homes Division of the Ministry (the "LTCH Division"), and the Chief Coroner for Ontario. The topic of the meeting was to explore whether Elizabeth Wettlaufer's offences (the "Offences") could have been detected and what, if anything, could be done in the future to detect such crimes earlier.

19. I expressed my belief that it may be possible to complete a data-driven project to determine if the Offences could have been detected (the "Project"). The Project was undertaken by the then Health Analytics Branch ("HAB"), from January to September 2017. The Project was an exploratory effort (also known as proof of concept) and remains at a preliminary stage. The Project is described in the PowerPoint presentation "Detecting LTC Homes with Excessive Rate of Mortality" dated September 13, 2017 (the "PowerPoint") (LTCI00070312_01), a copy of which is attached as **Exhibit "F"**.[3] The findings of the Project, as set out in the Powerpoint and in this Affidavit, should be considered preliminary as well.

20. Given that the Project remains at a preliminary stage, at this point, no decisions have been made to apply the Project to the LTC sector or to launch the approach described in this Affidavit. The Project describes one approach to assess deaths in LTC Homes using available data and a prediction algorithm, to determine if individual LTC Homes have a higher number of deaths than expected. This method requires additional steps to validate the assumptions and approach with additional scientific and clinical experts and representatives from the LTC sector.

[3] Exhibit 9, Ministry OR, Vol 1(b), Tab 102. This version of the Powerpoint has been redacted to remove identifying information about various LTC Homes.

Background on the Methodological Approach Selected for the Project

21. There are broad categories of factors associated with outcomes such as mortality in the LTC setting. Two major categories are:

(a) Factors associated with the individual residents. These would include characteristics such as age, sex, functional status, and morbidity (level of sickness); and

(b) Factors associated with the LTC Home such as the structure and processes used to care for residents.

22. Any approach that attempts to detect LTC Homes with higher numbers of deaths than expected will need to adjust for the differing resident characteristics within each home. For example, a LTC Home with residents who are older and sicker than an otherwise similar LTC Home with younger and healthier residents would have a higher number of deaths. Without adjusting for the characteristics of residents, it would be impossible to determine which LTC Homes had a higher number of deaths than what would otherwise be expected.

Standardized Mortality Ratio Approach to Detecting Unexpected Death

23. The Project team selected a Standardized Mortality Ratio approach to measuring and comparing LTC Homes. This approach has been used by CIHI to measure and compare mortality in Canadian hospitals for approximately the last ten years.

24. The Standardized Mortality Ratio approach attempts to isolate the association between resident mortality and the care processes in the LTC Home by removing the impact of resident characteristics associated with death. This process is called "risk adjustment" in statistical terms

and is a widely adopted and accepted practice when comparing outcomes in healthcare to ensure valid comparisons. This process is used to ensure that only the variable of interest is affecting the outcome of interest. For example, if one were to compare mortality rates across jurisdictions, the impact of age differences in the different jurisdictions might be adjusted or equalized so as to avoid a conclusion that one jurisdiction had a higher rate of death just because of a higher proportion of older people.

25. In the case of applying the Standardized Mortality Ratio to LTC Homes, risk adjustment ensures that the impact of factors such as age, sex, and level of sickness are equalized across all LTC Homes. Any remaining impact on death is then attributable to factors related to a specific LTC Home. The purpose of the risk[4] adjustment is to measure the number of deaths that are expected so that any death above and beyond this number are considered unexpected from a statistical perspective.

The Process Undertaken for the Project: Creating a LTC Home Standardized Mortality Ratio

26. For the purposes of the Project, the Standardized Mortality Ratio was defined by the number of observed deaths in a given period divided by the number of expected deaths. For example, a LTC Home with 10 observed deaths and 10 expected deaths would have a ratio of 1.0. A LTC Home with 10 observed deaths and 20 expected deaths would have a ratio of 0.5 which means that there were 50% fewer deaths than expected.

27. Creating a LTC Home Standardized Mortality Ratio required several steps:

[4] In this statistical context, risk is not good or bad, it is simply a measure of probability of a certain outcome.

(a) Determining the method to estimate the number of expected deaths: This step involved creating a risk-adjusted prediction algorithm that predicted the number of expected deaths in each LTC Home over a given time period. The prediction algorithm used routinely available healthcare data.

(b) Extracting the data: Once the prediction algorithm had been defined, this step was required to extract the specific data relating to LTC Home residents and the desired time periods from the large healthcare administrative databases held by IMDA.

(c) Determining the number of observed deaths: It was important to capture all deaths of LTC residents regardless of whether the death occurred in the LTC Home or another institutional setting (for example, after a resident had been transferred to hospital). This meant that the Project team captured the number of deaths in LTC Homes, as well as in hospitals and several other institutional settings for which data was available.

(d) Preparing the data: This step included data cleaning (i.e. excluding data with missing values) and transformation of variables (i.e. changing categorical variables – ordinal and nominal numbers – into several binary variables).

(e) Running the prediction algorithm and calculating a LTC Standardized Mortality Ratio: This step used the method determined in Step (a) and the extracted and prepared data to determine the observed number of deaths in each LTC Home and the number of expected deaths, which provided the values required to calculate a mortality ratio for each LTC Home.

Each step will be described in more detail.

(a) Determining the method to estimate the number of expected deaths

28. Creating the prediction algorithm involved the Project team selecting an appropriate statistical approach for the prediction and identifying relevant variables or "risk factors" predictive of death for consideration to include in the prediction algorithm. The process undertaken by the Project team is elaborated below.

29. The Project team decided to use two different approaches to creating the prediction algorithm, as follows:

(a) a traditional statistical approach, which attempts to select variables of interest *a priori* though consultation with clinical experts and published materials; and

(b) an automated approach where variables are selected through machine learning techniques. Specifically, the machine learning techniques used by the Project team were Random Forest, Decision Tree, and Extreme Gradient Boost. Machine learning is a subset of artificial intelligence that uses statistical techniques to give computers the ability to "learn" with data and improve, without being explicitly programmed, through the construction of inferential statistical methods and computer-science algorithms. A machine learning model computes multiple permutations of predictor variables and learns from each one to make the best data-driven predictions.

30. Examples of the risk factor variables selected for potential inclusion in the prediction algorithm include (as listed on Slide 10 of the PowerPoint):

(a) Socio-demographic factors, such as sex and age;

(b) Health conditions, such as congestive heart failure, dementia, or cancer;

(c) Conditions reported in the most recent RAI-MDS instrument completed for a resident, such as the cognitive performance scale, depression scale, pain scale, weight loss, dehydration, edema, shortness of breath, delusions, leaving food uneaten, etc; and

(d) Acuity level, considering factors such as previous hospital admissions and/or emergency department attendances within set periods of time, as well as difficulties with activities of daily living or cognitive status deterioration.

31. Different variables were measured for different periods of time (as identified on Slide 11 of the PowerPoint). For example:

(a) Dehydration, edema, shortness of breath, vomiting and leaving food uneaten were measured for the 7 days prior to assessment[5]; whereas

(b) Difficulties with activities in daily living and cognitive status deterioration were based upon a comparison from 90 days ago.[6]

32. Under the machine learning approach, all the variables available in the RAI-MDS instruments were used to predict deaths, i.e. all approximately 600 variables in the assessment instruments were considered for potential inclusion in the prediction by the automated machine learning approach.

[5] Seven days was selected as this is how the question is worded on the RAI-MDS instrument.
[6] 90 days was selected as this is how the question is worded on the RAI-MDS instrument.

33. Under the traditional statistical approach, the Project team determined which RAI-MDS instrument variables were most appropriate to predict death *a priori* using the following steps:

(a) A review of the literature to determine whether any other entity had previously attempted to predict mortality in a LTC Home or similar institution over certain periods using data derived from RAI-MDS instruments. The Project team found five papers that were applicable and relevant, which were utilized as a starting point for the model.[7] Copies of those five papers (LTCI00072901, LTCI00072902, LTCI00072903, LTCI00072904 and LTCI00072905) are attached collectively as **Exhibit "G"**;

(b) The Project team then discussed internally how the approaches described in the literature could be implemented in Ontario, based on the available data sources; and

(c) The Project team consulted with clinical subject matter experts at the Office of the Chief Coroner, to obtain their input on the model and variables considered. The Project team specifically consulted the Chief Coroner for Ontario, Dr. Dirk Huyer, to confirm that the contemplated variables were clinically relevant and appropriately predictive of expected deaths. Dr. Reuven Jhiard, Deputy Chief Coroner, also provided expert clinical input into which variables would be most

[7] Brink and Kelley. Death in Long-term Care: A Brief Report Examining Factors Associated with Death within 31 Days of Assessment. Palliative Care: Research and Treatment 2015:9 1–5; Davina Porock, Debra Parker Oliver, Steve Zweig, Marilyn Rantz, David Mehr, Richard Madsen, and Greg Petroski. Predicting Death in the Nursing Home: Development and Validation of the 6-Month Minimum Data Set Mortality Risk Index. Journal of Gerontology: MEDICAL SCIENCES 2005, Vol. 60A, No. 4, 491–498; Kuo-Ping Yeh, Ming-Hsien Lin, Li-Kuo Liu, Liang-Yu Chen, Li-Ning Peng, Liang-Kung Chen. Functional decline and mortality in long-term care settings: Static and dynamic approach. Journal of Clinical Gerontology & Geriatrics 5 (2014) 13-17; Elia Biganzoli, Patrizia Boracchi, Luigi Mariani and Ettore Marubini. Feed Forward Neural Networks for the Analysis of Censored Survival Data: A Partial Logistic Regression Approach. Statistics in Medicine Statist. (1998) Med. 17, 1169-1186; O. Grigg and V. Farewell. An overview of risk-adjusted charts. J. R. Statist. Soc. A (2004) 167, Part 3, pp. 523–539

valuable to predict death during the consultation meeting. The Project team did not make any modifications to the model or variables considered as a result of the consultations.

The Project team also had to define the population that was being considered in the prediction algorithm for the predefined period of time. The population was defined as LTC Home residents in a 12 month fiscal year period (i.e., the 12 month study period selected to be reviewed for that model).

(b) Extracting the data

34. Once the predictive algorithm had been defined, the Project team had to extract the identified data relating to LTC Home residents for the desired time periods from the large healthcare administrative databases held by IMDA. These databases included the Registered Persons Database and several databases collected by CIHI covering other institutional settings (hospitals, complex continuing care, rehabilitation hospitals, etc.).

35. The data was extracted according to the time periods and variables described above and in the PowerPoint.

(c) Determining the number of observed deaths

36. To measure the observed number of deaths, the model reviewed the above-noted databases to determine the number of deaths at LTC Homes during the 12 month study period. For the purposes of the Project, death was defined as death in the LTC Home or in another institution within 30 days of discharge from a LTC Home.

37. For the 12 month period of time demonstrated in the PowerPoint (FY2015/16 – as seen on Slide 14), 21,074 residents of LTC Homes died, representing 19.6% of residents. The time periods assessed included fiscal years 2010/11 through 2016/17, though these results were not incorporated into the PowerPoint.

(d) Preparing the data

38. As outlined above, the Project team then engaged in data cleaning (i.e. excluding data with missing values) and transformation of variables (i.e. changing categorical variables – ordinal and nominal numbers – into several binary variables).

(e) Running the prediction algorithm and calculating a LTC Standardized Mortality Ratio

39. The prediction algorithm was then run on the extracted and prepared data using the traditional statistical approach, and the three machine learning approaches (i.e. Random Forest (Slide 31-36), Decision Tree (Slides 37-41) and Extreme Gradient Boosting (Slides 42-45)) to calculate the number of expected deaths. These machine learning approaches are all based on the concept of a decision tree analysis. A decision tree attempts to predict the value of a target variable (the probability of a LTC resident dying) based on a sequence of Yes/No questions ("decisions") about one or more explanatory variables which are the risk factors. Specifically:

- Decision Tree is built using the whole dataset considering all the risk factor variables;
- Random Forest is based on the decision tree principle but instead of using the whole set of data it builds multiple trees based on random selections from the

entire dataset. Each individual decision tree is built independently and simultaneously. The model with the best performance is selected automatically.

- Extreme Gradient is based on the same principle as Random Forest with the only difference being that the trees are built one at a time and each tree helps to improve on the errors made by the previous tree.

40. The predicted number of deaths were adjusted for different resident characteristics in the following manner. Individual level resident data, as described above, was used to predict the probability of death for individual residents. In the next step, all the probabilities of dying for individual residents are added up at the LTC Home level to come up with the expected number of deaths at the home level. This produces a number of expected deaths for each LTC Home as if all Homes had residents with similar characteristics.

41. After the prediction algorithm was run, the Project team calculated the observed and expected deaths in each LTC Home for a variety of time periods. It could then compare the rate of observed deaths to the rate of expected deaths, and identify those LTC Homes that had the higher ratios of observed deaths over expected death.

Assessing and Validating the Results of the Prediction Algorithms

42. The performance of the prediction algorithms was assessed using statistical tests that are broadly used in the scientific literature. These measures seek to describe the proportion of variance in the outcome variable - expected deaths - that are explained by the input variables and risk factors. Prediction algorithms that explain more of this variance would be thought to have better performance.

43. After the observed and expected deaths in each LTC Home were calculated, the Project team conducted validation sessions with scientists from an independent research organization called the Institute for Clinical Evaluative Sciences (the "Institute") in Toronto. All of these scientists were also faculty members of the University of Toronto. The Project team also undertook validation sessions with an additional professor at the University of Toronto. Both the Institute and the professor had several suggestions which the Project team explored, but found that these changes deteriorated the model performance without substantially changing the results. As such, the Project team did not make any modifications to the originally designed model as a result of the validation sessions.

44. A series of visualizations and numerical tests were applied to the calculations, as shown on Slides 20 – 27, 26, 40-41, 45, 48 – 55 of the PowerPoint, to facilitate detecting LTC Homes that might be outliers. These steps included the ranking of the Standardized Mortality Ratios, assessing the confidence intervals associated with the ratios, and creating benchmark levels. This was done to provide useful ways to show the calculations and to demonstrate the robustness of the calculations.

Coroner Data

45. The data sources used for the Project included CIHI data and the information in the Registered Persons Database. The Project did not utilize data from the Office of the Chief Coroner.

46. It is possible that additional information could be incorporated into the model from the Office of the Chief Coroner, such as information on the circumstances of death. I anticipate that such information could theoretically be fed back into the model to evaluate its accuracy (i.e. as a

validation tool). However, there are limitations to the usefulness of the Office of the Chief Coroner data, as such data has very little predictive value (i.e. it constitutes discovery after the fact), and the data is not complete (i.e. is not obtained for each deceased resident of LTC Homes).

47. One factor that the HSIM Division will consider in any project is the utility of collecting new and additional information versus the reporting burden. It is questionable whether there is additional coroner-specific data that would be sufficiently beneficial to outweigh the reporting burdens, especially noting that this data would not be comprehensive due to the nature of the coronial investigation process.

The Findings of the Project

48. As indicated on Slide 58 of the PowerPoint, the findings of the Project included that:

(a) all approaches (traditional statistical and machine learning) identified a similar set of predictor variables and of LTC Homes with higher numbers of observed deaths than expected deaths; and

(b) the similar output from the different approaches serve as a form of validation because the different statistical techniques resulted in similar risk factors and similar rankings of LTC Homes. The output from the predictive algorithms could be used to flag LTC Homes that appear to have higher number of deaths than expected.

49. The different predictive statistical approaches ultimately produced similar results, but the HAIB/HDSB assessed the machine learning approach to be the better option going forward, as

the model could be run on an automatic basis. Slide 46 of the PowerPoint includes a summary of the pros and cons of each of the three methods of machine learning used by the Project team. Of the machine learning options, the Extreme Gradient Boosting (XGBoost) would be the model HAIB/HDSB would suggest for regular monitoring. The model performance with XGBoost was better than with other techniques using the previously described measures of model performance. Furthermore, I am aware that XGBoost is consistently one of the top performing techniques in competitions designed to find successful prediction models.

50. In my view, the Project has produced a methodologically sound, potentially valuable approach that calculates the expected number of deaths for each LTC Home over a past time period based on the health status characteristics of the residents. It also creates a standardized ratio by dividing the observed number of deaths by the expected number of deaths, which is comparable across all LTC Homes. Based on this, the approach can flag particular LTC Home as having higher than expected number of deaths. Of note, the ratio is agnostic to the mechanism of death, i.e. it is not possible to determine the cause of higher numbers of observed deaths strictly from this tool.

51. One of the benefits of the tool is that it is comprehensive, in that all recorded deaths and all residents are included in the predictive model. Each LTC Home can be scored and ranked using this approach.

52. The model could also be expanded to include other events that might be predictive of mortality if comprehensive sources of data exist, including all hospital admissions and emergency department visits or for sub-sets of visits of interest such as fractures, pressure ulcers, pneumonia, and urinary tract infections (for example).

53. It is still to be determined whether and how the Project should best be implemented and by whom. If it is ultimately used by a partner, the uses to which the model is put could be fed back into the model in order to improve its results. However, policy and practical decisions regarding any implementation of this approach are premature as the Project is still at a proof of concept stage.

54. Presently, the HSIM Division has identified the LTCH Division and the Office of the Chief Coroner as potential partners that could utilize the model and implement the data obtained from the Project. No decision has yet been made as to what use (if any) this Project will have going forward. There have been no further discussions with the Ministry or the Office of the Chief Coroner about the Project at this time.

55. To my knowledge, no other jurisdictions or health systems (either within Canada or internationally) has attempted a comparable project of attempting to predict mortality in the LTC Home setting although, as mentioned previously, a similar approach is used in the hospital setting as a quality improvement strategy. Ontario is well-suited to implement this type of approach, as in this single payer system, the Ministry has person-specific data points associated with virtually every provincially-funded health care transaction in the Province.

The Limitations and Challenges of the Project

56. As indicated on Slides 61 and 62 of the PowerPoint, there are a number of limitations and challenges with this model, including that:

(a) The prediction algorithm used to calculate the number of expected deaths is still at a research stage;

(b) The number of expected deaths is determined by the risk factors included in the prediction algorithm which is defined by the data available. It is possible that certain risk factors are not being included because there is no data available for these risk factors either because they are not routinely collected in the RAI-MDS instruments or the selected prediction algorithm did not include these risk factors;

(c) There is no perfect way to validate this type of approach because there is no systematic way to know the circumstances leading to every death in the LTC setting, which means it is impossible to know what the true number of expected deaths would be;

(d) The model does not isolate the cause of death or provide any details on the organizational structure or processes contributing to or associated with death;

(e) many LTC Homes are small, meaning that:

(i) the associated confidence interval for adjusted rate or expected deaths is wide; and

(ii) the rates of death are not stable, so it is difficult to reliably identify a signal even if two years of data is analyzed; and

(f) the use of the variables or risk factors drawn from a resident's latest RAI-MDS instrument completed may reflect the status of dying, i.e. sicker residents are assessed more frequently within the days of their death.

57. An additional limitation of the Project is that it relies on observational data. This type of data arises when people are observed in different circumstances over which there is no control of

the factors. In an experimental study, people can be randomly allocated between groups and factors are controlled so that individual effects can be isolated to determine cause and effect. Prediction algorithms using observational data can only reveal associations. For example, on Slide 19, the relationship between the risk factors and mortality is displayed. One cannot say with certainty that any of those factors caused the death, only that they are associated with and predictive of death.

58. In sum, with smaller LTC Homes, a small number of deaths can substantially alter the mortality ratio. Random fluctuations in the number of deaths could cause a small LTC Home to substantially move up or down in ranking based on the higher number of observed deaths to expected deaths. In addition, if the Project were to be implemented for use going forward, the HSIM Division would want input from the sector itself, which could impact which model is utilized.

The Findings of the Project re: The Offences

59. Slide 20 of the PowerPoint represents the retrospective analysis of whether the Offences could or would have been detected, had the Project been in place at the material time. Three periods of time were reviewed, being: April 2011 to March 2012, July 2011 to June 2012, and April 2013 to March 2014. These coincided with some of the Offences committed at Caressant Care – Woodstock ("CCW").

60. The model ranked LTC Homes for each of those periods of time based on their respective adjusted rate of observed deaths to expected deaths. The higher adjusted rate of observed deaths to expected deaths meant that there were more observed deaths than were expected at a LTC Home based on the models used by the Project team, and the higher the ranking of the LTC

Home. In other words, the LTC Homes ranked highest (1, 2, 3…) had the highest adjusted rates of observed death relative to what was expected, and those ranked lowest (631, 632, 633…), which had the lowest adjusted rates of observed death relative to what was expected.

61. As indicated on Slide 20, CCW's mortality ratio was ranked 61 or 64 out of 633 LTC Homes reviewed for the time periods identified. In other words, for the time periods identified above, CCW had the 61st or 64th highest adjusted rate of observed deaths to expected deaths (i.e. was in the top 10% of LTC Homes in terms of more observed deaths than expected). The PowerPoint (at Slide 20) focused on CCW, as this was the LTC Home where the majority of the murders took place, as known to the Project team through media reports.

62. My conclusion based on the model is that it would have been virtually impossible to contemporaneously or retrospectively detect the Offences from a data perspective. Because the murders were spread out over several years at CCW, with a rate of one, two or three per year, the model would not have been sensitive enough to detect the increased death rate as a result of the Offences. In other words, the ranking of CCW would not have changed significantly as a result of the Offences either in a particular year or from when comparing years. However, in an instance more analogous to the Harold Shipman murders in the United Kingdom, where the rate of actual deaths far exceeded the rate of expected deaths for a particular institution in a particular year, this model may be able to detect that increased rate.

63. At the request of Commission Counsel and for the purposes of this Inquiry, I requested the Project team confirm the mortality ratio for CCW as compared to the same list of 633 LTC Homes in the years during and following the Offences. The table below demonstrates the ranking of CCW based on three different machine learning methods utilized:

LTC Home	Method	Year						
		2010	2011	2012	2013	2014	2015	2016
CCW	RF	62	70	63	72	90	122	55
	Logistic	89	70	69	66	104	175	79
	XGB	65	73	78	74	169	186	78

AFFIRMED BEFORE ME at the City of Toronto,)
in the Province of Ontario, on August 29, 2018)
)
)

Commissioner for Taking Affidavits

Dr. Michael Hillmer

Jessica Taylor Kras, a Commissioner, etc.,
Province of Ontario,
while a Student-at-Law.
Expires May 30, 2020.

This is Exhibit "A" referred to in the Affidavit of Dr. Michael Hillmer sworn August 29, 2018

Commissioner for Taking Affidavits (or as may be)

Jessica Taylor Kras, a Commissioner, etc.,
Province of Ontario,
while a Student-at-Law.
Expires May 30, 2020.

MICHAEL P. HILLMER, PhD

Education

PhD (Clinical Epidemiology) 2007
University of Toronto
Supervisor : P.A. Rochon, MD, MPH

MSc (Pharmacology) 1999
University of Toronto
Supervisor : S.M. MacLeod, MD, PhD

BSc (Honours Biochemistry) with high honours 1997
Carleton University, Ottawa

Experience

Executive Director, Information Management, Data, and Analytics, Health System Information Management Division, Ontario Ministry of Health and Long-Term Care — 2016 – Present

Assistant Professor (Status Only), University of Toronto — 2015 – Present

Director, Research, Analysis and Evaluation Branch, Ontario Ministry of Health and Long-Term Care — 2013 - 2016

Lecturer, University of Toronto — 2007 - 2015

Manager, Chronic Disease Unit, Ontario Ministry of Health and Long-Term Care — 2006 - 2012

Project Manager, Health Council of Canada — 2006 - 2007

Independent Consultant: Health services and policy research — 2004 - 2005

- Ontario Ministry of Health and Long-Term Care
  - Health Results Team – Critical Care Transformation Project
  - Minister of Health's Patient Safety Task Force
- Sunnybrook and Women's College Health Science Centre
  - Performance measurement in the general internal medicine division

Clinical Study Manager, Allied Clinical Research — 2000 - 2003

Grant Funding

Title		Grant Program	Agency	Amount (CDN)	Duration
Building Access to Specialist Care for remote, rural populations through eConsultation (BASE).	Co-Investigator	Partnerships for Health System Improvement (PHSI)	CIHR	$213,890	2016-2018
Exploring the association between the ownership status of Ontario's long-term care facilities and the quality of care	Co-applicant	Operating Grant	CIHR	$221,407	2004-2008
Putting patients first: A national patient-centered evaluation of electronic consultations to improve access to specialists	Co-Investigator	Project Grant	CIHR	$100,000	2016-2017
Systematic Prospective Assessment of Rapid Knowledge Synthesis - SPARKS Study	Co-Investigator	Project Grant	CIHR	$279,281	2016-18
Seniors- Adding Life to Years (SALTY)	Co-Investigator	Team Grant: Late Life Issues	CIHR	$699,616	2016-2018
Self-Formulated Conditional Plans for Changing Health Behaviour: A Systematic Review	Knowledge User	Knowledge Synthesis Grant	CIHR	$99,852	2013-14
Enhancing Uptake of Systematic Reviews	Knowledge User	Operating Grant	CIHR	$305,382	2014-17
Institutional characteristics of long-term care facilities in Ontario and their association with clinical outcomes	Principle Investigator	CIHR IHSPR Doctoral Research Award	CIHR	$63,417	2002-2006
Disseminating best practices in optimising Audit and Feedback: beyond business as usual	Co-Principal Investigator/ Knowledge User	Planning and Dissemination Grant - Institute Community Support	CIHR	$10,000	2015-16
Optimizing the health of seniors: The development, implementation, and evaluation of an electronic multi-chronic disease tool (e-MCD)	Knowledge User	Oper Grant:eHealth Innov Partnership Program(eHIPP)-Seniors w Complex Care Needs	CIHR	$276,958	2015-2018
Moving towards self management support	Knowledge User	Meetings, Planning and Dissemination Grant: PHSI	CIHR	$15,000	2008-2009
Ontario SPOR SUPPORT Unit	Knowledge User	SPOR SUPPORT Units	CIHR	$14,255,000	2013-18

Maximizing population benefit and impact by applying population risk tools: A new direction for diabetes prevention in Canada	Knowledge User	Operating Grant	CIHR	$100,000	2014-15
Quantifying future risk and burden of type 2 diabetes in Canada: tools to inform the prevention of obesity and diabetes	Knowledge User	Operating Grant-PA: INMD Start Up Funds (bridge funding) - Assistant Professors	CIHR	$100,000	2012-13
Establishing the Chair's Advisory Council (CAC) for the Inaugural Heart and Stroke Foundation(HSF)/Northern Ontario School of Medicine (NOSM) Aboriginal and Rural Health Research Chair	Knowledge User	Planning Grants - PA: First Nations, Inuit or Métis Planning Activities	CIHR	$25,000	2013-14
Measuring and improving the quality of ambulatory care for people with cardiovascular risk factors and/or chronic cardiovascular diseases	Knowledge User	Team Grant: Chronic Disease Risk and Intervention Strategies	CIHR	$1,998,740	2011-17
Measuring and improving the quality of care for patients with cardiovascular risk factors and/or chronic cardiovascular diseases	Knowledge User	Team Grant: Chronic Disease Risk and Intervention Strategies - LOI	CIHR	$10,000	2011-12
		TOTAL		**$18,773,543**	

Awards and Scholarships

1. CHSRF/CIHR Genesis Fellowship Award (2004-2005)
2. CIHR Doctoral Research Award (2002-2005)
3. Northwater Capital Management Award (2003)
4. University of Toronto Open Scholarship – (2001)
5. Father Sean O'Sullivan Research Centre Fellowships – (1998 and 1999)
6. University of Toronto Open Scholarship - (1998)
7. Dean's List - Carleton University - (1997)

Peer-reviewed Publications

1.	Marquez C, Mascarenhas AJ, Jassemi S, Park J, Moore JE, Blaine C, Bourdon G, Chignell M, Ellen ME, Fortin J, Graham ID, Hayes A, Hamid J, Hemmelgarn B, **Hillmer M**, Holmes B, Holroyd-Leduc J, Hubert L, Hutton B, Kastner M, Lavis JN, Michell K, Moher D, Ouimet M, Perrier L, Proctor A, Noseworthy T, Schuckel V, Stayberg S, Tonelli M, Tricco AC, Straus SE. Enhancing the uptake of systematic reviews of effects: what is the best format for health care managers and policy-

	makers? A mixed-methods study. Implementation Science. 2018 13:84.
2.	Squires J, Graham I, Hutchinson A, Bashir K, Sales A, Mackie C, Dorrance K, Lavis, J, Curran J, Francis J, Michie S, Brehaut J, Ivers N, Vine J, Noseworthy T, **Hillmer M**, Grimshaw J. S109 What attributes of context are relevant to dissemination and implementation? Perspectives from healthcare professionals, health system stakeholders, and change agents internationally. Proceedings from the 10th Annual Conference on the Science of Dissemination and Implementation. Arlington, VA, USA. December 2017. Implementation Science. 2018 13:728
3.	**Hillmer M**, Sandoval G, Elliot JA, Jain, M, Barker T, Prisniak A, Astley S, Rosella L. Diabetes risk reduction in primary care: evaluation of the Ontario Primary Care Diabetes Prevention Program. Canadian Journal of Public Health. 2017 Jun 16;108(2):e176-e184
4.	McGillion M, Yost J, Turner A, Bender D, Scott T, Carroll S, Ritvo P, Peter E, Lamy A, Furze G, Krull K, Dunlop V, Good A, Dvirnik N, Bedini D, Naus F, Pettit S, Henry S, Probst C, Mills J, Gossage E, Travale I, Duquette J, Taberner C, Bhavnani S, Khan JS, Cowan D, Romeril E, Lee J, Colella T, Choinière M, Busse J, Katz J, Victor JC, Hoch J, Isaranuwatchai W, Kaasalainen S, Ladak S, O'Keefe-McCarthy S, Parry M, Sessler DI, Stacey M, Stevens B, Stremler R, Thabane L, Watt-Watson J, Whitlock R, MacDermid JC, Leegaard M, McKelvie R, **Hillmer M**, Cooper L, Arthur G, Sider K, Oliver S, Boyajian K, Farrow M, Lawton C, Gamble D, Walsh J, Field M, LeFort S, Clyne W, Ricupero M, Poole L, Russell-Wood K, Weber M, McNeil J, Alpert R, Sharpe S, Bhella S, Mohajer D, Ponnambalam S, Lakhani N, Khan R, Liu P, Devereaux PJ. Technology-Enabled Remote Monitoring and Self-Management - Vision for Patient Empowerment Following Cardiac and Vascular Surgery: User Testing and Randomized Controlled Trial Protocol. JMIR Res Protoc. 2016. 1:5(3):e149
5.	Tricco AC, Cardoso R, Thomas SM, Motiwala S, Sullivan S, Kealey MR, Hemmelgarn B, Ouimet M, **Hillmer MP**, Perrier L, Shepperd S, Straus SE. Barriers and facilitators to uptake of systematic reviews by policy makers and health care managers: a scoping review. Implementation Science. 2016. 11:4.
6.	Ivers N, Tricco AC, Trikalinos TA, Dahabreh IJ, Danko KJ, Moher D, Straus SE, Lavis JN, Yu CH, Shojania K, Manns B, Tonelli M, Ramsay T, Edwards A, Sargious P, Paprica A, **Hillmer MP,** Grimshaw JM. Seeing the forests and the trees-innovative approaches to exploring heterogeneity in systematic reviews of complex interventions to enhance health system decision-making: a protocol. Systematic Reviews. 2014. 3(1):88.
7.	Bronskill SE, Rochon PA, Gill SS, Herrmann N, **Hillmer MP**, Bell CM, Anderson GM, Stukel TA. The relationship between variations in antipsychotic prescribing across nursing homes and short-term mortality: quality of care implications. MedCare. 2009 Sep;47(9):1000-8.
8.	**Hillmer MP**, Housser J, Watson DE. Improving prescribing, improving health. 2008. Healthcare Quarterly. 11(1):68-74.
9.	**Hillmer MP**, Redelmeir DA. Exercising privacy rights. Canadian Medical Association Journal. 2007. CMAJ. 177(12):1542-4.
10.	McFarlane PA, **Hillmer MP,** Dacouris N. A change from subcutaneous to intravenous erythropoietin therapy reduces cost-effectiveness of anemia therapy in hemodialysis patients. Nephron Clinical Practice. 2007. 107(3):c90-6. Epub 2007 Sep 21.
11.	**Hillmer MP**, Watson DE, Prebtani F, Leeb K. Why Health Care Renewal Matters: Lessons from Diabetes. 2007. Health Care Papers. 7(4):54-60.
12.	**Hillmer MP**, Rochon PA, Stukel TA, Bronskill SE, Gomes T, Sykora K, Wodchis W, Kopp A, Gurwitz JH, Anderson GM. Variation in nursing home antipsychotic prescribing rates. 2007. Archives of Internal Medicine. 167(7):676-683.
13.	Hillmer M, Krahn M, **Hillmer MP**, Pariser P, Naglie G. Prescribing patterns for Alzheimer disease:

	Survey of Canadian family physicians. 2006. *Canadian Family Physician*. 52(2):208-209.
14.	**Hillmer MP**, Wodchis W, Teare GF, Naglie G, Bronskill SE, Gill SS, Anderson GM, Rochon PA, Fries BE. Skilled nursing facility rehabilitation and discharge to home after stroke. 2005. *Archives of Physical Medicine and Rehabilitation*. 86(3):442-448.
15.	**Hillmer MP**, Wodchis WP, Gill SS, Anderson GM, Rochon PA. Nursing Home Profit Status and Quality of Care: Is there any evidence of an association? *Medical Care Research and Review*. 2005. 62(2):139-166. **Listed on the Journal's "Most Cited Articles" list. Ranked 15th of all time as of February 2016**
16.	Gill SS, Bronskill SE, Mamdani M, Sykora K, Li P, Shulman KI. Anderson GM, **Hillmer MP**, Wodchis WP, Rochon PA. Representation of patients with dementia in clinical trials of donepezil. 2004. *Canadian Journal of Clinical Pharmacology*. 11 (2): e274-e285
17.	Lee PE, Gill SS, Freedman M, Bronskill SE, **Hillmer MP**, Rochon PA. Atypical Neuroleptic Therapy in the Treatment of Behavioural and Psychological Symptoms of Dementia: A Systematic Review. 2004. *British Medical Journal*. 329(7457):75 Selected for abstraction by Evidence-Based Mental Health (Module 32, Dec. 6)
18.	**Hillmer MP**, Salama S, MacLeod SM. Limitations of the athymic mouse model for the study of keloid scars. 2002. *Canadian Journal of Plastic Surgery*. 10(2):56-61.
19.	**Hillmer MP**, MacLeod SM. Experimental Keloid Scar Models – A Review of the Methodological Issues. 2002. *Journal of Cutaneous Medicine and Surgery*. 6(4):354-9.

Theses

1. **Hillmer MP**. The association between the ownership status of Ontario's long-term care homes and the quality of resident care. PhD Thesis. University of Toronto. 2007.
2. **Hillmer MP**. Pharmacotherapy of keloid scars. MSc Thesis. University of Toronto. 2000.
3. **Hillmer MP**. Isolation and characterization of the multicatalytic proteasome complex from the gallfly, *"Epiblemma scudderiana"*. Undergraduate Thesis. Department of Biochemistry. Carleton University. 1997.

Peer-reviewed Abstracts

1.	Wang S, Shi S, Rangrej J, Girdler S, Custers T, **Hillmer M**, Malikov K. Advanced analytics of the Vitamin D testing in Ontario as a case study of public policy, abstract 305, Oral presentation. Canadian Association of Health Services and Policy Research Conference. Montreal, Canada. May 2018, Montreal, Canada.
2.	**Hillmer M**, Fréel S, Cobbler C, Clemmensen A, Paprica A, Srinivasan V, Fenton S. Measuring Health Research Funding Impact in Ontario: The Health System Research Fund (HSRF) Impact Assessment Framework. Canadian Association of Health Services and Policy Research Conference. Montreal, Canada. May 2015.
3.	**Hillmer M**, Sandoval GA, Elliott JA, Jain M, Barker T, Prisniak A, Astley S, Rosella L. Diabetes risk reduction in primary care: evaluation of the Ontario Primary Care Diabetes Prevention Program. Canadian Association of Health Services and Policy Research Conference. Montreal, Canada. May 2015.
4.	Baker GR, Fairclough L, **Hillmer M**, Jackson T. Creating Capacity in Support of System Transformation in Ontario. Canadian Association of Health Services and Policy Research Conference. Panel Presentation. Montreal, Canada. May 2015.
5.	Madeley C, Barlett A, Brooks D, Cafazzo J, Faulds C, Gershon A, Glennie J, **Hillmer M**, Hay C, Hayes A,

	Kaplan A , LeBlanc L, Licskai C, Lundie M, McIntyre K, Plaxton J, Pringle J, Maleki-Yazdi R. A multi stakeholder collaboration to improve outcomes in patients with chronic obstructive pulmonary disease (COPD) in Ontario: Value Demonstrating Initiative (VDI) on COPD. Canadian Respiratory Conference. Ottawa, Canada. April 2015.
6.	Wilson MG, Gauvin FP, **Hillmer M**, Lavis JN, Moat KA, Panisset U. The state-of-the art in policy-focused knowledge translation. Canadian Association for Health Services and Policy Research Annual Conference, Toronto, Canada. May 2014.
7.	Barker T, **Hillmer MP**, Prisniak A. An Assessment of a Primary Care-Based Diabetes Prevention Program Delivered in Ontario, Canada. American Diabetes Association: 72nd Scientific Sessions. Philadelphia, United States. June 2012.
8.	**Hillmer MP**, Clayman J. Development of a Chronic Disease Prioritization Aid to Assist Policy & Decision Makers. Academy Health: Annual Research Meeting. Chicago, United States. June 2009.
9.	**Hillmer MP**, Wodchis WP, Cernat G, Gill SS, Stukel TA, Anderson GM, Rochon PA. Avoidable hospitalizations of nursing home residents in Ontario. 6th Annual International Gerontology Association – European Congress, St. Petersburg, Russia. July 2007.
10.	Prebtani F, **Hillmer MP**, Leeb K, Watson D. Patterns of healthcare utilization among individuals with diabetes. Health Statistics Data Users Conference. Ottawa, Ontario. September 2007.
11.	**Hillmer MP**, Wodchis WP, Sykora K, Stukel T, Anderson GM, Rochon PA. Nurse staffing in Ontario's for-profit and not-for-profit long-term care facilities. Department of Health, Policy, Management, and Evaluation Annual Research Day, Toronto, Ontario. May 2004.
12.	McFarlane PA, **Hillmer MP**, Dacouris N. A change from subcutaneous to intravenous erythropoietin therapy reduces cost-effectiveness of anemia therapy in hemodialysis patients. Canadian Society of Nephrology Annual Meeting. Toronto, Ontario. May 2004
13.	**Hillmer MP**, Wodchis WP, Gill SS, Anderson GM, Rochon PA. Profit status of nursing homes in North America: Is there a difference? *Presented at the following meetings:* • Canadian Geriatrics Society Annual Scientific Meeting. Toronto, Ontario. May 2004 • Canadian Institutes of Health Research – Institute of Health Services and Policy Research Annual Research Meeting. Montreal, Quebec. November 2003. • Academy Health's 20th Annual Research Meeting. Nashville, Tennessee. June 2003.
14.	Hillmer, MD, **Hillmer MP**, Krahn M, Naglie G. Alzheimer's prescribing in Canada: Knowledge, attitudes, and practices of Canadian family physicians. *Presented at the following meetings:* • Canadian Geriatrics Society Annual Scientific Meeting. Ottawa, Ontario, Canada. May 2003. Tri-University Geriatric Resident Research Day, Guelph, Ontario June 2003.
15.	**Hillmer MP**, Bronskill SE, Rochon PA. Is the risk of hip fracture affected by the staff-to-patient ratio in Ontario long-term care facilities? A Proposed study. Department of Health, Policy, Management, and Evaluation Annual Research Day, Toronto, Ontario. May 2002.
16.	Salama S, **Hillmer MP**, MacLeod SM. Keloid scars: Limitations of studying therapeutic modalities using animal models. Abstracts from the Canadian Society of Plastic Surgeons 55th Annual Meeting, Jasper, Alberta. May 2001.
17.	**Hillmer MP**, Salama S, MacLeod SM. The use of animal models to study keloid scars. Canadian Journal of Surgery. Abstracts from the Royal College of Physicians and Surgeons Canada 69th Annual Meeting. Edmonton, Alberta. September 2000.
18.	**Hillmer MP**, Salama S. MacLeod SM. Experimental study of keloid scars and its potential for therapeutic advances in Africa. Joint Meeting of VII World Conference on Clinical Pharmacology and Therapeutics – Division of Clinical Pharmacology and 4th Congress of the European Association for Clinical Pharmacology and Therapeutics (EACPT). Florence, Italy. July 2000.

Presentations

1.	Connecting Privacy Conference. "Where are we going with Health Information Management in Ontario?" Toronto, Ontario. December 6, 2017.
2.	Big Data & Analytics for the Public Sector, Toronto, Ontario – May 30/31, 2017
3.	GovConnect Ontario Speaker, Toronto, Ontario – May 09, 2017
4.	Innovation Fund Provincial Oversight Committee. Innovation Fund Showcase November 2016. – Panel Moderator
5.	"Leveraging Big Data & Analytics In The Public Sector" Speaker Oct. 18/19, 2016
6.	Ministry Update on Provincial Health Analytics. Presentation at Ontario Health Association (OHA) Leading the Way to Better Health Care Analytics. Toronto, Canada. June 22, 2016
7.	Research to Policy: Informing decision-making in health services policy and practice from a research impact assessment perspective. Presentation by Canadian Health Services & Policy Research Alliance. Presentation at National Forum 2016 Transforming Health Care for Canada's aging, frail population, Toronto, Ontario. May 13, 2016.
8.	Use of Evidence for Health System Policymaking. Presentation at University Health Network (UHN) Division of Medical Oncology Grand Rounds. Toronto, Canada. December 17, 2015.
9.	Health Services Research and Policy Making in Ontario. Presentation at Toronto Health Economics and Technology Assessment (THETA) Collaborative Rounds. Toronto, Canada. October 9, 2015.
10.	Harnessing the Power of Administrative Data to Drive Health System Innovation in Ontario. Presentation to the Arthritis Industry Forum. Toronto, Canada. September 25, 2015.
11.	Health Services Research and Policy Making in Ontario. Presentation at Women's College Hospital Institute for Health System Solutions and Virtual Care (WIHV) Innovation Rounds. Toronto, Canada. June 16, 2015.
12.	Research, Innovation, and Ontario's Health System Priorities. Ontario Centres of Excellence Discovery Conference. Toronto, Canada. April 28, 2015.
13.	Ontario's Health Care System. Seminar at Institute of Health Policy, Management and Evaluation, University of Toronto. Toronto, Canada. October 23, 2014.
14.	Challenges and Opportunities in Child Health and Social Policy. Child Health and Social Policy Seminar Series. Toronto, Canada. October 1, 2014.
15.	Health Services Research and Knowledge Translation in Ontario. Presentation to the French Language Health Services Advisory Council. Toronto, Canada. October 1, 2014.
16.	Ontario's Health Care System. Presentation to Delegation from China. Toronto, Canada. September 25, 2014.
17.	Harvesting and Linking Data. Big Data Forum at McMaster Innovation Park. Hamilton, Canada. September 24, 2014.
18.	How can research influence clinical best practices and policy for children and youth who need assistive technology services? Presentation at Thames Valley Children's Centre. Toronto, Canada. September 17, 2014,
19.	Research Policy and Knowledge Transfer: Perspectives from a Knowledge User from the Ontario Ministry of Health and Long-Term Care. Presentation to the Better 2 Program. Edmonton, Canada. June 16, 2014.
20.	Personal and professional advice and "stories from the field". ACHIEVE Career Session at the Centre for Research on Inner City Health, Li Ka Shing Knowledge Institute, St. Michael's Hospital. Toronto, Canada. March 28, 2014.

21.	Chronic Disease and Multi-Morbidity in Ontario. CIHR Institute of Health Services & Policy Research - Policy Rounds: Improving Care for People with Multiple Chronic Health Conditions (Canada-wide webinar). Toronto, Canada. March 26, 2014.
22.	Health Services Research and Knowledge Translation in Ontario. Invited seminar at the Centre for Health Economics and Policy Analysis (CHEPA), McMaster University. Hamilton, Canada. February 26, 2014.
23.	Health System Research Fund (HSRF). The Centre for Research in Community Interventions to Promote Optimal Aging at Home - A Knowledge Translation and Exchange Forum. Toronto, Canada. February 12, 2014.
24.	Health System Transformation. Presentation to the Gateway Rural Health Research Institute Collaboration. Stratford, Canada. January 22, 2014.
25.	Caring for People with Multiple Chronic Conditions. Health System Performance Research Network (HSPRN) Symposium – Caring for People with Multiple Chronic Conditions: A Necessary Intervention for Ontario. Toronto, Canada. October 22, 2013.
26.	Chronic Disease Prevention and Management: Canadian Context and Experience. Medecins Sans Frontieres/Doctors without Borders (MSF) workshop on existing models of care for the management of chronic disease. Geneva, Switzerland. September 12, 2013.
27.	Aboriginal Health in Ontario. Ontario Ministry of Health and Long-Term Care Public Health Division First Nation / Public Health Unit Education Day. Toronto, Canada. March 21, 2011.
28.	The Ontario Health Care System and Aboriginal Health Initiatives in Ontario. Aboriginal Health in Ontario. Toronto, Canada. March 8, 2011.
29.	Coming to grips with uncertainty: Exploring the parallels between the academic and bureaucratic approach to clinical epidemiology. St. Michael's Hospital Clinical Epidemiology Rounds. Toronto, Canada. November 26, 2009.
30.	Chronic Disease Prevention and Management in Ontario. Making the invisible visible: A conference on sickle cell anemia hosted by the Sickle Cell Association of Ontario and the Black Health Alliance. Toronto, Canada. November 21, 2009.
31.	Chronic Disease Prevention and Management. Ontario Association of Naturopathic Doctors Annual Conference. Toronto, Canada. April 2009.
32.	Chronic Disease Prevention and Management: A Policymaker's Perspective. Chronic Disease Prevention and Management in Primary Care: Which Shoe Fits? Queen's University Continuing Professional Development. Kingston, Canada. October 2008.
33.	Chronic Disease Prevention and Management in Ontario. Working together to prevent and manage chronic disease: Ideas, Innovation, and Insight Conference hosted by St. Joseph's Health Centre. Toronto, Canada. May 2008.
34.	The association between the ownership status of Ontario's long-term care homes and the quality of resident care. City-wide Clinical Epidemiology Rounds, University of Toronto. Toronto, Canada. April 2008.
35.	Understanding the landscape of chronic disease prevention in Ontario. Ontario Heart Health Network Annual Conference. Toronto, Canada. April 2008.
36.	Avoidable hospitalizations of nursing home residents. Kunin-Lunenfeld Applied Research Unit Rounds, Baycrest Centre. Toronto, Ontario. November 2006.
37.	Nurse staffing in Ontario's for-profit and not-for-profit long-term care facilities. Canadian Geriatrics Society. Halifax, Canada. June 2005.
38.	Nurse staffing in Ontario's for-profit and not-for-profit long-term care facilities. Tri-University Trainee Research Day. Toronto, Canada. June 2003.

39.	Quality of care in the nursing home. Does profit status matter? • Kunin-Lunenfeld Applied Research Unit Rounds, Baycrest Centre. Toronto, Canada. March 2003. • Institute for Clinical Evaluative Sciences Rounds, Sunnybrook and Women's College Health Sciences Centres. Toronto, Canada. December 2003.
40.	Keloids and the African experience. Centre for Evaluation of Medicines Rounds, McMaster University. Hamilton, Canada. January 2000.
41.	Pharmacotherapy for the treatment and prevention of keloid scars. Weekly Departmental Seminar, Department of Pharmacology, University of Toronto. Toronto, Canada. September 1998.

Key Note Addresses

1.	Vizient Canadian Decision Support Conference – November 30, 2017
2.	MedAssets Canadian Decision Support Conference December 06, 2016
3.	Canadian Knowledge Mobilization Forum. Toronto, Ontario. June 28, 2016.
4.	The Art and Science of Healthcare Policy in the 21st Century: Moving the Innovation Agenda Forward. Presentation at the Ontario Psychiatric Outreach Program (OPOP) Annual Retreat. Ottawa, Canada. September 17, 2015.
5.	The Next Frontier of Chronic Disease Prevention and Management: 2010 Hypertension Collaborative, Heart and Stroke Foundation of Ontario. Toronto, Canada. March 27, 2010.

External Program Reviews

1. **Manitoba Training Program External Review – July 2017**

The Manitoba Deputy Minister of Health and Dean of Medicine at the University of Manitoba commissioned an external review of the Manitoba Training Program for Health Services Research. My partner was Dr. Stephen Bornstein of Memorial University. The final report was submitted in July 2017.

Graduate Thesis Committees

Member, PhD Committee, Lisa Strifler, 2015 -
Supervisor: Sharon Strauss, MD, FRCP(C), MSc, HBSc
University of Toronto, Institute of Health Policy, Management, and Evaluation

Thesis Defence Participation

1. External Examiner, Simon Trevarthen, Masters of Strategic Foresight and Innovation, Ontario College of Art and Design, August 2016. Academic Advisor, Alexander Manu
2. Internal Examiner, Delia Sinclair Frigault, MSc. Health Services Research. Institute for Health Policy, Management, and Evaluation, University of Toronto. September 2016. Thesis: Responsive Behaviours in Dementia: Developing and Implementing the Behavioural Supports Ontario Initiative

Scientific / Planning Committees

1. CIHR Best Brains Exchange: Artificial Intelligence and Machine Learning Approaches to Improving Population Health. April 28, 2017
2. 2018 International Population Data Linkage Conference Scientific Committee. September 2018. Banff, Alberta.

3. Ontario Ministry of Health and Ontario Medical Association Innovation Fund Provincial Oversight Committee Innovation Showcase 2016. Toronto, Ontario.

Selection Committees

1. 2018 International Population Data Linkage Research Symposium. Abstract review committee
2. Nova Scotia Health Research Foundation Real Impact Fellowship – November 2016 –
3. Ontario Ministry of Health and Ontario Medical Association Innovation Fund Provincial Oversight Committee 2015-2017
4. 2017 Cochrane Symposium. Abstract review Committee. Hamilton, Ontario.

Graduate Teaching

Courses

1. University of Toronto, Institute for Health Policy, Management, and Evaluation Knowledge Transfer and Exchange: The Art and Science of Making Research Relevant and Increasing Utilization. HAD5727H.
    - Winter 2015
    - Winter 2016

Academic Courses - Guest Lectures

1. University of Toronto, Institute for Health Policy, Management, and Evaluation Knowledge Transfer and Exchange: The Art and Science of Making Research Relevant and Increasing Utilization ""Health Systems & influencing policy makers", March 27, 2018. Professor Monika Kastner.
2. University of Toronto, Institute for Health Policy, Management, and Evaluation. Graduate Student Union Seminar Series. "Decision Making and Evidence". October 2017.
3. University of Toronto, Institute for Health Policy, Management, and Evaluation Knowledge Transfer and Exchange: The Art and Science of Making Research Relevant and Increasing Utilization ""Health Systems & influencing policy makers", March 6, 2017. Professor Monika Kastner.
4. University of Toronto, Institute for Health Policy, Management, and Evaluation. Program Planning and Evaluation. Masters of Health Administration. January 25, 2016. Professor Rhonda Cockerill.
5. University of Toronto, Institute for Health Policy, Management, and Evaluation. Evidence Review: Approaches and Methods for Health Systems and Policy. September 25, 2015. Professor Mark Dobrow.
6. Ryerson University, Ted Rogers School of Management. The Health Care System (CHSM 301): Beyond Medicare: Home and Community Based Care and Long-term Care. February 12, 2016. Professor Jake Pringle.

7. Ryerson University, Ted Rogers School of Management. The Health Care System (CHSM 301): Beyond Medicare: Home and Community Based Care and Long-term Care. December 2, 2015. Professor Jake Pringle.

Manuscript Peer Review

British Medical Journal	2
Journal of Critical Care	1
Health Policy	1
McMaster Health Forum Reviews	5

McMaster Health Forum Policy Briefs – Merit Reviews

1. Gauvin FP, Waddell K, Lavis JN. Rapid synthesis: Fostering an organizational culture supportive of evidence-informed policies. Hamilton, Canada: McMaster Health Forum, 3 November 2017.
2. Moat KA, Wicks M, Wilson MG. Citizen Brief: Integrating Data Across Sectors for Public Service Improvement in Ontario. Hamilton, Canada: McMaster Health Forum, 5 March 2016. Improving Leadership Capacity in Primary and Community Care in Ontario
3. Wilson MG, Lavis JN, Moat KA. Citizen Brief: Building a Primary-Care 'Home' for Every Ontarian. Hamilton, Canada: McMaster Health Forum, 6 February 2016.
4. Lavis JN, Moat KA, Tapp C, Young C. Evidence Brief: Improving Leadership Capacity in Primary and Community Care in Ontario. Hamilton, Canada: McMaster Health Forum, 30 January 2015.
5. Wilson MG, Lavis JN. Dialogue Summary: Designing Integrated Approaches to Support People with Multimorbidity in Ontario. Hamilton, Canada: McMaster Health Forum, 21 October 2013

Book Reviews

1. McGregor, Margaret J., and Lisa A. Ronald. 2011. Residential Long-Term Care for Canadian Seniors: Nonprofit, ForProfit or Does It Matter? IRPP Study, No. 14. Montreal: Institute for Research on Public Policy. http://irpp.org/wp-content/uploads/assets/research/faces-of-aging/residential-long-term-care-for-canadas-seniors/IRPP-Study-no1.pdf

2. Chapter 1: Ontario's Health System: Key Insights for Engaged Citizens, Professionals and Policymakers. John Lavis, Editor. 2016. McMaster Health Forum

This is Exhibit "B" referred to in the Affidavit of Dr. Michael Hillmer sworn August 29, 2018

Commissioner for Taking Affidavits (or as may be)

Jessica Taylor Kras, a Commissioner, etc.,
Province of Ontario,
while a Student-at-Law.
Expires May 30, 2020.

MINISTRY-LHIN PERFORMANCE AGREEMENT
APRIL 1, 2013 – MARCH 31, 2015

BETWEEN:

Her Majesty the Queen in right of Ontario, as represented by the Minister of Health and Long-Term Care ("MOHLTC")

- and -

South West Local Health Integration Network ("LHIN")

Introduction

The *Local Health System Integration Act*, 2006 (LHSIA), the Memorandum of Understanding (MOU) and the Ministry-LHIN Performance Agreement (Agreement) are the key elements of the accountability framework between the MOHLTC and the Local Health Integration Networks (LHINs).

The Agreement identifies the MOHLTC's key operational and funding expectations of the LHINs that are not already addressed in the LHSIA or the MOU. It recognizes that the MOHLTC and the LHINs have a joint responsibility to serve the public interest and effectively oversee the use of public funds. The Agreement reflects the LHINs' critical role in ensuring enhanced access and quality of healthcare in a fiscally sustainable manner while acknowledging the MOHLTC's responsibility to apply appropriate and legitimate scrutiny of fiscal management and health services delivery by the LHINs.

The MOHLTC has communicated provincial strategic direction that provides a vision for system change and reinforces the principles articulated in the *Excellent Care for All Act*, 2010. The MOHLTC and the LHINs used this vision to develop a Performance Framework focused on better patient outcomes and value for healthcare dollars. The framework includes the following shared system goals:

- Enhanced Person-Centred Care
- Improved System Integration and Enhanced Coordination and Transitions of Care
- Implementation of Evidence-Based Practices to Drive Quality, Value and Improved Health Outcomes
- Financial Sustainability

A number of key initiatives have been introduced to transform the healthcare system and achieve the vision set forth by the MOHLTC. The LHINs will work with health service providers and other providers to enhance collaboration within and between sectors and ensure alignment with current provincial strategies, including:

- Health System Funding Reform: a new funding strategy that features patient based funding to facilitate fiscal sustainability and person-centred care. This will impact hospital, Community Care Access Centre (CCAC), and Long-Term Care Homes (LTCH) budgets.

- Health Links: an innovative approach to enhancing coordinated care for people who access the system frequently and at multiple entry points.

- Seniors Strategy: a provincial initiative to keep seniors healthy and at home longer and reduce pressures on hospitals and LTCHs by increasing capacity in the community.

- Mental Health and Addictions Strategy: an inter-ministerial commitment to improve the well-being of all Ontarians and create healthy, resilient communities.

To further support the transformation agenda and address the demographic and fiscal challenges facing Ontario, comprehensive service capacity planning that includes both the MOHLTC and the LHINs is required.

Primary Purpose of the Agreement

1. The Agreement outlines the mutual understanding between the MOHLTC and the LHIN of their respective performance obligations in the period from April 1, 2013 to March 31, 2015 covering the 2013-2014 and 2014-2015 fiscal years. The agreement is an accountability agreement for the purposes of section 18 of the LHSIA.

Principles

2. Both parties will carry out the responsibilities and obligations based on principles that reflect:

   a) Alignment with provincial priorities and strategies;
   b) Sustainability of the healthcare system by maximizing the efficient and effective use of public funds;
   c) Performance improvement;
   d) High-quality, person-centred service delivery;
   e) Consistency;
   f) Consultation and collaboration among MOHLTC, LHINs, health service providers, other providers and the applicable communities;
   g) Openness and transparency; and
   h) Innovation, creativity and flexibility.

Definitions

3. The following terms have the following meanings in the Agreement:

   "Agreement" means this Agreement, including any schedules, and any instrument which amends this Agreement.

   "Annual Business Plan" means the plan for spending the funding received by the LHIN from the MOHLTC and included in the Agreement as required by subclause 18(2) (d) of the LHSIA.

"**Community**" has the meaning set out in subsection 16(2) of the LHSIA.

"**Consolidation Report**" means a report that includes the LHIN's revenues and expenditures for LHIN operations and transfer payments to health service providers, and balance sheet accounts for the LHIN.

"**Dedicated Service Funding**" means, in respect of a specific service, the funding that must be used by the LHIN to fund the provision of the specific service.

"**eHealth**" means the coordinated and integrated use of electronic systems, information and communication technologies to facilitate the collection, exchange and management of personal health information in order to improve the quality, access, productivity and sustainability of the healthcare system. Key application areas of eHealth in Ontario include, but are not limited to:

- Electronic health information systems (e.g., electronic medical records, hospital information systems, electronic referral and scheduling systems, digital imaging and archiving systems, chronic disease management systems, laboratory information systems, drug information and ePrescribing systems)
- Electronic health information access systems (e.g., provider portals, consumer eHealth)
- Underlying enabling systems (e.g., client/provider/user registries, health information access layer)
- Remote healthcare delivery systems (e.g., telemedicine services)

"**eHealth Ontario**" means the government agency responsible to the Minister of Health and Long-Term Care which is a corporation without share capital created and continued in Ontario Regulation 43/02 made under the *Development Corporations Act.*

"**Fiscal year**" means April 1 to March 31.

"**Health service provider**" has the meaning set out in section 2 of the LHSIA.

"**Regular Report**" means a report that includes a statement of the LHIN's revenues, actual expenditures, forecasted expenditures for LHIN operations, transfer payments, an explanation of variances as required between the forecasted expenditures and revenues, and the identification of any financial and performance risks.

"**Schedule**" means any one of and "Schedules" means any two or more of the schedules appended to the Agreement, including the following:

1. General;
2. Local Health System Program Management;
3. Long-Term Care Homes Program Specific Management
4. Funding and Allocations;
5. Local Health System Performance; and
6. Integrated Reporting.

"**Service accountability agreement**" means the service accountability agreement that the LHIN and a health service provider are required to enter into under subsection 20 (1) of the LHSIA.

"Year-end" means the end of a fiscal year.

Accountability

4. **Both parties** will fulfill their performance obligations in accordance with the terms of the Agreement.

5. **Both parties** will collaborate and cooperate to:

   a) Facilitate the achievement of the requirements of the Agreement;
   b) Promote financial sustainability and efficient utilization of financial resources;
   c) Develop clear and achievable service and financial performance obligations and identify risks to performance;
   d) Establish clear lines of communication and responsibility; and
   e) Work diligently to resolve issues in a proactive and timely manner.

6. The **LHIN** is responsible for managing its performance, the performance of the local health system, and collaborating with other providers to support provincial goals, as set out in the Agreement and using its authority under law. The **MOHLTC** is responsible for collaborating with the LHIN to achieve those ends. The MOHLTC and the LHIN recognize that issues may arise in the local health system that will require joint MOHLTC-LHIN problem-solving, decision making and action.

Performance Improvement

7. **Both parties** will follow a proactive and responsive approach to performance improvement based on the following principles:

   a) Prudent financial management of public healthcare resources;
   b) Better access to high quality, person-centred services;
   c) Strengthened transitions in care across the entire patient journey;
   d) Ongoing performance improvement;
   e) An orientation to problem-solving; and
   f) A focus on relative risk of non-performance.

8. Where matters arise that could significantly affect either the LHIN or MOHLTC's ability to perform their obligations under the Agreement, they shall provide written notice to the other party as soon as reasonably possible (a "Performance Factor"). Notice shall include a description of any remedial action the party has taken or plans to take to remedy the issue. Receipt of notice will be acknowledged within five business days of the date of the notice.

9. **Both parties** agree to meet and discuss the "Performance Factor" within one calendar month of the date of the notice. During the meeting, using the principles set out in paragraph 7 above, the parties will discuss:

   a) The causes of the Performance Factor;

   b) The impact of the Performance Factor and whether it poses a "low", "moderate" or "high" risk to achieving the obligations of the Agreement;

c) The steps in the performance improvement process to be taken to mitigate the impact of the Performance Factor; and

d) Whether revisions or amendments to a party's performance obligations are required.

10. Where a LHIN Performance Factor is not mutually resolved, the Minister will determine the remedies to improve performance, depending on the extent, exposure or level of risk.

Next MOHLTC LHIN Agreement

11. **Both Parties** will enter into a new agreement under section 18 of the LHSIA to be effective at the end of the Agreement. If the new agreement is not signed by the Parties by April 1, 2015 the Agreement will continue in force until the new agreement is signed. Both Parties will make their best efforts to sign a new agreement as soon as they are able.

General

12. Any amendment to the Agreement will only be effective if it is in writing and signed by the authorized representative(s) of each party.

13. The **LHIN** will not assign any duty, right or interest under the Agreement without the written consent of the MOHLTC.

14. If a due date for materials falls on a weekend or on a holiday recognized by the MOHLTC, the materials are due on the next business day.

15. Each Schedule applies to the 2013-15 fiscal years, unless stated otherwise in a Schedule. Some of the performance obligations in a Schedule may apply only to one fiscal year, as stated in that Schedule.

16. **Each party** will communicate with each other about matters pertaining to the Agreement through the following persons:

To the MOHLTC:
Ministry of Health and Long-Term Care,
Health System Accountability and Performance Division
Hepburn Block, 5th Floor
80 Grosvenor Street,
Toronto, ON M7A 1R3

Attention:
Assistant Deputy Minister,
Health System Accountability and Performance

Fax: (416) 212-1859
Telephone: (416) 212-1134
E-mail: Catherine.Brown@ontario.ca

With a copy to:
Director, Local Health Integration Network (LHIN) Liaison Branch
80 Grosvenor St.
5th Floor, Hepburn Block
Toronto, ON M7A 1R3

Fax: (416) 326-9734
Telephone: (416) 314-1864
E-mail: Kathryn.McCulloch@ontario.ca

To the LHIN:
South West Local Health Integration Network
201 Queens Avenue, Suite 700
London, ON N6A 1J1

Attention: Chair

Fax: (519) 672-6562
Telephone: (519) 672-0445
Email: Jeff.Low@lhins.on.ca

With a copy to:
South West Local Health Integration Network
201 Queens Avenue, Suite 700
London, ON N6A 1J1

Attention: CEO

Fax: (519) 672-6562
Telephone: (519) 672-0445
Email: Michael.Barrett@lhins.on.ca

Made effective this 1st day of April, 2013 by:

Her Majesty the Queen in right of Ontario, as represented by the Minister of Health and Long-Term Care:

Deb Matthews

The Honourable Deb Matthews
Minister of Health and Long-Term Care

South West Local Health Integration Network

By:

Jeff Low
Chair

SCHEDULE 1: GENERAL

Provincial Priorities and Strategies

1. The **MOHLTC** will establish provincial priorities and strategies for the health system and communicate these priorities to the **LHIN.**

2. The **LHIN** will:

   a) Work with the MOHLTC, health service providers and other providers in the local health system to achieve and accelerate provincial priorities and strategies;

   b) Work to align the Quality Improvement Plan objectives and priorities of its health service providers to improve the quality of care across sectors and the healthcare system.

3. **Both parties** will work together to develop a collaborative process to support current and future service capacity planning so that decisions about local service provision will advance provincial priorities and strategies.

Provincial Health Agencies

4. The **MOHLTC** will work with the following provincial health agencies to ensure they equally consider the role of the LHINs as local health system managers:

   a) Cancer Care Ontario;
   b) eHealth Ontario;
   c) Health Quality Ontario; and
   d) Ontario Agency for Health Protection and Promotion ("Public Health Ontario").

5. The **LHIN** will work with the provincial health agencies listed in paragraph 4 of this Schedule to support the fulfillment of provincial priorities and strategies.

Consistency

6. The **MOHLTC** will identify common issues and services for which a consistent approach across LHINs is required.

7. The **LHIN** will work collaboratively with other LHINs, and in accordance with the MOU, to ensure a consistent approach for common issues and services, including those identified by the MOHLTC under paragraph 6 of this Schedule.

Local System Coordination and Integration

8. The **LHIN** will work with its health service providers and other LHINs to improve governance, coordination and integration of healthcare delivery across the continuum of care both within and between LHINs.

Community Engagement

9. The **LHIN** will fulfill its community engagement requirements in accordance with the LHIN Community Engagement Guidelines and Toolkit (dated February 2011) to ensure greater clarity and transparency of process.

Information Management

10. The **MOHLTC** will:

    a) Develop, maintain and support health data standards; communicate health data reporting requirements and standards to the LHIN and health service providers; advise/inform health service providers of reporting and data quality issues; and inform the LHINs and health service providers of reporting timelines;

    b) Consult with the LHIN to identify LHIN data/information requirements that support data infrastructure for LHIN operational needs, and prepare data sharing agreements and / or amendments to existing agreements as required; and

    c) Receive data and information from health service providers on behalf of the LHIN and provide timely access to the appropriate data to support health system needs.

11. The **LHIN** will:

    a) Require health service providers to submit data and information as communicated by the MOHLTC under subparagraph 10(a) of this Schedule to the MOHLTC, Canadian Institute for Health Information, or other third party;

    b) Identify LHIN data/information requirements to support the LHIN analysis at the local level, and work collaboratively with the MOHLTC to develop appropriate methodology, consistent data analysis and reporting; and

    c) Work with health service providers to improve data quality and timeliness as necessary.

12. **Both parties** will avoid duplicating data and information management infrastructure and processes, determine and prioritize data and information products, and streamline reporting requirements and timelines for the LHIN and health service providers.

Compliance Protocols

13. The **MOHLTC** will:

    a) Retain its compliance, inspection and enforcement authorities under legislation; and

    b) Inform the LHIN as soon as reasonably possible on matters related to compliance, inspection and enforcement in LTCHs and otherwise through a mutually agreeable reporting schedule.

14. The **LHIN** will:

a) Exercise its legislative and contractual authorities as necessary or as required under law, including conducting or requiring audits and reviews of health service providers; and

b) Inform the MOHLTC as soon as reasonably possible:

i) Of non-compliance by a health service provider with an assigned agreement, a service accountability agreement or legislation that has not been resolved to the LHIN's satisfaction; or

ii) Of a health service provider that is licensed or approved to operate a LTCH,

a) That is experiencing financial issues;

b) Where the LHIN is aware that there is risk to resident health and/or safety in a LTCH; or

c) Where the results of an audit or review conducted or required by a LHIN identify problems.

eHealth

15. The **MOHLTC** will:

a) Set technical and information management standards related to eHealth and implementation / compliance timeframes for the interoperability of the health system in Ontario, including standards related to content, architecture, technology, privacy and security; and

b) Review annual LHIN Cluster eHealth plans as submitted by the LHINs.

16. The **LHIN** will:

a) Assist its respective LHIN Cluster to prepare an annual LHIN Cluster eHealth plan that aligns with the provincial eHealth priorities for 2013-15, to be submitted to the MOHLTC for review;

b) Include eHealth commitments in service accountability agreements requiring health service providers to:

i) Assist the LHIN to implement provincial eHealth priorities for 2013-15;

ii) Comply with any technical and information management standards, including those related to data, architecture, technology, privacy and security, set for health service providers by the MOHLTC or the LHIN within the timeframes set by the MOHLTC or the LHIN, as the case may be;

iii) Implement and use the approved provincial eHealth solutions identified in the LHIN Cluster eHealth plan;

iv) Implement technology solutions that are compatible or interoperable with the provincial blueprint and with the LHIN Cluster eHealth plan; and

v) Include, in their annual planning submissions, plans for achieving eHealth priority initiatives, including full adoption by all hospitals of Ontario Laboratory Information System by March 2015.

17. **Both parties** will work together, and in conjunction with eHealth Ontario and Ontario Telemedicine Network as appropriate, to:

a) Participate in forums for the discussion of eHealth issues at a provincial level to identify options to support the roll out of eHealth initiatives and related eHealth issues including local health system needs, challenges, and opportunities and eHealth standards, definitions, and architectural frameworks; and

b) Inform one another of significant issues or initiatives that contribute to or have an impact on provincial or local eHealth issues, strategies or work plans.

Capital

18. Both parties will:

a) Follow the November 2010 *MOHLTC-LHIN Joint Review Framework for Early Capital Planning Stages*;

b) Work together during the term of the Agreement to develop a revised or updated capital planning and delivery model for the early capital planning stages informed by service capacity planning by the MOHLTC, the LHINs and other provincial health agencies;

c) Follow the MOHLTC's current *Health Infrastructure Renewal Fund Guidelines*; and

d) Work together to devolve the review and approval process for Own-Funds Capital Projects from the MOHLTC to the LHIN, as appropriate.

Emergency Management

19. **Both parties** will work together to implement the approved policy: "The LHIN Role in Emergency Management" (dated August 2012).

General Performance Obligations

20. The **MOHLTC** will provide the LHIN with, and develop as appropriate, those provincial standards (such as operational, financial or service standards and policies, operating manuals and program eligibility), directives and guidelines that apply to health service providers, including providing the LHIN with relevant program manuals.

21. The **LHIN** will:

a) Require health service providers to provide services funded by the LHIN in accordance with provincial standards, directives and guidelines provided pursuant to paragraph 20 of this Schedule;

b) Provide certificates of compliance, or attestations as the case may be, to the MOHLTC in form and substance as required by the MOHLTC;

c) Maintain the 10% reduction in executive office costs that it achieved between April 1, 2011 and March 31, 2013 against its 2010/11 budget;

d) Require its hospitals and CCAC to maintain the 10% reduction that they achieved between April 1, 2011 and March 31, 2013 against their respective 2010/11 budgets;

e) Not use, nor permit its hospitals and CCAC to use, funding provided under the Agreement to increase executive office budgeted costs during the term of the Agreement; and

f) Report on their executive costs in an attestation to the MOHLTC, and require its hospitals and its CCAC to report on their respective executive office costs in an attestation to the MOHLTC.

22. **Both parties** will work together to ensure that government priorities and implementation of provincial strategies are reflected in accountability planning submission templates, service accountability agreements and schedules with health service providers and other providers.

Annual Review and Update

23. **Both Parties** agree to review and update the Schedules annually, as necessary to better reflect the Primary Purpose, within 120 days of a budget announcement of the Government of Ontario.

SCHEDULE 2: LOCAL HEALTH SYSTEM PROGRAM SPECIFIC MANAGEMENT

Provincial Programs

1. The **MOHLTC** and the **LHIN** will establish a coordinated and effective system for the management of provincial programs.

2. The **MOHLTC** will:

   a) Identify provincial programs, determine any terms and conditions, including dedicated service funding, related to these provincial programs and communicate these to the LHIN; and

   b) Establish:

      (i) Roles and responsibilities related to provincial program delivery; and

      (ii) Performance management, monitoring and evaluation processes.

3. The **LHIN** will fulfill requirements as may be identified under paragraph 2 of this Schedule and work with other LHINs to coordinate provincial program service delivery.

Other MOHLTC Programs

4. If the **MOHLTC** establishes expectations and requirements for other programs, it will advise the LHIN.

5. The **LHIN** will require health service providers that provide the specific program to provide program services in accordance with the expectations and requirements established by the MOHLTC.

Devolution

6. The **MOHLTC**:

   a) Will determine the devolution of province-wide programs to the LHINs;

   b) Will consult with LHINs before identifying a Lead LHIN; and

   c) May specify the terms and conditions applicable to the funding and administration of the province-wide program after its devolution.

7. The **LHIN** will:

   a) Administer the devolved program in accordance with the "Agreement Concerning the Devolution of Provincial Programs", also known as the Lead LHIN Model Agreement and any terms and conditions specified by the MOHLTC; and

b) Confirm any proposed changes to the Lead LHIN Model Agreement with the MOHLTC prior to implementation.

Community Health Centres ("CHCs")

8. The **MOHLTC** will support the development of Quality Improvement Plans by providing the required templates, guidance and accompanying supports.

9. The **LHIN** will require each CHC to submit a Quality Improvement Plan to Health Quality Ontario that is aligned with and supports local health system priorities.

Mental Health

10. The **MOHLTC** will:

a) Determine and advise the LHIN of the number of housing units that receive rent supplements for persons with serious mental illness and the specific agencies that receive the rent supplements for these units from the MOHLTC;

b) Determine and advise the LHIN of the required service levels for supports to housing services for persons with serious mental illness who occupy the housing units that receive rent supplements as described in subparagraph 10(a) of this Schedule;

c) For forensic mental health services, determine and advise the LHIN of:

(i) the number and type of forensic mental health inpatient beds, the forensic case management initiatives, and the Transitional Rehabilitation Housing Programs' numbers and models;

(ii) the designated hospitals that provide forensic mental health services; and

(iii) the required service levels for forensic mental health services;

and

d) Determine and advise the LHIN of the type (adult or paediatric, inpatient, residential, day treatment or outpatient) and quantity of specialty eating disorder services, where applicable.

11. The **LHIN** will:

a) Fund the provision by health service providers of a combination of community mental health services for the local health system, including services for people who have been in conflict with the criminal justice system;

b) Fund the provision by health service providers of the following services:

(i) Supports to housing services for persons who occupy the housing units that receive rent supplements at the service levels as described in subparagraph 10(b) of this Schedule;

(ii) forensic mental health services that include forensic mental health inpatient beds, forensic case management initiatives, and the Transitional Rehabilitation Housing Programs at the service levels as described in subparagraph 10(c) of this Schedule; and

(iii) specialty eating disorder services as described in subparagraph 10(d) of this Schedule;

c) Require health service providers, designated as psychiatric facilities under the *Mental Health Act*, to provide the essential mental health services in accordance with the specific designation for that site and discuss any material changes to the service delivery models or service levels with the MOHLTC; and

d) Not make any changes to the types and/or levels of service as specified under paragraph 10 of this Schedule without MOHLTC approval.

Addictions

12. The **MOHLTC** will:

a) Determine and advise the LHIN of type and quantity of problem gambling treatment and prevention services;

b) Determine and advise the LHIN of the number of housing units that receive rent supplements for persons with problematic substance use and the specific agencies who receive the rent supplements for these units from the MOHLTC; and

c) Determine and advise the LHIN of the required service levels for supports to housing services for persons with problematic substance use who occupy the housing units that receive rent supplements as described in paragraph 12(b) of this Schedule.

13. The **LHIN** will:

a) Fund the provision by health service providers of the following services:

(i) Problem gambling treatment and prevention services as described in subparagraph 12(a) of this Schedule;

(ii) Supports to housing services for persons who occupy the housing units that receive rent supplements as described in subparagraph 12(c) of this Schedule; and

(iii) A combination of substance abuse treatment services for the local health system;

and

b) Not make any proposed changes to types and/or levels of service as specified under paragraph 12 of this Schedule without MOHLTC approval.

SCHEDULE 3: LONG-TERM CARE HOMES
PROGRAM SPECIFIC MANAGEMENT

Definitions

1. Definitions below apply to Schedule 3: Long-Term Care Homes and Schedule 4: Funding and Allocations:

"Acknowledgement and Consent Agreement" means an agreement entered into between the MOHLTC, the operator of a LTCH, and one or more lenders or secured parties, by which the MOHLTC consented to, or agreed to request a consent to, any of the following: (a) a mortgage of real property associated with the LTCH, (b) an assignment of a Development Agreement with the MOHLTC, and/or (c) an assignment of a service agreement;

"Beds in Abeyance" means LTCH beds licensed or approved by the MOHLTC, for which the LTC health service provider has obtained written permission from the Director, PICB, in accordance with the LTCHA for the beds not to be available for occupancy.;

"Construction Funding Subsidy per diem" or **"CFS per diem"** means any per diem funding paid pursuant to a Development Agreement;

"Convalescent Care Beds" means those short-stay beds, licensed or approved under the LTCHA, that are part of a short-stay convalescent care program for which residents may be eligible for admission in accordance with regulations under the LTCHA;

"Development Agreement" means an agreement between the MOHLTC and a LTC health service provider, or a proposed LTC health service provider, to develop, upgrade, retrofit or redevelop LTCH beds;

"Funding Policies" means the funding and financial management policies determined by the MOHLTC for LTCHs as the same may be amended from time to time. Funding Policies establish the rates, and amounts and envelopes of all funding provided to LTC health service providers by the MOHLTC or the LHIN, including Supplementary Funding. Funding Policies also establish the applicable conditions for funding, the funding reconciliation rules, and the form, manner and content and date for submission of reports;

"Interim Beds" means those short-stay beds that are licensed or approved under the LTCHA and that fall within the definition of "interim bed" in accordance with regulations under the LTCHA;

"LTCH" means long-term care home;

"LTCH Protocol" means the document titled "Long-Term Care Homes Protocol" as prepared and amended by the MOHLTC;

"LTCHA" means the *Long-Term Care Homes Act, 2007* and regulations thereunder;

"LTC health service provider" means a health service provider that is a licensee within

the meaning of subsection 2(1) of the LTCHA;

"Supplementary Funding" means funding for LTCH beds provided directly by the MOHLTC to LTC health service providers in accordance with applicable Funding Policies and pursuant to a funding agreement between MOHLTC and the LTC health service provider;

"service agreement" means the agreement pursuant to which funding is provided to a LTC health service provider and includes a service accountability agreement;

"service accountability agreement" means the service accountability agreement between a LHIN and a LTC health service provider required by section 20 of the LHSIA; and

"Short-Stay Respite Beds" means those short-stay beds, licensed or approved under the LTCHA, that are part of a short-stay respite care program for which residents may be eligible for admission in accordance with regulations under the LTCHA.

Funding

2. The **MOHLTC** will:

a) Determine and provide to the LHIN, the amount of funding that a LHIN may provide to a LTC health service provider together with any applicable terms and conditions;

b) Determine any net projected unused funding for all LHINs that, as of September 30 in each fiscal year, has not or is projected not to be used by LTC health service providers;

c) Reallocate a share of the net projected unused funding to the LHIN if the LHIN is projected to be overspent on its funding for the LTCH per diem rate;

d) If there is net projected unused funding remaining after the reallocation, allocate to the LHIN by December 31 of each year a share of the unused funding in proportion to the number of LTCH beds that are licensed or approved and in operation in the LHIN's geographic area, other than (i) Beds in Abeyance and (ii) beds funded by the LHIN pursuant to paragraphs 18 and 21 of this Schedule, compared to the provincial total number of LTCH beds that are licensed or approved and in operation in the Province, other than Beds in Abeyance and beds funded by all the LHINs pursuant to paragraphs 18 and 21 of this Schedule to their respective Ministry LHIN Performance Agreements; and

e) At its discretion, provide Supplementary Funding.

3. The **LHIN** will distribute and reconcile the funding provided under paragraph 2 of this Schedule, pursuant to the terms of a service accountability agreement that is consistent with and requires adherence to the Funding Policies and any additional terms and conditions. For greater certainty, the LHIN may not provide any more funding to LTC health service providers than is identified in paragraph 2 of this Schedule, except as provided in the Funding Policies and this Schedule.

4. If a LTC health service provider's beds are closed or transferred to another LHIN, or if a LTC health service provider's licence expires, is surrendered or is revoked under the LTCHA, the residual funding for the beds provided under subparagraph 2 (a) of this Schedule reverts to the **MOHLTC**.

Construction Funding Subsidy (CFS)

5. The **MOHLTC** will:

   a) Determine the CFS per diem and the LTC health service providers in the geographic area of the LHIN that will receive the per diem, including any conditions on the funding and the number of beds for which the LTC health service provider will receive the CFS per diem; and

   b) Provide the CFS per diem to the LHIN.

6. The **LHIN** will provide the CFS per diem to LTC health service providers for each approved or licensed bed that is identified in paragraph 5 of this Schedule and operated in accordance with the MOHLTC's conditions of funding, applicable legislation or Development Agreement.

7. Every service accountability agreement entered into between the LHIN and the LTC health service provider during the term of the Agreement and in the future will contain an obligation on the **LHIN** to provide the CFS per diem to the LTC health service provider for the length of time set out in the particular Development Agreement for the particular beds.

Assignment of LTC Service Agreement

8. Where the MOHLTC has entered into an Acknowledgement and Consent Agreement with a LTC health service provider and one or more lenders of the LTC health service provider (Lender) prior to the proclamation of the LTCHA, the **LHIN** will treat the MOHLTC's consent to assign the service agreement under the Acknowledgement and Consent Agreement as if MOHLTC had provided the consent on behalf of the LHIN.

9. Where an Acknowledgement and Consent Agreement or a Development Agreement between the MOHLTC and the LTC health service provider provides that the MOHLTC will request the LHIN to consent to an assignment of the service agreement, to the Lender or person designated by the Lender, the **LHIN** will consent to the assignment of the service agreement to that person where the MOHLTC so requests, and the consent shall be subject to terms and conditions similar to those of the Acknowledgement and Consent Agreement or the Development Agreement as the case may be.

10. In addition, the **LHIN** will not unreasonably withhold consent requested from a Lender, or from a receiver or receiver and manager appointed by a Lender or by a court order, to assign its or the LTC health service provider's right, title and interest in the service agreement or any part thereof or interest therein to another party, subject to all applicable legislative requirements.

11. Where the **MOHLTC**

a) has entered into a Development Agreement with a LTCH health service provider or a proposed LTCH health service provider (an "Operator");

b) has consented to the grant of a security interest to a Lender under the Development Agreement; and

c) has directed the LHIN to consent to the assignment of the Operator's rights under a service accountability agreement,

then the **LHIN**,

d) Shall deliver to the Lender a commitment, in the MOHLTC's standard form, to provide the LHIN's consent to the assignment of the Operator's rights under the service accountability agreement between the Operator and the LHIN;

e) Upon the grant of a licence to the Operator in respect of the Home, and for so long as a CFS is to be paid in respect of the Home, shall consent to the grant of a security interest in the service accountability agreement between the LHIN and the Operator in respect of the Home, provided that:

1) The security interest in the service accountability agreement may only be exercised together with the exercise of a security interest in the licence for the beds; and

2) The security interest is subject to all applicable statutory requirements and restrictions, including section 107 of the LTCHA and sections 2(2), 19 and 20 of the LHSIA; and

f) Shall amend section 15.8 of the service accountability agreement in respect of the Home to remove the following sentence: "No assignment or subcontract shall relieve the HSP from its obligations under the Agreement or impose any liability upon the LHIN to any assignee or subcontractor."

Beds in Abeyance

12. The **MOHLTC** will review and may approve Beds in Abeyance applications in accordance with the Beds in Abeyance policy and LTCH Protocol.

13. In the event that an application is approved, the **LHIN** may seek and the **MOHLTC** may grant permission to temporarily use the amount of funding available as a result of any approved Beds in Abeyance applications. If the MOHLTC approves the LHIN's request, the LHIN may use the funding in accordance with the approval, including any conditions that may attach to the approval.

Short-Stay Program Beds

14. The **MOHLTC** will:

a) Determine the minimum threshold for occupancy for Short-Stay Respite Beds to

inform approval of these beds in accordance with the LTCH Protocol;

b) Determine the minimum number of Convalescent Care Beds and Interim Beds in the Province;

c) In consultation with the LHIN, determine the LTC health service providers that will provide the Convalescent Care Beds and the Interim Beds and the number of those beds from the minimum number of beds determined in subparagraph (b) of this paragraph; and

d) Set other conditions for the operation of Convalescent Care Beds and Interim Beds.

15. The LHIN will:

a) Take action as appropriate to improve the utilization of Short-Stay Respite Beds;

b) Have the ability to set, in its discretion, a threshold for occupancy of Short-Stay Respite Beds that is higher than the minimum set by the MOHLTC pursuant to subparagraph14 (a) of this Schedule;

c) Determine which LTC health service providers will provide Short-Stay Respite Beds within the existing licensed or approved beds of each home and the number of such beds;

d) Advise and/or make a proposal to MOHLTC about matters referred to in subparagraph 14(c) of this Schedule;

e) Incorporate the conditions referred to in subparagraph 14(d) of this Schedule in service accountability agreements;

f) At its discretion, request that the MOHLTC approve the conversion of existing licensed or approved beds into Convalescent Care Beds additional to those identified in subparagraph14(b) of this Schedule in accordance with the LTCH Protocol; and

g) Provide from its allocation, all additional funding for the converted Convalescent Care Beds approved by the MOHLTC pursuant to subparagraph 15(f) of this Schedule to LTC health service providers in accordance with the Funding Policies, including the additional subsidy for Convalescent Care Beds and the resident co-payment portion of the base level-of-care per diem funding.

LHIN-Requested LTCH Beds

16. In paragraphs 17 and 18 of this Schedule "LHIN Requested LTCH Beds" means, subject to a determination under subparagraph 18(b) of this Schedule, a LTCH bed funded by the LHIN out of its allocation, other than its allocation for LTCHs:

a) That would increase the bed capacity of an existing LTCH licence issued under section 99, or an approval granted under section 130 of the LTCHA; or

b) In the case of a development or redevelopment, that is over and above the number of LTCH beds that the MOHLTC has approved a LTC health service provider for development or redevelopment.

17. The **LHIN** will:

a) At its discretion, request LHIN Requested LTCH Beds;

b) In its request identify (i) the number of LHIN Requested LTCH Beds requested; (ii) the estimated amount of funding required to support the beds in accordance with the Funding Policies, including Supplementary Funding and funding that would be paid in accordance with paragraphs 3 and 6 of this Schedule; and (iii) where, subject to a determination under subparagraph 18(b) of this Schedule, the funding will be found within the LHIN's allocation, other than its allocation for LTCHs; and

c) Fund the LHIN Requested LTCH Beds in accordance with the Funding Policies and paragraphs 3 and 6 of this Schedule if the LHIN's request for LHIN Requested LTCH Beds is granted by the MOHLTC.

18. The **MOHLTC** will:

a) Consider the LHIN's request for LHIN Requested LTCH Beds and decide whether to grant the request.

b) Determine the amount of funding, if any, that the MOHLTC may contribute;

c) Confirm the amount of the funding required to support the beds in accordance with the Funding Policies, including Supplementary Funding and funding that would be calculated pursuant to paragraphs 2 and 5 of this Schedule; and

d) Reallocate the confirmed funding from the sources identified by the LHIN to (i) the LHIN's allocation for LTCH beds for all funding to be paid in accordance with paragraphs 3 and 6 of this Schedule; and (ii) the MOHLTC's allocation for Supplementary Funding when the LHIN Requested LTCH Beds are available for occupancy.

LHIN-Requested Temporary LTCH Beds

19. In paragraphs 20 and 21 of this Schedule, "LHIN Requested Temporary LTCH Beds" means a LTCH bed for which the MOHLTC would issue a temporary licence in accordance with section 111 of the LTCHA or increase the bed capacity of a temporary licence in accordance with the LTCHA, on the condition that the LTCH bed will be funded by the LHIN out of the LHIN's allocation, which may include funding approved for temporary use under paragraph 13 of this Schedule.

20. The **LHIN** will:

a) At its discretion, make a request for LHIN Requested Temporary LTCH Beds for a term of no longer than 5 years;

b) In its request identify (i) the number of LHIN Requested Temporary LTCH Beds requested; (ii) the estimated amount of funding required to support the beds in accordance with the Funding Policies, including Supplementary Funding and funding that would be paid in accordance with paragraph 3 of this Schedule; and (iii) where the funding will be found within the LHIN's allocation; and

c) If the request is approved pursuant to paragraph 21 of this Schedule, provide the funding identified in subparagraph 21(b) of this Schedule for the LHIN Requested Temporary LTCH Beds in accordance with the Funding Policies for the term of the temporary licence issued by the MOHLTC, including any increases in this funding and Supplementary Funding after the date the temporary licence is issued by the MOHLTC for these beds.

21. The **MOHLTC** will:

a) Consider the LHIN's request for LHIN Requested Temporary LTCH Beds and decide whether to grant the request;

b) Confirm the amount of funding required to support the beds in accordance with the Funding Policies, including Supplementary Funding and the funding paid in accordance with paragraph 3 of this Schedule.

SCHEDULE 4: FUNDING and ALLOCATIONS

Definitions

1. In this Schedule, the following terms have the following meanings:

"Annual Balanced Budget" means that, in a fiscal year, the total revenues are greater than or equal to the total expenses. Further, for the LHIN, the meaning of annual balanced budget is also subject to Public Sector Accounting Board (PSAB) rules as well as any interpretations issued by the MOHLTC in financial management policies, directives or guidelines under paragraph 8 of this Schedule.

"Health System Funding Reform (HSFR) Funding" is comprised of HBAM Funding and QBP Funding.

"Health Based Allocation Model (HBAM)" is a population health-based funding methodology that uses population and clinical information to inform funding allocation.

"HBAM Funding" means the portion of funding allocated to a health service provider based on the results of HBAM allocation methodology.

"Multi-year funding targets" means the funding targets for more than one fiscal year.

"Non-HSFR Funding" is the portion of hospital and community care access centre funding net of HSFR Funding.

"Operating Budget" means the budget for the LHIN's corporate operations.

"Quality Based Procedures (QBP)" means the evidence-based funding determination that uses a 'price times volume' methodology to calculate the funding for a targeted set of specific patient groups/procedures.

"QBP Funding" means the portion of funding allocated to a health service provider as a result of QBP analyses using QBP allocation methodology as communicated to the LHINs by the Ministry from time to time.

"Transfer Payment Budget" means the budget for the LHIN's funding of health service providers.

Funding

2. The government's overall provincial LHIN funding allocations that have been updated from the 2013-14 Printed Estimates to include any additional funding to August 31, 2013 and any reallocations initiated by the LHINs are set out in the following tables, in this Schedule:

a) Table 1 – Statement of Overall LHIN Provincial 2013-14 Funding Allocation
b) Table 1a – Statement of Overall LHIN Provincial 2013-14 Funding Allocation for Hospitals and Community Care Access Centres
c) Table 3 – Statement of Overall LHIN Provincial 2013-14 Dedicated Service Funding

by Sector.

3. The MOHLTC:

a) Will provide to the LHIN on September 20, 2013 the 2013-14 funding allocation that has been updated from the 2013-14 Printed Estimates to include any additional funding to August 31, 2013 and any reallocations initiated by the LHIN, set out in the following tables in this Schedule:

(i) Table 2 – Statement of Individual LHIN 2013-14 Funding Allocation
(ii) Table 2a – Statement of Individual LHIN 2013-14 Funding Allocation for Hospitals and Community Care Access Centres
(iii) Table 3a – Statement of Individual LHIN 2013-14 Dedicated Service Funding by Sector;

b) As the LHIN makes funding allocation decisions at the sector level throughout the year, will revise the Health Service Provider Transfer Payment Allocation by Sector – Initiatives allocation in Table 2 in this Schedule to the appropriate sectors;

c) Will reconcile all funding provided to the LHIN under the Agreement on an annual basis;

d) Will recover funding from the LHIN if the MOHLTC has advised the LHIN that the particular funding is recoverable;

e) May set terms and conditions for any of the funding set out in the tables in this Schedule, including the type of funding, whether the funding is subject to annual adjustment, and whether and in what circumstances the funding may be recoverable from the LHIN by the MOHLTC;

f) Has determined that HSFR Funding set out in Tables 1a and 2a is subject to annual adjustment by the MOHLTC, and QBP Funding included in the HSFR Funding set out in Tables 1a and 2a in this Schedule is subject to annual adjustment and is recoverable by the MOHLTC; and

g) May require the LHIN to carry out certain initiatives.

4. The LHIN:

a) Will allocate the funds provided by the MOHLTC for 2013-15, in accordance with the LHSIA, the Agreement and any applicable terms and conditions of which the LHIN is advised by the MOHLTC, including those set out in paragraph 3 of this Schedule;

b) Will carry out MOHLTC-required initiatives that may include:

(i) Aboriginal Community Engagement, French Language Health Services, French Language Health Planning Entities, LHIN Shared Services Office, Diabetes Regional Coordination Centre Program, Emergency/Alternative Level of Care Performance Leads, Emergency Department LHIN Leads and Critical Care LHIN Leads, as set out in Table 2 in this Schedule under LHIN Operating Allocation – Initiatives; and

(ii) Aging At Home, Urgent Priorities Fund, ALC Investment, Behavioural Supports Ontario Project and funding for Community Investment Initiatives as set out in Table 2 in this Schedule under Health Service Provider Transfer Payment Allocation – Initiatives.

c) May, at its discretion, provide additional funding for the services for which Dedicated Service Funding is identified; and

d) May, only with prior approval from the MOHLTC, reallocate unused Dedicated Service Funding to another service. If the MOHLTC does not give approval, the LHIN shall return unused Dedicated Service Funding to the MOHLTC.

Long-Term Care Homes

5. The funding allocations in Tables 1 and 2 for LTCHs are only estimates that are subject to adjustment in accordance with the Funding Policies as defined in Schedule 3, including adjustments for reconciliation, Beds in Abeyance, and Construction Funding Subsidy per diem.

Annual Balanced Budget Requirements

6. The **LHIN** will:

a) Plan for an Annual Balanced Budget for its operations and health service provider transfer payments;

b) Achieve an Annual Balanced Budget for its operations; and

c) Require health service providers who receive LHIN funding through transfer payments to achieve an Annual Balanced Budget.

Multi-Year Funding Requirements

7. The **LHIN** will plan and manage LHIN forecasted expenses for the LHIN's Operating and Transfer Payment Budgets within the multi-year funding targets set out in this schedule and the Multi-Year Funding Framework. Multi-year funding targets are to be used for planning purposes only and may be revised upward or downward at the discretion of the MOHLTC.

Financial Management Polices and Guidelines

8. The **MOHLTC** may develop and issue to the LHIN policies, directives and guidelines related to financial management.

9. The **LHIN** will comply with all applicable legislation, including the Financial Administration Act; any MOHLTC policies, directives and guidelines issued to the LHIN related to financial management; and government financial management policies, guidelines, and directives, including the following:

a) Multi-Year Funding Framework;

b) Parameters for Financial Health Framework;
c) Fiscal Prudence through Contingency Planning Policy; and
d) Parameters for In-Year and Year-End Reallocations Policy.

Accounting Standards

10. The **MOHLTC**:

a) Will issue interpretations and modifications relating to Public Sector Accounting Board (PSAB) standards, based on advice from the Office of the Provincial Controller; and

b) May review the documentation described in paragraph 11 of this Schedule during regular business hours and upon twenty-four hours' notice to the LHIN.

11. The **LHIN** will:

a) Prepare its financial reports and statements on its Operating and health service provider Transfer Payment Budgets, including its Annual Business Plan, based on the Public Sector Accounting Board (PSAB) standards, subject to interpretations and modifications issued under paragraph 10 of this Schedule.

b) Maintain documentation to support all financial statements and related payment instructions, including funding approval letters to health service providers and service accountability agreements signed between the LHIN and its health service providers.

Table 1: Statement of Overall LHIN Provincial 2013-14 Funding Allocation		
	2013-14 Funding Allocation (000s)	2014-15 Funding Allocation (000s)
Total LHIN Operating Allocation	24,971,536.5	TBD
Total Health Service Provider (HSP) Transfer Payment Allocation	24,881,083.6	TBD
Operation of LHIN	63,920.2	TBD
Initiatives	26,532.7	TBD
E-Health	.0	TBD
Total Health Service Provider Transfer Payment Allocation by Sector		
Operations of Hospitals	16,403,556.6	TBD
Grants to compensate for Municipal Taxation - Public Hospitals	3,739.6	TBD
Long Term Care Homes	3,421,313.5	TBD
Community Care Access Centres	2,215,870.7	TBD
Community Support Services	429,803.4	TBD
Acquired Brain Injury	47,326.2	TBD
Assisted Living Services in Supportive Housing	236,922.4	TBD
Community Health Centres	362,422.7	TBD
Community Mental Health	688,095.4	TBD
Addictions Program	174,462.5	TBD
Specialty Psychiatric Hospitals	608,035.4	TBD
Grants to Compensate for Municipal Taxation - Psychiatric Hospitals	126.3	TBD
Initiatives	289,408.9	TBD

Table 1a: Statement of Overall LHIN Provincial 2013-14 Funding Allocation for Hospitals and Community Care Access Centres		
	2013-14 Funding Allocation (000s) [1]	2014-15 Funding Allocation (000s) [1]
Hospitals	**16,403,556.5**	**TBD**
Health System Funding Reform (HSFR)	6,268,996.7	TBD
Includes One-time Mitigation Funding	43,935.7	TBD
Non-HSFR	10,134,559.8	TBD
Community Care Access Centre	2,215,870.7	**TBD**
Health System Funding Reform (HSFR)	599,997.7	TBD
Includes One-time Mitigation Funding	3,335.3	**TBD**
Non-HSFR	1,615,873.0	**TBD**

[1] The amounts in this table are included in Table 1 under the respective sectors.

Table 2: Statement of Individual LHIN 2013-14 Funding Allocation		
	2013-14 Funding Allocation (000s)	2014-15 Funding Allocation (000s)
Total LHIN Operating Allocation	2,229,111.6	TBD
Total Health Service Provider (HSP) Transfer Payment Allocation	2,222,624.3	TBD
Operation of LHIN	4,895.7	TBD
Initiatives	1,591.6	TBD
E-Health		TBD
Total Health Service Provider Transfer Payment Allocation by Sector		
Operations of Hospitals	1,559,323.6	TBD
Grants to compensate for Municipal Taxation – Public Hospitals	451.5	TBD
Long Term Care Homes	309,872.8	TBD
Community Care Access Centres	190,402.6	TBD
Community Support Services	34,650.2	TBD
Acquired Brain Injury	4,634.1	TBD
Assisted Living Services in Supportive Housing	17,341.2	TBD
Community Health Centres	17,874.7	TBD
Community Mental Health	51,652.7	TBD
Addictions Program	10,509.2	TBD
Specialty Psychiatric Hospitals		TBD
Grants to Compensate for Municipal Taxation - Psychiatric Hospitals		TBD
Initiatives	25,911.7	TBD

Table 2a: Statement of Individual 2013-14 Funding Allocation for Hospitals and Community Care Access Centres		
	2013-14 Funding Allocation (000s) [1]	2014-15 Funding Allocation (000s) [1]
Hospitals	**1,559,323.6**	**TBD**
Health System Funding Reform (HSFR)	560,505.2	TBD
Includes One-time Mitigation Funding	21,715.4	TBD
Non-HSFR	998,818.4	TBD
Community Care Access Centre	**190,402.6**	**TBD**
Health System Funding Reform (HSFR)	51,295.8	TBD
Includes One-time Mitigation Funding	-	TBD
Non-HSFR	139,106.8	TBD

[1] The amounts in this table are included in Table 1 under the respective sectors.

Table 3: Statement of Overall LHIN Provincial 2013-14 Dedicated Service Funding by Sector	
	2013-14 Dedicated Service Funding Allocation
Hospitals	
Post Construction Operating Plan	TBD
Community Health Centres	
Uninsured Persons Services	$4,075,382
Mental Health	
Consumer Survivor Initiatives	$12,000,355
Addictions	
Problem Gambling Treatment Services	$11,083,282
Community Care Access Centres	
School Health Professional and Personal Support Services	$84,091,615
Other	
Compensation Under Specified Initiatives / Agreements [1]	$85,191,853

[1] Includes CHC physician salaries and psychiatric sessional fees for community and hospital-based agencies.

Table 3a: Statement of Individual LHIN 2013-14 Dedicated Service Funding by Sector	
	2013-14 Dedicated Service Funding Allocation
Hospitals	
Post Construction Operating Plan	TBD
Community Health Centres	
Uninsured Persons Services	$24,200
Mental Health	
Consumer Survivor Initiatives	$720,550
Addictions	
Problem Gambling Treatment Services	$645,117
Community Care Access Centres	
School Health Professional and Personal Support Services	$8,717,301
Other	
Compensation Under Specified Initiatives / Agreements [1]	$4,663,610

[1] Includes CHC physician salaries and psychiatric sessional fees for community and hospital-based agencies.

SCHEDULE 5: LOCAL HEALTH SYSTEM PERFORMANCE

Definitions

1. In this Schedule, the following terms have the following meanings:

"**LHIN baseline**" means the result at a given time for a performance indicator that provides a starting point for measuring changes in local health system performance and for establishing LHIN targets for future local health system performance;

"**LHIN target**" means a planned result for an indicator against which actual results can be compared;

"**Performance indicator**" means a measure of local health system performance for which a LHIN target will be set, and the LHIN will be held accountable for achieving results under the terms of the Agreement for the local health system in connection with a performance indicator;

"**Provincial target**" means an optimal performance result for an indicator, which may be based on expert consensus, performance achieved in other jurisdictions, or provincial expectations;

"**CTAS**" means Canadian Emergency Department Triage and Acuity Scale; and

"**CMG**" means Case Mix Group.

General Obligations

2. Under the LHSIA and the *Commitment to the Future of Medicare Act, 2004* the **LHIN** will measure and plan to improve performance at the local level through service accountability agreements with health service providers.

Specific Obligations

3. The **MOHLTC** will:

a) Calculate the results for the performance indicators set out in Tables 1, 2 and 3;

b) Provide the LHIN with calculated results for the performance indicators by the release dates set out in Schedule 6, and supporting performance information as requested by the LHIN, such as the performance of health service providers; and

c) Provide the LHIN with technical documentation for the performance indicators set out in Tables 1, 2 and 3, including the methodology, inclusions and exclusions.

4. The **LHIN** will:

a) Work to achieve the LHIN's performance targets for the performance indicators set out in Tables 1, 2 and 3;

b) Report quarterly on the performance of the local health system on all performance indicators; and

c) Report on the performance of the local health system on all performance indicators in the LHIN Annual Report.

Table 1: Performance Indicators

- Objective: To enhance person-centred care
- Expected Outcome: Persons will experience improved access to healthcare services identified below in alignment with best practices.

INDICATOR	Provincial target	LHIN Baseline 2013-14	LHIN Target 2013-14
90th Percentile Emergency Room (ER) Length of Stay for Admitted Patients	8 hours	23.80 hours	23.50 hours
90th Percentile ER Length of Stay for Non-Admitted Complex (CTAS I-III) Patients	8 hours	6.50 hours	6.50 hours
90th Percentile ER Length of Stay for Non-Admitted Minor Uncomplicated (CTAS IV-V) Patients	4 hours	3.77 hours	3.90 hours
Percent of Priority IV Cases Completed Within Access Target for Cancer Surgery *	Priority IV: 84 days	91%	90%
Percent of Priority IV Cases Completed Within Access Target for Cardiac By-Pass Procedures *	Priority IV: 90 days	99.6%	90%
Percent of Priority IV Cased Completed Within Access Target for Cataract Surgery *	Priority IV: 182 days	97%	90%
Percent of Priority IV Cases Completed Within Access Targets for Hip Replacement *	Priority IV: 182 days	89%	90%
Percent of Priority IV Cases Completed Within Access Target for Knee Replacement *	Priority IV : 182 days	83%	90%
Percent of Priority IV Cases Completed Within Access Target for MRI Scan *	Priority IV : 28 days	45%	60%
Percent of Priority IV Cases Completed Within Access Target for Diagnostic CT Scan *	Priority IV : 28 days	90%	90%

* The reporting for these indicators has been revised starting 2013/14. Previous Agreements included the 90th percentile wait time for these surgical and diagnostic imaging services.

Table 2: Performance Indicators			
• Objective: To improve system integration and enhance coordination of care while ensuring better transitions to various care settings. • Expected Outcome: Persons will be able to navigate the healthcare system and receive the care they need, when and where they need it.			
INDICATOR	Provincial target	LHIN Baseline 2013-14	LHIN Target 2013-14
Percentage of Alternate Level of Care (ALC) Days	9.46%	10.51%	9.46%
90th Percentile Wait Time from Community for CCAC In-Home Services – Application from Community Setting to first CCAC Service (excluding case management)	TBD	26 days	24 days
Wait Time from When CCAC Receives Application to Long Term Care Home to When Assessment for Eligibility is Completed *	TBD		

* New indicator for 2013/14. The MOHLTC and the LHINs will monitor performance in 2013/14 and work together to refine quality and consistency of data. Targets will be established starting 2014/15.

Table 3: Performance Indicators			
• Objective: To implement evidence based practice to drive quality and value and improve health outcomes • Expected Outcome: Persons will receive quality inpatient care and coordinated post-discharge care, leading to reduced readmission rates that may improve survival, quality of life and other outcomes without increasing cost.			
INDICATOR	Provincial target	LHIN Baseline 2013-14	LHIN Target 2013-14
Readmissions within 30 days for Selected CMGs	TBD	16.81%	15.10%
Repeat Unscheduled Emergency Visits within 30 days for Mental Health Conditions *	TBD	15.60%	15.60%
Repeat Unscheduled Emergency Visits within 30 days for Substance Abuse Conditions *	TBD	31.80%	28.60%

* The methodology for these indicators has been revised starting 2013/14. Results may not be comparable to the previous Agreement.

SCHEDULE 6: INTEGRATED REPORTING

General Obligations

1. The MOHLTC and the LHIN will report to each other as set out in Table 1.

2. The **MOHLTC** will:

   a) Provide any necessary training, instructions, materials, data, templates, forms, and guidelines to the LHIN to assist with the completion of the reports listed in Table 1; and

   b) As required, develop reporting requirements relating to government priorities and notify the LHIN of the requirements.

3. **Both parties** will:

   a) Work together to ensure a timely flow of information, including financial records, to fulfill the reporting requirements of both parties; and

   b) Finalize the Annual Business Plan within 120 days of a budget announcement by the Government of Ontario as part of the annual review set out in Schedule 1: General.

Table 1: MOHLTC and LHIN Reporting Obligations (2013/14)

Due Date	Description of Item
2013/2014	
APRIL	
April 16, 2013	MOHLTC will provide to the LHIN a Year End Report confirming the expenditures and revenue related to its transfer payments as of March 31 of the preceding fiscal year
April 30, 2013	MOHLTC will provide to the LHIN the forms for the Year-end Consolidation Report
April 30, 2013	The LHIN will submit to the MOHLTC a Quarterly Expense Report using the forms provided by the MOHLTC
April 30, 2013	The LHIN will submit to the MOHLTC an Attestation as required under the *Broader Public Sector Accountability Act* (*BPSAA*)
MAY	
May 13, 2013	MOHLTC will provide the LHIN with the most recent quarter of data for indicators in Schedule 5: Local Health System Performance
May 14, 2013	MOHLTC will provide to the LHIN a Year End Report with updated expenditures and revenue related to its transfer payments as of March 31 of the preceding fiscal year
May 17, 2013	The MOHLTC will provide to the LHIN for planning and reporting purposes the initial preliminary allocation for 2013-14
May 31, 2013	The LHIN will submit to the MOHLTC the year-end consolidation report using forms provided by the MOHLTC and the draft Audited Financial Statement if the signed statements are not ready by May 31 of each fiscal year to which the Agreement applies
JUNE	
June 3, 2013	The LHIN will submit to the MOHLTC a report on performance indicators using the forms provided by the MOHLTC
On or about the 7th working day (date may vary on IFIS GL close as advised by the MOHLTC)	MOHLTC will make the expenditure and revenue report available to the LHIN in APTS for the LHIN's review
June 28, 2013	The LHIN will submit to the MOHLTC Q1 Regular and Consolidation Report using the forms provided by the MOHLTC
June 28, 2013	The LHIN will submit to the MOHLTC an Annual Report for the previous fiscal year in accordance with MOHLTC requirements
June 28, 2013	The LHIN will submit to the MOHLTC a Board approved report on consultant use for the previous fiscal year using the template provided in the Minister's Directive under the *BPSAA*

Due Date	Description of Item
JULY	
July 31,2013	The LHIN will submit to the MOHLTC a Quarterly Expense Report using the forms provided by the MOHLTC
July 31,2013	The LHIN will submit to the MOHLTC an Attestation as required under the *BPSAA*
AUGUST	
August 12, 2013	The MOHLTC will provide to the LHIN the most recent quarter of performance data for indicators in Schedule 5: Local Health System Management
August 15, 2013	The MOHLTC will provide the preliminary approved allocation for the current fiscal year, as of July 31, 2013
August 30, 2013	MOHLTC will provide to the LHIN the forms and information requirements for the Multi-year Consolidation Report
SEPTEMBER	
September 3, 2013	The LHIN will submit to the MOHLTC a report on performance indicators using the forms provided by the MOHLTC
On or about the 7th working day (date may vary on IFIS GL close as advised by the MOHLTC)	The MOHLTC will make the expenditure and revenue report available to the LHIN in APTS for the LHIN's review
September 30, 2013	The LHIN will submit to the MOHLTC Q2 Regular and Consolidation Report using the forms provided by the MOHLTC
September 30, 2013	The MOHLTC will provide to the LHIN the forms and information requirements for the 2014/15 Annual Business Plan
OCTOBER	
October 31, 2013 (or date necessary to meet central agency reporting requirements as advised by the MOHLTC)	The LHIN will submit to the MOHLTC a Multi-year Consolidation Report using the form provided by the MOHLTC
By October 31, 2013	The LHIN will submit to the MOHLTC an Attestation as required under the *BPSAA*
October 31, 2013	The LHIN will submit to the MOHLTC a Quarterly Expense Report using the forms provided by the MOHLTC
NOVEMBER	
November 12, 2013	MOHLTC will provide to the LHIN the most recent quarter of performance data for indicators in Schedule 5: Local Health System Management
DECEMBER	
December 2, 2013	The LHIN will submit to the MOHLTC a report on performance indicators using the forms provided by the MOHLTC

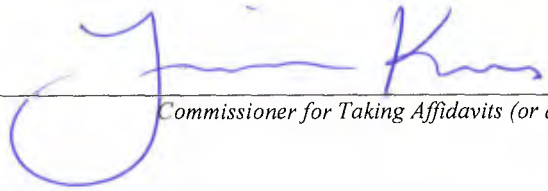
Due Date	Description of Item
On or about the 7th working day (date may vary on IFIS GL close as advised by the MOHLTC)	The MOHLTC will make the expenditure and revenue report available to the LHIN in APTS for the LHIN's review
December 31, 2013	LHIN will submit to the MOHLTC Q3 Regular and Consolidation Report including final year-end forecast using the forms provided by the MOHLTC
JANUARY	
January 31, 2014	MOHLTC will provide the LHIN with year-end instructions (including templates)
By January 31, 2014	The LHIN will submit to the MOHLTC an Attestation required under the *BPSAA*
January 31, 2014	The LHIN will submit to the MOHLTC a Quarterly Expense Report using the forms provided by the MOHLTC
FEBRUARY	
February 10, 2014	MOHLTC will provide the LHIN with most recent quarter of performance data for indicators in Schedule 5: Local Health System Performance
February 14, 2014	MOHLTC will provide to the LHIN the forms and requirements for the Annual Report (non-financial content)
February 28, 2014	The LHIN will submit to the MOHLTC a Draft 2014/15 Annual Business Plan using the forms provided by the MOHLTC
MARCH	
March 3, 2014	The LHIN will submit to the MOHLTC a report on performance indicators using the forms provided by the MOHLTC
March 28, 2014	MOHLTC will provide to the LHIN the forms for the Annual Report (financial content)
2014/2015	
APRIL	
April 15, 2014	MOHLTC will provide to the LHIN a Year End Report confirming the expenditures and revenue related to its transfer payments as of March 31 of the preceding fiscal year
April 15, 2014	The LHIN will submit to the MOHLTC Year End Reallocation Report on actual expenditures related to in-year reallocations as of March 31 of the preceding fiscal year
April 30, 2014	MOHLTC will provide to the LHIN the forms for the Year-end Consolidation Report
By April 30, 2014	The LHIN will submit to the MOHLTC an Attestation as required under the *BPSAA*
April 30, 2014	The LHIN will submit to the MOHLTC a Expense Report using the forms provided by the MOHLTC

Due Date	Description of Item
MAY	
May 12, 2014	The MOHLTC will provide to the LHIN the most recent quarter of performance data for indicators in Schedule 5: Local Health System Performance
May 13, 2014	MOHLTC will provide to the LHIN a Year End Report with updated expenditures and revenue related to its transfer payments as of March 31, of the preceding fiscal year
May 16, 2014	The MOHLTC will provide to the LHIN for planning and reporting purposes the initial preliminary allocation for 2014-15
May 30, 2014 (or date necessary to meet central agency reporting requirements as advised by the MOHLTC)	The LHIN will submit to the MOHLTC the year-end consolidation report using forms provided by the MOHLTC and the draft Audited Financial Statement if the signed statements are not ready by May 31 of each fiscal year to which the Agreement applies
JUNE	
June 2, 2014	The LHIN will submit to the MOHLTC a report on performance indicators using the forms provided by the MOHLTC
On or about the 7th working day (date may vary on IFIS GL close as advised by the MOHLTC)	The MOHLTC will make the expenditure and revenue report available to the LHIN in APTS for the LHIN's review
June 30, 2014	The LHIN will submit to the MOHLTC Q1 Regular and Consolidation Report using the forms provided by the MOHLTC
June 30, 2014	The LHIN will submit to the MOHLTC an Annual Report for the previous fiscal year in accordance with MOHLTC requirements
June 30, 2014	The LHIN will submit to the MOHLTC a Board approved report on consultant use for the previous fiscal year using the template provided in the Minister's Directive under the *BPSAA*
JULY	
July 31,2014	The LHIN will submit to the MOHLTC a Quarterly Expense Report using the forms provided by the MOHLTC
July 31,2014	The LHIN will submit to the MOHLTC an Attestation as required under the *BPSAA*
AUGUST	
August 12, 2014	The MOHLTC will provide to the LHIN the most recent quarter of performance data for indicators in Schedule 5: Local Health System Management
August 15, 2014	The MOHLTC will provide the preliminary approved allocation for the current fiscal year, as of July 31, 2014
August 29, 2014	MOHLTC will provide to the LHIN the forms and information requirements for the Multi-year Consolidation Report

Due Date	Description of Item
SEPTEMBER	
September 2, 2014	The LHIN will submit to the MOHLTC a report on performance indicators using the forms provided by the MOHLTC
On or about the 7th working day (date may vary on IFIS GL close as advised by the MOHLTC)	The MOHLTC will make the expenditure and revenue report available to the LHIN in APTS for the LHIN's review
September 30, 2014	The LHIN will submit to the MOHLTC Q2 Regular and Consolidation Report using the forms provided by the MOHLTC
September 30, 2014	The MOHLTC will provide to the LHIN the forms and information requirements for the 2014/15 Annual Business Plan
OCTOBER	
October 31, 2014 (or date necessary to meet central agency reporting requirements as advised by the MOHLTC)	The LHIN will submit to the MOHLTC a Multi-year Consolidation Report using the form provided by the MOHLTC
By October 31, 2014	The LHIN will submit to the MOHLTC an Attestation as required under the *BPSAA*
October 31, 2014	The LHIN will submit to the MOHLTC a Quarterly Expense Report using the forms provided by the MOHLTC
NOVEMBER	
November 12, 2014	MOHLTC will provide to the LHIN the most recent quarter of performance data for indicators in Schedule 5: Local Health System Management
DECEMBER	
December 3, 2014	The LHIN will submit to the MOHLTC a report on performance indicators using the forms provided by the MOHLTC
On or about the 7th working day (date may vary on IFIS GL close as advised by the MOHLTC)	The MOHLTC will make the expenditure and revenue report available to the LHIN in APTS for the LHIN's review
December 31, 2014	LHIN will submit to the MOHLTC Q3 Regular and Consolidation Report including final year-end forecast using the forms provided by the MOHLTC
JANUARY	
January 30, 2015	MOHLTC will provide the LHIN with year-end instructions (including templates)
By January 30, 2015	The LHIN will submit to the MOHLTC an Attestation required under the *BPSAA*

Due Date	Description of Item
January 30, 2015	The LHIN will submit to the MOHLTC a Quarterly Expense Report using the forms provided by the MOHLTC
FEBRUARY	
February 10, 2015	MOHLTC will provide the LHIN with most recent quarter of performance data for indicators in Schedule 5: Local Health System Performance
February 13, 2015	MOHLTC will provide to the LHIN the forms and requirements for the Annual Report (non-financial content)
February 28, 2015	The LHIN will submit to the MOHLTC a Draft 2015/16 Annual Business Plan using the forms provided by the MOHLTC
MARCH	
March 3, 2015	The LHIN will submit to the MOHLTC a report on performance indicators using the forms provided by the MOHLTC
March 27, 2015	MOHLTC will provide to the LHIN the forms for the Annual Report (financial content)

This is Exhibit "C" referred to in the Affidavit of Dr. Michael Hillmer sworn August 29, 2018



Commissioner for Taking Affidavits (or as may be)

Jessica Taylor Kras, a Commissioner, etc.,
Province of Ontario,
while a Student-at-Law.
Expires May 30, 2020.

LONG-TERM CARE HOME SERVICE ACCOUNTABILITY AGREEMENT

For the Period: April 1, 2013 - March 31, 2016

Index to Agreement

THIS SERVICE ACCOUNTABILITY AGREEMENT effective as of April 1, 2013

B E T W E E N:

SOUTH WEST LOCAL HEALTH INTEGRATION NETWORK (the "LHIN")

AND

Caressant-Care Nursing and Retirement Homes Limited (the "HSP")

IN RESPECT OF:

Caressant Care Woodstock Nursing Home located at

81 Fyfe Avenue, Woodstock, Ontario, N4S 8Y2 (the "Home")

Background:

The *Local Health System Integration Act, 2006* requires that the LHIN and the HSP enter into a service accountability agreement. The service accountability agreement supports a collaborative relationship between the LHIN and the HSP to improve the health of Ontarians through better access to high quality health services, to co-ordinate health care in local health systems and to manage the health system at the local level effectively and efficiently.

In this context, the HSP and the LHIN agree that the LHIN will provide funding to the HSP on the terms and conditions set out in this Agreement to enable the provision of services to the local health system by the HSP.

ARTICLE 1.0- DEFINITIONS & INTERPRETATION

1.1 **Definitions.** In this Agreement the following terms will have the following meanings:

"**Act**" means the *Long-Term Care Homes Act, 2007* and the regulations made under the *Long Term Care Homes Act, 2007* as it and they may be amended from time to time;

"**Accountability Agreement**" refers to this Agreement in place between the Minister and the LHIN pursuant to the terms of s. 18 of LHSIA;

"**Agreement**" means this agreement and includes the Schedules and any instrument amending this agreement or the Schedules;

"**Annual Balanced Budget**" means that, in each calendar year of the term of this Agreement, the total expenses of the HSP in respect of the Services are less than or equal to the total revenue of the HSP in respect of the Services.

"**Applicable Law**" means all federal, provincial or municipal laws, orders, rules, regulations, common law, licence terms or by-laws, and includes terms or conditions of a licence or approval issued under the Act, that are applicable to the HSP, the Services, this Agreement and the Parties' obligations under this Agreement during the term of this Agreement;

"**Applicable Policy**" means any orders, rules, policies, directives or standards of practice issued or adopted by the LHIN, by the MOHLTC or by other ministries or agencies of the province of Ontario that are applicable to the HSP, the Services, this Agreement and the Parties' obligations under this Agreement during the term of this Agreement. Without limiting the generality of the foregoing, Applicable Policy includes the Design Manual and the Long Term Care Funding and Financial Management Policies and all other manuals, guidelines, policies and other documents listed on the Policy Web Pages as those manuals, guidelines, policies and other documents may be amended from time to time;

"**Approved Funding**" has the meaning ascribed to it in Schedule B;

"**Beds**" means the long term care home beds that are licensed or approved under the Act and identified in Schedule A, as the same may be amended from time to time;

"**Board**" means in respect of an HSP that is:

(i) a corporation, the board of directors;
(ii) A First Nation, the band council;
(iii) a municipality, the committee of management;
(iv) a board of management established by one or more municipalities or by one or more First Nations' band councils, the members of the board of management;
(v) a partnership, the partners;
(vi) a sole proprietorship, the sole proprietor.

"**BPSAA**" means the *Broader Public Sector Accountability Act, 2010,* and the regulations made under the Broader Public Sector Accountability Act, 2010 as it and they may be amended from time to time;

"**CEO**" means the individual accountable to the Board for the provision of the Services in accordance with the terms of this Agreement;

"**CFMA**" means the *Commitment to the Future of Medicare Act, 2004*, and the regulations made under the *Commitment to the Future of Medicare Act, 2004*, as it and they may be amended from time to time;

"**Compliance Declaration**" means a compliance declaration substantially in the form set out in Schedule "E";

"**Confidential Information**" means information that is (i) marked or otherwise identified as confidential by the disclosing Party at the time the information is provided to the receiving Party; and (ii) eligible for exclusion from disclosure at a public board meeting in accordance with section 9 of LHSIA. Confidential Information does not include information that (a) was known to the receiving Party prior to receiving the information from the disclosing Party; (b) has become publicly known through no wrongful act of the receiving Party; or (c) is required to be disclosed by law, provided that the receiving Party provides Notice in a timely manner of such requirement to the disclosing Party, consults with the disclosing Party on the proposed form and nature of the disclosure, and ensures that any disclosure is made in strict accordance with Applicable Law;

"Conflict of Interest" in respect of an HSP, includes any situation or circumstance where: in relation to the performance of its obligations under this Agreement

(i) the HSP;
(ii) a member of the HSP's Board or
(iii) any person employed by the HSP who has the capacity to influence the HSP's decision,

has other commitments, relationships or financial interests that:

(iv) could or could be seen to interfere with the HSP's objective, unbiased and impartial exercise of its judgement; or
(v) could or could be seen to compromise, impair or be incompatible with the effective performance of its obligations under this Agreement;

"**Construction Funding Subsidy**" has the meaning ascribed to it in Schedule B;

"**controlling shareholder**" of a corporation means a shareholder who or which holds (or another person who or which holds for the benefit of such shareholder), other than by way of security only, voting securities of such corporation carrying more than 50% of the votes for the election of directors, provided that the votes carried by such securities are sufficient, if exercised, to elect a majority of the board of directors of such corporation.

"**Days**" means calendar days;

"**Design Manual**" means the MOHLTC design manual in effect and applicable to the development, upgrade, retrofit or redevelopment of the Home or Beds subject to this Agreement;

"Director" has the same meaning as the term "Director" in the Act;

"Effective Date" means April 1, 2013;

"**e-Health**" means the coordinated and integrated use of electronic systems, information and communication technologies to facilitate the collection, exchange and management of personal health information in order to improve the quality, access, productivity and sustainability of the healthcare system.

"**Explanatory Indicator**" means a measure of HSP performance for which no Performance Target is set. Technical specifications of specific Explanatory Indicators can be found in the "L-SAA 2013-16 Indicator Technical Specifications" document.

"FIPPA" means the *Freedom of Information and Protection of Privacy Act, Ontario* and the regulations made under the *Freedom of Information and Protection of Privacy Act, Ontario,* as it and they may be amended from time to time;

"**Funding**" means the amounts of money provided by the LHIN to the HSP in each Funding Year of this Agreement. Funding includes Approved Funding and Construction Funding Subsidy;

"**Funding Year**" means in the case of the first Funding Year, the period commencing on the January 1 prior to the Effective Date and ending on the following December 31, and

in the case of Funding Years subsequent to the first Funding Year, the period commencing on the date that is January 1 following the end of the previous Funding Year and ending on the following December 31;

"**Home**" means the building where the Beds are located and for greater certainty, includes the Beds and the common areas and common elements which will be used at least in part, for the Beds, but excludes any other part of the building which will not be used for the Beds being operated pursuant to this Agreement;

"**HSP's Personnel**" means the controlling shareholders (if any), directors, officers, employees, agents, volunteers and other representatives of the HSP. In addition to the foregoing HSP's Personnel shall include the contractors and subcontractors and their respective shareholders, directors, officers, employees, agents, volunteers or other representatives;

"Indemnified Parties" means the LHIN and its officers, employees, directors, independent contractors, subcontractors, agents, successors and assigns and her Majesty the Queen in Right of Ontario and her Ministers, appointees and employees, independent contractors, subcontractors, agents and assigns. Indemnified Parties also includes any person participating on behalf of the LHIN in a Review.;

"**Interest Income**" means interest earned on the Funding;

"**Licence**" means one or more of the licences or the approvals granted to the HSP in respect of the Beds at the Home under Part VII or Part VIII of the Act;

"LHSIA" means the *Local Health System Integration Act, 2006* and the regulations under the *Local Health System Integration Act, 2006* as it and they may be amended from time to time;

"**Minister**" means the Minister of Health and Long-Term Care;

"MOHLTC" means the Minister or the Ministry of Health and Long-Term Care, as is appropriate in the context;

"**Notice**" means any notice or other communication required to be provided pursuant to this Agreement, LHSIA, the Act or the CFMA;

"Party" means either of the LHIN or the HSP and "Parties" mean both of the LHIN and the HSP;

"Performance Agreement" means an agreement between an HSP and its CEO that requires the CEO to perform in a manner that enables the HSP to achieve the terms of this Agreement;

"Performance Corridor" means the acceptable range of results around a Performance Target;

"Performance Factor "means any matter that could or will significantly affect a Party's ability to fulfill its obligations under this Agreement;

"**Performance Indicator**" means a measure of HSP performance for which a Performance Target is set; Technical specifications of specific Performance Indicators can be found in the "L-SAA 2013-16 Indicator Technical Specifications" document;

"**Performance Standard**" means the acceptable range of performance for a Performance Indicator or a Service Volume that results when a Performance Corridor is applied to a Performance Target;

"**Performance Target**" means the level of performance expected of the HSP in respect of a Performance Indicator or a Service Volume;

"**Planning Submission**" means the planning document submitted by the HSP to the LHIN. The form, content and scheduling of the Planning Submission will be identified by the LHIN;

"**Policy Web Pages**" means the web pages available at www.health.gov.on.ca/lsaapolicies, and at www.health.gov.on.ca/erssldpolitique or such other URLs or Web pages as the LHIN or the Ministry may advise from time to time. Capital policies can be found at Http //www.health.gov.on.ca/english/providers/program/ltc_redev/awardeeoperator.html;

"**RAI MDS Tools**" means the standardized Resident Assessment Instrument – Minimum Data Set (RAI MDS") 2.0, the RAI MDS 2.0 User Manual and the RAI MDS Practice Requirements, as the same may be amended from time to time;

"**Reports**" means the reports described in Schedule C as well as any other reports or information required to be provided under LHSIA, the Act or this Agreement;

"**Resident**" has the meaning ascribed to the term "resident" under the Act;

"**Review**" means a financial or operational audit, investigation, inspection or other form of review requested or required by the LHIN under the terms of LHSIA or this Agreement, but does not include the annual audit of the HSP's financial statements;

"**Schedule**" means any one of, and "**Schedules**" mean any two or more, as the context requires, of the schedules appended to this Agreement and includes:

A. Description of Home and Beds
B. Additional Terms and Conditions Applicable to the Funding Model
C. Reporting Requirements
D. Performance
E. Form of Compliance Declaration

"**Services**" means the operation of the Beds and the Home and the accommodation, care, programs, goods and other services that are provided to residents (i) to meet the requirements of the Act; (ii) to obtain Approved Funding; and (iii) to fulfill all commitments made to obtain a Construction Funding Subsidy.

"**Service Volume**" means a measure of Services for which a Performance Target is set.

1.2 **Interpretation.** Words in the singular include the plural and vice-versa. Words in one gender include both genders. The headings do not form part of this Agreement. They are

for convenience of reference only and will not affect the interpretation of this Agreement. Terms used in the Schedules shall have the meanings set out in this Agreement unless separately and specifically defined in a Schedule in which case the definition in the Schedule shall govern for the purposes of that Schedule.

ARTICLE 2.0 - TERM AND NATURE OF THIS AGREEMENT

2.1 **Term**. The term of this Agreement will commence on the Effective Date and will expire on the earlier of (i) March 31, 2016 or (ii) the expiration or termination of all Licences, unless this Agreement is terminated earlier or extended pursuant to its terms.

2.2 **A Service Accountability Agreement.** This Agreement is a service accountability agreement for the purposes of subsection 20(1) of LHSIA and Part III of the CFMA.

2.3 **Notice.** Notice was given to the HSP that the LHIN intended to enter into this Agreement. The HSP hereby acknowledges receipt of such Notice in accordance with the terms of the CFMA.

2.4 **Prior Agreements.** The parties acknowledge and agree that all prior agreements for the Services are terminated.

ARTICLE 3.0 - PROVISION OF SERVICES

3.1 **Provision of Services.**

(a) The HSP will provide the Services in accordance with, and otherwise comply with:

(i) the terms of this Agreement;
(ii) Applicable Law; and
(iii) Applicable Policy.

(b) Unless otherwise provided in this Agreement, the HSP will not reduce, stop, start, expand, cease to provide or transfer the provision of the Services except with Notice to the LHIN and if required by Applicable Law or Applicable Policy, the prior written consent of the LHIN.

(c) The HSP will not restrict or refuse the provision of Services to an individual, directly or indirectly, based on the geographic area in which the person resides in Ontario.

3.2 **Subcontracting for the Provision of Services.**

(a) The Parties acknowledge that, subject to the provisions of the Act and LHSIA, the HSP may subcontract the provision of some or all of the Services. For the purpose of this Agreement, actions taken or not taken by the subcontractor and Services provided by the subcontractor will be deemed actions taken or not taken by the HSP and Services provided by the HSP.

(b) When entering into a subcontract the HSP agrees that the terms of the subcontract will enable the HSP to meet its obligations under this Agreement. Without

limiting the foregoing, the HSP will include a provision that permits the LHIN or its authorized representatives, to audit the subcontractor in respect of the subcontract if the LHIN or its authorized representatives determines that such an audit would be necessary to confirm that the HSP has complied with the terms of this Agreement.

(c) Nothing contained in this Agreement or a subcontract will create a contractual relationship between any subcontractor or its directors, officers, employees, agents, partners, affiliates or volunteers and the LHIN.

3.3 Conflict of Interest. The HSP will use the Funding, provide the Services and otherwise fulfil its obligations under this Agreement without an actual, potential or perceived Conflict of Interest. The HSP will disclose to the LHIN without delay any situation that a reasonable person would interpret as an actual, potential or perceived Conflict of interest and comply with any requirements prescribed by the LHIN to resolve any Conflict of Interest.

3.4 E-health/Information Technology Compliance. The HSP agrees to

(i) comply with any technical and information management standards, including those related to architecture, technology, privacy and security set for health service providers by the MOHLTC, eHealth Ontario or the LHIN within the timeframes set by the MOHLTC or the LHIN as the case may be;

(ii) implement and use the approved provincial e-health solutions identified in the LHIN e-health plan; and

(iii) implement technology solutions that are compatible or interoperable with the provincial blueprint and with the LHIN e-health plan.

ARTICLE 4.0 - FUNDING

4.1 Funding. Subject to the terms of this Agreement, and in accordance with the applicable provisions of the Accountability Agreement, the LHIN will provide the Funding by depositing the Funding in monthly instalments over the Term, into an account designated by the HSP provided that the account resides at a Canadian financial institution and is in the name of the HSP.

4.2 Conditions of Funding

(a) The HSP will:

(i) use the Funding only for the purpose of providing the Services in accordance with the terms of this Agreement;
(ii) not use the Funding for compensation increases prohibited by Applicable Law;
(iii) meet all obligations in the Schedules;
(iv) fulfill all other obligations under this Agreement; and
(v) maintain an Annual Balanced Budget.

(b) Interest Income will be reported to the LHIN and is subject to a year-end reconciliation. The LHIN may deduct the amount equal to the Interest Income from any further funding

instalments under this or any other agreement with the HSP or the LHIN may require the HSP to pay an amount equal to the unused Interest Income to the Ministry of Finance.

4.3 **Limitation on Payment of Funding**. Despite section 4.1, the LHIN:

(i) will not provide any funds to the HSP until this Agreement is fully executed;

(ii) may pro-rate the Funding if this Agreement is signed after the Effective Date;

(iii) will not provide any funds to the HSP until the HSP meets the insurance requirements described in section 11.4;

(iv) will not be required to continue to provide funds

(a) if the Minister or the Director so directs under the terms of the Act;
(b) while the Home is under the control of an Interim Manager pursuant to s. 157 of the Act; or
(c) in the event the HSP breaches any of its obligations under this Agreement until the breach is remedied to the LHIN's satisfaction; and

(iv) may adjust the amount of funds it provides to the HSP in any Funding Year pursuant to Article 5.

4.4 **Additional Funding.** Unless the LHIN has agreed to do so in writing, the LHIN is not required to provide additional funds to the HSP for providing services other than the Services or for exceeding the requirements of Schedule D.

4.5 **Additional Terms and Conditions**. The LHIN may add such further terms or conditions on the use of the Funding as are required for the LHIN to meet its obligations under the Accountability Agreement, Applicable Law or Applicable Policy as the same may be amended during the Term.

4.6 **Appropriation.** Funding under this Agreement is conditional upon an appropriation of moneys by the Legislature of Ontario to the MOHLTC and funding of the LHIN by the MOHLTC pursuant to LHSIA. If the LHIN does not receive its anticipated funding the LHIN will not be obligated to make the payments required by this Agreement.

4.7 **Procurement of Goods and Services**.

(a) If the HSP is subject to the procurement provisions of the BPSAA, the HSP will abide by all applicable directives and guidelines issued by the Management Board of Cabinet.

(b) If the HSP is not subject to the procurement provisions of the BPSAA, the HSP will have a procurement policy in place that requires the acquisition of supplies, equipment or services valued at over $25,000 through a competitive process that ensures the best value for funds expended. If the HSP acquires supplies, equipment or services with the Funding it will do so through a process that is consistent with this policy.

4.8 **Disposition**. The HSP will not sell, lease or otherwise dispose of any assets purchased

with Funding, except as may be required by Applicable Law or otherwise in accordance with Applicable Policy.

ARTICLE 5.0 – ADJUSTMENT AND RECOVERY OF FUNDING

5.1 Adjustment of Funding.

(a) The LHIN may adjust the Funding in any of the following circumstances:

(i) in the event of changes to Applicable Law or Applicable Policy that affect Funding;

(ii) on a change to the Services;

(iii) if required by either the Director or the Minister under the Act;

(iv) in the event that a breach of this Agreement is not remedied to the satisfaction of the LHIN; and

(v) as otherwise permitted by this Agreement.

(b) Funding recoveries or adjustments required pursuant to 5.1(a) may be accomplished through the adjustment of Funding, requiring the repayment of Funding and/or through the adjustment of the amount of any future funding installments. Approved Funding already expended properly in accordance with this Agreement will not be subject to adjustment. The LHIN will, at its sole discretion, and without liability or penalty, determine whether the Funding has been expended properly in accordance with this Agreement.

(c) In determining the amount of a funding adjustment under 5.1 (a) (iv) or (v), LHIN shall take into account the following principles:

(i) resident care must not be compromised through a funding adjustment arising from a breach of this Agreement;
(ii) the HSP should not gain from a breach of this Agreement;
(iii) if the breach reduces the value of the Services, the funding adjustment should be at least equal to the reduction in value; and
(iv) the funding adjustment should be sufficient to encourage subsequent compliance with this Agreement;

and such other principles as may be articulated in Applicable Law or Applicable Policy from time to time.

5.2 Provision for the Recovery of Funding. The HSP will make reasonable and prudent provision for the recovery by the LHIN of any Funding for which the conditions of Funding set out in subsection 4.2(a) are not met and will hold this Funding in an interest bearing account until such time as reconciliation and settlement has occurred with the LHIN.

5.3 Settlement and Recovery of Funding for Prior Years.

(a) The HSP acknowledges that settlement and recovery of Funding can occur up to seven years after the provision of Funding.

(b) Recognizing the transition of responsibilities from the MOHLTC to the LHIN, the HSP agrees that if the Parties are directed in writing to do so by the MOHLTC, the LHIN will settle and recover funding provided by the MOHLTC to the HSP prior to the transition of the funding for the Services to the LHIN, provided that such settlement and recovery occurs within seven years of the provision of the funding by the MOHLTC. All such settlements and recoveries will be subject to the terms applicable to the original provision of funding.

5.4 Debt Due.

(a) If the LHIN requires the re-payment by the HSP of any Funding the amount required will be deemed to be a debt owing to the Crown by the HSP. The LHIN may adjust future funding instalments to recover the amounts owed or may, at its discretion, direct the HSP to pay the amount owing to the Crown and the HSP shall comply immediately with any such direction.

(b) All amounts repayable to the Crown will be paid by cheque payable to the "Ontario Minister of Finance" and mailed or delivered to the LHIN at the address provided in section 13.1.

5.5 Interest Rate. The LHIN may charge the HSP interest on any amount owing by the HSP at the then current interest rate charged by the Province of Ontario on accounts receivable.

ARTICLE 6.0 – PLANNING & INTEGRATION

6.1 Planning for Future Years.

(a) **Advance Notice.** The LHIN will give at least sixty Days' Notice to the HSP of the date by which a Planning Submission, approved by the HSP's governing body, must be submitted to the LHIN.

(b) **Multi-Year Planning.** The Planning Submission will be in a form acceptable to the LHIN and may be required to incorporate (i) prudent multi-year financial forecasts; (ii) plans for the achievement of Performance Targets; and (iii) realistic risk management strategies. It will be aligned with the LHIN's then current Integrated Health Service Plan and will reflect local LHIN priorities and initiatives. If the LHIN has provided multi-year planning targets for the HSP, the Planning Submission will reflect the planning targets.

(c) **Multi-year Planning Targets**. The Parties acknowledge that the HSP is not eligible to receive multi-year planning targets under the terms of Schedule B in effect as of the Effective Date. In the event that Schedule B is amended over the Term and the LHIN is able to provide the HSP with multi-year planning targets, the HSP acknowledges that these targets are: (A) targets only, (B) provided solely for the purposes of planning, (C) are subject to confirmation and (D) may be changed at the discretion of the LHIN. The HSP will proactively manage the risks associated with multi-year planning and the potential changes to the planning targets. The LHIN agrees that it will communicate any

material changes to the planning targets as soon as reasonably possible.

(d) **Service Accountability Agreements.** Subject to advice from the Director about the HSP's history of compliance under the Act and provided that the HSP has fulfilled its obligations under this Agreement, the parties expect that they will enter into a new service accountability agreement at the end of the Term. The LHIN will give the HSP at least six months' Notice if the LHIN does not intend to enter into negotiations for a subsequent service accountability agreement because the HSP has not fulfilled its obligations under this Agreement. The HSP acknowledges that if the LHIN and the HSP enter into negotiations for a subsequent service accountability agreement, subsequent funding may be interrupted if the next service accountability agreement is not executed on or before the expiration date of this Agreement.

6.2 Community Engagement & Integration Activities

(a) **Community Engagement.** The HSP will engage the community of diverse persons and entities in the area where it provides health services when setting priorities for the delivery of health services and when developing plans for submission to the LHIN including but not limited to the HSP's Planning Submission and integration proposals.

(b) **Integration.** The HSP will, separately and in conjunction with the LHIN and other health service providers, identify opportunities to integrate the services of the local health system to provide appropriate, co-coordinated, effective and efficient services.

(c) **Reporting.** The HSP will report on its community engagement and integration activities as requested by the LHIN and in any event, in its Q4 Performance Report to the LHIN.

6.3 Planning and Integration Activity Pre-proposals.

(a) **General:** A pre-proposal process has been developed to (i) reduce the costs incurred by an HSP when proposing operational or service changes; (ii) assist the HSP to carry out its statutory obligations; and (iii) enable an effective and efficient response by the LHIN. Subject to specific direction from the LHIN, this pre-proposal process will be used in the following instances:

(i) the HSP is considering an integration, or an integration of services, as defined in LHSIA between the HSP and another person or entity;

(ii) the HSP is proposing to reduce, stop, start, expand or transfer the location of Services;

(iii) to identify opportunities to integrate the services of the local health system, other than those identified in (i) or (ii) above; or

(iv) if requested by the LHIN.

(b) **LHIN Evaluation of the Pre-proposal**: Use of the pre proposal process is not formal Notice of a proposed integration under s. 27 of LHSIA. LHIN consent to develop the project concept outlined in a pre-proposal does not constitute approval to proceed with the project. Nor does LHIN consent to develop a project concept presume the

issuance of a favourable decision, should such a decision be required by section 25 or 27 of LHSIA. Following the LHIN's review and evaluation, the HSP may be invited to submit a detailed proposal and a business plan for further analysis. Guidelines for the development of a detailed proposal and business case will be provided by the LHIN.

(c) Where an HSP integrates its services with those of another person and the integration relates to services funded in whole or in part by the LHIN, the HSP will follow the provisions of s. 27 of LHSIA. Without limiting the foregoing, a transfer of services from the HSP to another person or entity is an example of an integration to which s. 27 may apply.

6.4 Proposing Integration Activities in the Planning Submission. No integration activity described in subsection 6.3 may be proposed in a Planning Submission unless the LHIN has consented, in writing, to its inclusion pursuant to the process set out in 6.3.

6.5 Termination of Designation of Convalescent Care Beds.

(a) Notwithstanding s. 6.3, the provisions in this sub article 6.5 apply to the termination of a designation of convalescent care Beds.

(b) The HSP may at any time terminate the designation of the convalescent care Beds and revert them back to long-stay Beds by giving thirty (30) calendar days' prior written notice of termination to the Ministry and to the LHIN. A convalescent care Bed will revert to a long-stay Bed on the later of thirty (30) calendar days after the HSP has given the notice of termination, or on the day that the resident who is occupying that convalescent care Bed has been discharged from that Bed.

(c) The LHIN may terminate the designation of the convalescent care Beds at any time, upon giving at least sixty (60) calendar days' written notice to the HSP. A convalescent care Bed will revert to a long-stay Bed on the later of sixty (60) calendar days after the LHIN has given the notice of termination, or on the day that the resident who is occupying that convalescent care Bed has been discharged from that Bed.

6.6 In this Article 6, the terms "integrate", "integration" and "services" have the same meanings attributed to them in subsection 2(1) and section 23 respectively of LHSIA, as it and they may be amended from time to time.

"**service**" includes,

(a) a service or program that is provided directly to people,
(b) a service or program, other than a service or program described in clause (i), that supports a service or program described in that clause, or
(c) a function that supports the operations of a person or entity that provides a service or program described in clause (i) or (ii).

"**integrate**" includes,

(i) to co-ordinate services and interactions between different persons and entities,
(ii) to partner with another person or entity in providing services or in operating,
(iii) to transfer, merge or amalgamate services, operations, persons or entities,
(iv) to start or cease providing services,

(v) to cease to operate or to dissolve or wind up the operations of a person or entity,

and "integration" has a similar meaning;

ARTICLE 7.0 – PERFORMANCE

7.1 Performance. The Parties will strive to achieve on-going performance improvement. They will address performance improvement in a proactive, collaborative and responsive manner.

7.2 Performance Factors.

(a) Each Party will notify the other Party of the existence of a Performance Factor, as soon as reasonably possible after the Party becomes aware of the Performance Factor. The Notice will:

(i) describe the Performance Factor and its actual or anticipated impact;
(ii) include a description of any action the Party is undertaking, or plans to undertake, to remedy or mitigate the Performance Factor;
(iii) indicate whether the Party is requesting a meeting to discuss the Performance Factor; and
(iv) address any other issue or matter the Party wishes to raise with the other Party.

(b) The recipient Party will provide a written acknowledgment of receipt of the Notice within seven Days of the date on which the Notice was received ("Date of the Notice").

(c) Where a meeting has been requested under 7.2(a) the Parties agree to meet and discuss the Performance Factors within fourteen Days of the Date of the Notice, in accordance with the provisions of subsection 7.3.

7.3 Performance Meetings. During a meeting on performance, the Parties will:
(i) discuss the causes of a Performance Factor;
(ii) discuss the impact of a Performance Factor on the local health system and the risk resulting from non-performance; and
(iii) determine the steps to be taken to remedy or mitigate the impact of the Performance Factor (the "Performance Improvement Process").

7.4 The Performance Improvement Process.

(a) The Performance Improvement Process will focus on the risks of non-performance and problem-solving. It may include one or more of the following actions:
(i) a requirement that the HSP develop and implement an improvement plan that is acceptable to the LHIN;
(ii) the conduct of a Review;
(iii) a revision and amendment of the HSP's obligations; and or
(iv) an in-year, or year end, adjustment to the Funding;

among other possible means of responding to the Performance Factor or improving performance.

(b) Any performance improvement process begun under a prior service accountability agreement that was not completed under the prior agreement will continue under this Agreement. Any performance improvement required by a LHIN under a prior service accountability agreement will be deemed to be a requirement of this Agreement until fulfilled or waived by the LHIN.

ARTICLE 8.0 - REPORTING, ACCOUNTING AND REVIEW

8.1 Reporting

(a) **Generally.** The LHIN's ability to enable its local health system to provide appropriate, co-ordinated, effective and efficient health services as contemplated by LHSIA, is heavily dependent on the timely collection and analysis of accurate information. The HSP acknowledges that the timely provision of accurate information related to the HSP, its Residents and its performance of its obligations under this Agreement, is under the HSP's control.

(b) **Specific Obligations.** The HSP

(i) will provide to the LHIN, or to such other entity as the LHIN may direct, in the form and within the time specified by the LHIN, the Reports other than personal health information as defined in subsection 31 (5) of the *CFMA*, that (i) the LHIN requires for the purposes of exercising its powers and duties under this Agreement, LHSIA or for the purposes that are prescribed under LHSIA, or (ii) may be requested under the CFMA;

(ii) will comply with the applicable reporting standards and requirements in both Chapter 9 of the Ontario Healthcare Reporting Standards and the RAI MDS Tools;

(iii) will fulfil the specific reporting requirements set out in Schedule C;

(iv) will ensure that every Report is complete, accurate, signed on behalf of the HSP by an authorized signing officer where required and provided in a timely manner and in a form satisfactory to the LHIN; and

(v) agrees that every Report submitted by or on behalf of the HSP, will be deemed to have been authorized by the HSP for submission.

(c) **RAI/MDS.** Without limiting the foregoing, the HSP

(i) will conduct quarterly assessments of Residents, and all other assessments of Residents required by the RAI/MDS Tools, using the RAI/ MDS Tools;

(ii) will ensure that the RAI-MDS Tools are used correctly to produce an accurate assessment of the HSP's Residents (RAI MDS Data);

(iii) will submit the RAI-MDS Data to the Canadian Institute for Health Information in an electronic format at least quarterly in accordance with the submission guidelines set out by CIHI; and

(iv) acknowledges that if used incorrectly, the RAI-MDS Tools can increase Funding beyond that to which the HSP would otherwise be entitled. The HSP will therefore have systems in place to regularly monitor, evaluate and where necessary correct the quality and accuracy of the RAI-MDS Data.

(d) **French Language Services.** If the HSP is required to provide services to the public in French under the provisions of the *French Language Services Act*, the HSP will be required to submit a French language services report to the LHIN. If the HSP is not required to provide services to the public in French under the provisions of the *French Language Service Act*, it will be required to provide a report to the LHIN that outlines how the HSP addresses the needs of its local Francophone community

(e) **Declaration of Compliance.** On or before March 1 of each Funding Year, the Board will issue a Compliance Declaration declaring that the HSP has complied with the terms of this Agreement. The form of the declaration is set out in Schedule E and may be amended from time to time through the term of this Agreement

(f) **Financial Reductions.** Notwithstanding any other provision of this Agreement, and at the discretion of the LHIN, the HSP may be subject to a financial reduction if any of the Reports are received after the due date, are incomplete, or are inaccurate where the errors or delay were not as a result of either LHIN actions or inaction or the actions or inactions of persons acting on behalf of the LHIN. If assessed, the financial reduction will be taken from funding designated for this purpose in Schedule B as follows:

(i) if received within 7 days after the due date, incomplete or inaccurate, the financial penalty will be the greater of (i) a reduction of 0.02 percent (0.02%) of the Funding; or (ii) two hundred and fifty dollars ($250.00); and
(ii) for every full or partial week of non-compliance thereafter, the rate will be one half of the initial reduction.

8.2 Reviews.

(a) During the term of this Agreement and for seven (7) years after the term of this Agreement, the HSP agrees that the LHIN or its authorized representatives may conduct a Review of the HSP to confirm the HSP's fulfillment of its obligations under this Agreement. For these purposes the LHIN or its authorized representatives may, upon twenty-four hours' Notice to the HSP and during normal business hours enter the HSP's premises to:

(i) inspect and copy any financial records, invoices and other financially-related documents,other than personal health information as defined in subsection 31(5) of the CFMA, in the possession or under the control of the HSP which relate to the Funding or otherwise to the Services; and

(ii) inspect and copy non-financial records,other than personal health information as defined in subsection 31(5) of the *CFMA*, in the possession or under the control

of the HSP which relate to the Funding, the Services or otherwise to the performance of the HSP under this Agreement.

(b) The cost of any Review will be borne by the HSP if the Review (i) was made necessary because the HSP did not comply with Applicable Law or Policy; or (ii) determines that the HSP has not fulfilled its obligations under Applicable Law or Policy. .

(c) To assist in respect of the rights set out in (b) above the HSP shall disclose any information requested by the LHIN or its authorized representatives, and shall do so in a form requested by the LHIN or its authorized representatives.

(d) The HSP may not commence a proceeding for damages or otherwise against any person with respect to any act done or omitted to be done, any conclusion reached or report submitted that is done in good faith in respect of a Review..

(e) HSP's obligations under sub article 8.2 will survive any termination or expiration of this Agreement.

8.3 Document Retention and Record Maintenance. The HSP will

(i) retain all records (as that term is defined in FIPPA) related to the HSP's performance of its obligations under this Agreement for seven (7) years after the termination or expiration of the term of this Agreement. The HSP's obligations under this paragraph will survive any termination or expiry of this Agreement;

(ii) keep all financial records, invoices and other financially-related documents relating to the Funding or otherwise to the Services in a manner consistent with either generally accepted accounting principles or international financial reporting standards as advised by the HSP's auditor; and

(iii) keep all non-financial documents and records relating to the Funding or otherwise to the Services in a manner consistent with all Applicable Law.

8.4 Disclosure of Information.

(a) FIPPA. The HSP acknowledges that the LHIN is bound by FIPPA and that any information provided to the LHIN in connection with this Agreement may be subject to disclosure in accordance with FIPPA.

(b) Confidential Information. The Parties will treat Confidential Information as confidential and will not disclose Confidential Information except with the consent of the disclosing Party or as permitted or required under FIPPA, the Municipal Freedom of Information and Protection of Privacy Act, the Personal Health Information Protection Act, the Act, court order, subpoena or other Applicable Law. Notwithstanding the foregoing, the LHIN may disclose information that it collects under this Agreement in accordance with LHSIA and the CFMA.

8.5. Transparency. The HSP will post a copy of this Agreement and each Compliance Declaration submitted to the LHIN during the term of this Agreement in a conspicuous and easily accessible public place at the Home and on its public website if the HSP operates a public website.

8.6 **Auditor General**. For greater certainty the LHIN's rights under this article are in addition to any rights provided to the Auditor General under the *Auditor General Act* (Ontario).

ARTICLE 9.0 - ACKNOWLEDGEMENT OF LHIN SUPPORT

9.1 **Publication**. For the purposes of this Article 9, the term "publication" means any material on or concerning the Services that the HSP makes available to the public, regardless of whether the material is provided electronically or in hard copy. Examples include a web-site, an advertisement, a brochure, promotional documents and a report. Materials that are prepared by the HSP in order to fulfil its reporting obligations under this Agreement are not included in the term "publication".

9.2 **Acknowledgment of Funding Support.**

(a) The HSP agrees all publications will include

(i) an acknowledgment of the Funding provided by the LHIN and the Government of Ontario. Prior to including an acknowledgement in any publication, the HSP will obtain the LHIN's approval of the form of acknowledgement. The LHIN may, at its discretion, decide that an acknowledgement is not necessary; and

(ii) a statement indicating that the views expressed in the publication are the views of the HSP and do not necessarily reflect those of the LHIN or the Government of Ontario.

(b) The HSP shall not use any insignia or logo of Her Majesty the Queen in right of Ontario, including those of the LHIN, unless it has received the prior written permission of the LHIN to do so.

ARTICLE 10.0 – REPRESENTATIONS, WARRANTIES AND COVENANTS

10.1 **General**. The HSP represents, warrants and covenants that:

(i) it is, and will continue for the term of this Agreement to be, a validly existing legal entity with full power to fulfill its obligations under this Agreement;

(ii) it has the experience and expertise necessary to carry out the Services;

(iii) it holds all permits, licences, consents intellectual property rights and authorities necessary to perform its obligations under this Agreement;

(iv) all information that the HSP provided to the LHIN in its Planning Submission or otherwise in support of its application for funding was true and complete at the time the HSP provided it, and will, subject to the provision of Notice otherwise, continue to be true and complete for the term of this Agreement;

(v) it has not and will not for the term of this Agreement, enter into a non-arm's

transaction that is prohibited by the Act; and

(vi) it does, and will continue for the term of this Agreement to, operate in compliance with all Applicable Law and Applicable Policy.

10.2 Execution of Agreement. The HSP represents and warrants that:

(i) it has the full power and authority to enter into this Agreement; and
(ii) it has taken all necessary actions to authorize the execution of the Agreement.

10.3 Governance.

(a) The HSP represents warrants and covenants that it has established, and will maintain for the period during which this Agreement is in effect, policies and procedures:

(i) that set out a code of conduct for, and that identify the ethical obligations of HSP's Personnel;
(ii) To ensure the ongoing effective functioning of the HSP;
(iii) for effective and appropriate decision-making;
(iv) for effective and prudent risk-management, including the identification and management of potential, actual and perceived conflicts of interest;
(v) for the prudent and effective management of the Funding;
(vi) to monitor and ensure the accurate and timely fulfillment of the HSP's obligations under this Agreement and compliance with the Act and LHSIA;
(vii) to enable the preparation, approval and delivery of all Reports; and
(viii) to address complaints about the provision of Services, the management or governance of the HSP.

(b) The HSP represents and warrants that it:

(i) has, or will have within 60 days of the execution of this Agreement, a Performance Agreement with its CEO.
(ii) will take all reasonable care to ensure that its CEO complies with the Performance Agreement; and
(iii) will enforce the HSP's rights under the Performance Agreement.

10.4 Funding, Services and Reporting. The HSP represents warrants and covenants that

(a) The Funding is, and will be continued to be, used only to provide the Services in accordance with the terms of this Agreement:

(b) the Services are and will continue to be provided:

(i) by persons with the expertise, professional qualifications, licensing and skills necessary to complete their respective tasks; and
(ii) in compliance with Applicable Law and Applicable Policy; and

(c) Every Report is, and will continue to be, accurate and in full compliance with the provisions of this Agreement, including any particular requirements applicable to

the Report.

10.5 **Supporting Documentation**. Upon request, the HSP will provide the LHIN with proof of the matters referred to in this Article.

ARTICLE 11.0 - LIMITATION OF LIABILITY, INDEMNITY & INSURANCE

11.1 **Limitation of Liability**. The Indemnified Parties will not be liable to the HSP or any of the HSP's Personnel for costs, losses, claims, liabilities and damages howsoever caused (including any incidental, indirect, special or consequential damages, injury or any loss of use or profit of the HSP) arising out of or in any way related to the Services or otherwise in connection with this Agreement, unless caused by the gross negligence or wilful act of any of the Indemnified Parties.

11.2 **Same.** For greater certainty and without limiting subsection 11.1, the LHIN is not liable for how the HSP and the HSP's Personnel carry out the Services and is therefore not responsible to the HSP for such Services. Moreover the LHIN is not contracting with or employing any HSP's Personnel to carry out the terms of this Agreement. As such, it is not liable for contracting with, employing or terminating a contract with or the employment of any HSP's Personnel required to carry out this Agreement, nor for the withholding, collection or payment of any taxes, premiums, contributions or any other remittances due to government for the HSP's Personnel required by the HSP to carry out this Agreement.

11.3 **Indemnification.** The HSP hereby agrees to indemnify and hold harmless the Indemnified Parties from and against any and all liability, loss, costs, damages and expenses (including legal, expert and consultant costs), causes of action, actions, claims, demands, lawsuits or other proceedings, (collectively "Claims"), by whomever made, sustained, brought or prosecuted, including for third party bodily injury (including death), personal injury and property damage, in any way based upon, occasioned by or attributable to anything done or omitted to be done by the HSP or the HSP's Personnel in the course of the performance of the HSP's obligations under, or otherwise in connection with, this Agreement, unless solely caused by the negligence or wilful misconduct of any Indemnified Parties. The HSP further agrees to indemnify and hold harmless the Indemnified Parties for any incidental, indirect, special or consequential damages, or any loss of use, revenue or profit, by any person, entity or organization, including without limitation the LHIN, claimed or resulting from such Claims.

11.4 **Insurance.**

(a) **Generally.** The HSP shall protect itself from and against all claims that might arise from anything done or omitted to be done by the HSP and the HSP's Personnel under this Agreement and more specifically all claims that might arise from anything done or omitted to be done under this Agreement where bodily injury (including personal injury), death or property damage, including loss of use of property is caused.

(b) **Required Insurance.** The HSP will put into effect and maintain, with insurers having a secure A.M. Best rating of B+ or greater, or the equivalent, all the necessary and appropriate insurance that a prudent person in the business of the HSP would maintain including, but not limited to, the following at its own expense.

1. **Commercial General Liability Insurance.** Commercial General Liability Insurance, for third party bodily injury personal injury and property damages to an to an inclusive limit of not less than five million dollars per occurrence and not less than two million dollars products and completed operations aggregate. The policy will include the following clauses:

(i) The Indemnified Parties as additional insureds;
(ii) Contractual Liability;
(iii) Cross-Liability
(iv) Independent Contractors;
(v) Products and Completed Operations Liability;
(vi) A valid WSIB Clearance Certificate, or Employers Liability and Voluntary Compensation, which ever applies;
(vii) Tenants Legal Liability (for premises/building leases only);
(viii) Non-Owned automobile coverage with blanket contractual and physical damage coverage for hired automobiles; and,
(ix) A thirty-Day written notice of cancellation, termination or material change.

2. Property insurance on property of every description, including business interruption for the term of "all risk" of physical loss or damage, providing coverage to a limit of not less than the full replacement cost, including earthquake and flood. Such insurance shall be written to include replacement cost value and shall not include a co-insurance clause. All reasonable deductibles and/or self-insured retentions are the responsibility of the HSP.

3. Boiler and machinery insurance (including pressure objects, machinery objects and service supply objects) on a comprehensive basis. Such insurance shall be written to include repair and replacement value and shall not include a co-insurance clause. All reasonable deductibles and/or self insured retentions are the responsibility of the HSP.

4. Comprehensive Crime insurance, Disappearance, Destruction and Dishonest coverage.

5. **Professional Liability Insurance**. Professional Liability Insurance to an inclusive limit of not less than five million dollars per occurrence for each claim of negligence resulting in bodily injury, death or property damage, arising directly or indirectly from the professional services rendered by the HSP, its officers, agents or employees.

6. Administrators Errors & Omission Liability Insurance, to an inclusive limit of not less than 2 million dollars per claim, with an annual aggregate of not less than 4 million dollars, responding to claims of wrongful acts of the HSP directors, board members, employees and volunteers in the discharge of their duties on behalf of the HSP.

(c) **Certificates of Insurance.** The HSP will provide the LHIN with proof of the insurance required by this Agreement in the form of a valid certificate of insurance that references this Agreement and confirms the required coverage, on or before the commencement of this Agreement, and renewal replacements on or before the expiry of

any such insurance. Upon the request of the LHIN, a copy of each insurance policy shall be made available to it. The HSP shall ensure that each of its subcontractors obtains all the necessary and appropriate insurance that a prudent person in the business of the subcontractor would maintain and that the Indemnified Parties are named as additional insureds with respect to any liability arising in the course of performance of the subcontractor's obligations under the subcontract.

ARTICLE 12.0 - TERMINATION

12.1 Termination by the LHIN.

(a) **Immediate Termination.** The LHIN may terminate this Agreement immediately upon giving Notice to the HSP if:

(i) the HSP is unable to provide or has discontinued the Services in whole or in part or the HSP ceases to carry on business;

(ii) the HSP makes an assignment, proposal, compromise, or arrangement for the benefit of creditors, or is petitioned into bankruptcy, or files for the appointment of a receiver;

(iii) the LHIN is directed, pursuant to the Act, to terminate this Agreement by the Minister or the Director;

(iv) the Home has been closed in accordance with the Act; or

(v) as provided for in section 4.6, the LHIN does not receive the necessary funding from the MOHLTC.

(b) **Termination in the Event of Financial Difficulties.** If the HSP makes an assignment, proposal, compromise, or arrangement for the benefit of creditors, or is petitioned into bankruptcy, or files for the appointment of a receiver the LHIN will consult with the Director before determining whether this Agreement will be terminated. If the LHIN terminates this Agreement because a person has exercised a security interest as contemplated by section 107 of the Act, the LHIN would expect to enter into a service accountability agreement with the person exercising the security interest or the receiver or other agent acting on behalf of that person where the person has obtained the Director's approval under s. 110 of the Act and has met all other relevant requirements of Applicable Law.

(c) **Opportunity to Remedy Material Breach**. If an HSP breaches any material provision of this Agreement, including, but not limited to, the reporting requirements in Article 8 and the representations and warranties in Article 10 and the breach has not been satisfactorily resolved under Article 7, the LHIN will give the HSP Notice of the particulars of the breach and of the period of time within which the HSP is required to remedy the breach. The Notice will advise the HSP that the LHIN will terminate this Agreement:

(i) at the end of the Notice period provided for in the Notice if the HSP fails to remedy the breach within the time specified in the Notice; or

(ii) prior to the end of the Notice period provided for in the Notice if it becomes apparent to the LHIN that the HSP cannot completely remedy the breach within that time or such further period of time as the LHIN considers reasonable, or the HSP is not proceeding to remedy the breach in a way that is satisfactory to the LHIN; and

the LHIN may then terminate this Agreement in accordance with the Notice.

12.2 Termination of Services by the HSP.

(a) Except as provided in 12.2(b) and (c) below, the HSP may terminate this Agreement at any time, for any reason, upon giving the LHIN at least six months' Notice.

(b) Where the HSP intends to cease providing the Services and close the Home, the HSP will provide Notice to the LHIN at the same time the HSP is required to provide notice to the Director under the Act. The HSP will ensure that the closure plan required by the Act is acceptable to the LHIN.

(c) Where the HSP intends to cease providing the Services as a result of an intended sale or transfer of a License in whole or in part, the HSP will comply with s. 6.3 of this Agreement. Notice under s. 27 of LHSIA will not be effective unless accompanied by a transition plan that is acceptable to the LHIN, if such a transition plan is requested pursuant to s. 6.3.

12.3 Consequences of Termination.

(a) If this Agreement is terminated pursuant to this Article, the LHIN may:

(i) cancel all further Funding instalments;
(ii) demand the repayment of any Funding remaining in the possession or under the control of the HSP;
(iii) determine the HSP's reasonable costs to wind down the Services; and
(iv) permit the HSP to offset the costs determined pursuant to subsection (iii), against the amount owing pursuant to subsection (ii).

(b) Despite (a), if the cost determined pursuant to section 12.3(a) (iii) exceeds the Funding remaining in the possession or under the control of the HSP the LHIN will not provide additional monies to the HSP to wind down the Services.

12.4 Effective Date. The effective date of any termination under this Article will be the last Day of the Notice period, the last Day of any subsequent Notice period or immediately, which ever applies.

12.5 Corrective Action. Despite its right to terminate this Agreement pursuant to this Article, the LHIN may choose not to terminate this Agreement and may take whatever corrective action it considers necessary and appropriate, including suspending Funding for such period as the LHIN determines, to ensure the successful completion of the Services in accordance with the terms of this Agreement.

ARTICLE 13.0 – NOTICE

13.1 Notice. A Notice will be in writing; delivered personally, by pre-paid courier, or sent by facsimile with confirmation of receipt or by any form of mail where evidence of receipt is provided by the post office. A Notice will be addressed to the other Party as provided below or as either Party will later designate to the other in writing:

To the LHIN:
South West Local Health Integration Network

201 Queens Avenue, Suite 700
London, ON N6A 1J1
Attention:
Michael Barrett
Chief Executive Officer

Fax: (519) 672-6562
Telephone: (519) 672-0445

To the HSP:
Caressant Care Woodstock Nursing Home

81 Fyfe Avenue
Woodstock, Ontario N4S 8Y2
Attention:
Brenda Van Quaethem
Administrator

Fax: (519) 539-7467
Telephone: (519) 539-6461

13.2 Notices Effective From. A Notice will be effective at the time the delivery is made if the Notice is delivered personally, by pre-paid courier or by facsimile. If delivered by mail, a Notice will be effective five business days after the day it was mailed.

ARTICLE 14.0- INTERPRETATION

14.1 Interpretation. In the event of a conflict or inconsistency in any provision of this Agreement, the main body of this Agreement will prevail over the Schedules.

14.2 Jurisdiction. Where this Agreement requires compliance with the Act, the Director will determine compliance and advise the LHIN. Where the Act requires compliance with this Agreement, the LHIN will determine compliance and advise the Director.

14.3 Determinations by the Director. All determinations required by the Director under this Agreement are subject to an HSP's rights of review and appeal under the Act.

14.4 The Act. For greater clarity, nothing in this Agreement supplants or otherwise excuses the HSP from the fulfillment of any requirements of the Act. The HSP's obligations in respect of LHSIA and this Agreement are separate and distinct from the HSP's obligations under the Act.

ARTICLE 15.0 – ADDITIONAL PROVISIONS

15.1 Currency. All payment to be made by the LHIN or the HSP under this Agreement shall be made in the lawful currency of Canada.

15.2 Invalidity or Unenforceability of Any Provision. The invalidity or unenforceability of

any provision of this Agreement will not affect the validity or enforceability of any other provision of this Agreement and any invalid or unenforceable provision will be deemed to be severed.

15.3 **Terms and Conditions on Any Consent**. Any consent or approval that the LHIN may grant under this Agreement is subject to such terms and conditions as the LHIN may reasonably require.

15.4 **Waiver.** A Party may only rely on a waiver of the Party's failure to comply with any term of this Agreement if the other Party has provided a written and signed Notice of waiver. Any waiver must refer to a specific failure to comply and will not have the effect of waiving any subsequent failures to comply.

15.5 **Parties Independent**. The Parties are and will at all times remain independent of each other and are not and will not represent themselves to be the agent, joint venturer, partner or employee of the other. No representations will be made or acts taken by either Party which could establish or imply any apparent relationship of agency, joint venture, partnership or employment and neither Party will be bound in any manner whatsoever by any agreements, warranties or representations made by the other Party to any other person or entity, nor with respect to any other action of the other Party.

15.6 **LHIN is an Agent of the Crown.** The Parties acknowledge that the LHIN is an agent of the Crown and may only act as an agent of the Crown in accordance with the provisions of LHSIA. Notwithstanding anything else in this Agreement, any express or implied reference to the LHIN providing an indemnity or any other form of indebtedness or contingent liability that would directly or indirectly increase the indebtedness or contingent liabilities of the LHIN or Ontario, whether at the time of execution of this Agreement or at any time during the term of this Agreement, will be void and of no legal effect.

15.7 **Express Rights and Remedies Not Limited.** The express rights and remedies of the LHIN are in addition to and will not limit any other rights and remedies available to the LHIN at law or in equity. For further certainty, the LHIN has not waived any provision of any applicable statute, including the Act, LHSIA and the CFMA, nor the right to exercise its right under these statutes at any time.

15.8 **No Assignment.** The HSP will not assign either this Agreement or the Funding in whole or in part, directly or indirectly, without the prior written consent of the LHIN which consent shall not be unreasonably withheld. No assignment or subcontract shall relieve the HSP from its obligations under this Agreement or impose any liability upon the LHIN to any assignee or subcontractor. The LHIN may assign this Agreement or any of its rights and obligations under this Agreement to any one or more of the LHINs or to the MOHLTC.

15.9 **Governing Law.** This Agreement and the rights, obligations and relations of the Parties hereto will be governed by and construed in accordance with the laws of the Province of Ontario and the federal laws of Canada applicable therein. Any litigation or arbitration arising in connection with this Agreement will be conducted in Ontario unless the Parties agree in writing otherwise.

15.10 **Survival.** The provisions in Articles 1.0, 2.4, 4.6, 5.0, 8.0, 10.5, 11.0, 13.0, 14.0 and 15.0

will continue in full force and effect for a period of seven years from the date of expiry or termination of this Agreement.

15.11 Further Assurances. The Parties agree to do or cause to be done all acts or things necessary to implement and carry into effect this Agreement to its full extent.

15.12 Amendment of Agreement. This Agreement may only be amended by a written agreement duly executed by the Parties.

15.13 Counterparts. This Agreement may be executed in any number of counterparts, each of which will be deemed an original, but all of which together will constitute one and the same instrument.

ARTICLE 16.0 - ENTIRE AGREEMENT

16.1 Entire Agreement. This Agreement together with the appended Schedules constitutes the entire Agreement between the Parties with respect to the subject matter contained in this Agreement and supersedes all prior oral or written representations and agreements.

The Parties have executed this Agreement on the dates set out below.

SOUTH WEST LOCAL HEALTH INTEGRATION NETWORK

Jeff Low, Board Chair — Date: July 8/13

And by:

Michael Barrett
Chief Executive Officer — Date: JUL 0 8 2013

Organization Name: Caressant Care Woodstock Nursing Home

By:

James Lavelle
President — Date: March 27, 2013
I have authority to bind the HSP

And by:

N/A
I have authority to bind the HSP — Date

Schedule A: Description of Home and Beds

A.1 - General Information				
Full Legal Name of Licensee	Caressant-Care Nursing and Retirement Homes Limited			
Legal Name of Home	Caressant Care Woodstock Nursing Home			
LTCH Facility ID Number (Master Number for RAI MDS)	NH2623			
Address	81 Fyfe Avenue			
City	Woodstock	**Postal Code:**	N4S 8Y2	
Accreditation organization	CARF			
Date of last Accreditation	2012	**Years Awarded:**	3	

A.2 - Licensed or Approved Beds & Classification							
	New	**A**	**B**	**C**	**D**	**Total Beds**	**Expiry Date**
LTC Beds	60	-	-	95	-	155	2024/06/27
Temporary Beds	-	4	-	4	-	8	See "Interim Beds" comments below
Total Beds	60	4	0	99	0	163	--

A.3 - Bed Type		
Bed Type	**# of Beds**	**Comments**
Long stay beds	155	
Veterans' Priority Access Beds	0	
Convalescent Care Beds	0	
Respite Beds	0	
Interim Beds	8	Approval and term of licence from Ministry of Health and Long Term Care to be confirmed at a later date.
Beds in Abeyance	0	
Total	163	Note: Total should equal the number under "Total Beds" in A.2 above.
Other beds available for use under a short term authorization or temporary emergency licence	0	

Schedule B

Additional Terms and Conditions Applicable to the Funding Model

1.0 Background. The LHINs provide subsidy funding to long-term care home health service providers pursuant to a funding model set by the MOHLTC. The current model provides estimated per diem funding that is subsequently reconciled. The current funding model is under review and may change during the term of the Agreement. As a result, and for ease of amendment during its term, the Agreement incorporates certain terms and conditions that relate to the funding model in this Schedule B.

2.0 Additional Definitions. Any terms not otherwise defined in this Schedule have the same meaning attributed to them in the Agreement. The following terms have the following meanings:

"Approved Funding" **means the allowable subsidy for the Term determined by reconciling the Estimated Provincial Subsidy in accordance with Applicable Law and Applicable Policy**

"**Construction Funding Subsidy**" or **"CFS"** means the funding that the MOHLTC agreed to provide to the HSP in an agreement for the construction, development, redevelopment, retrofitting or upgrading of beds (a "Development Agreement").

"**Envelope**" is a portion of the Estimated Provincial Subsidy that is designated for a specific use. There are four Envelopes in the Estimated Provincial Subsidy as follows:

(a) the "Nursing and Personal Care" envelope;
(b) the "Program and Support Services" envelope;
(c) the "Raw Food" envelope; and
(d) **the "Other Accommodation" envelope.**

"Estimated Provincial Subsidy" **means the estimated provincial subsidy calculated in accordance with Applicable Policy.**

"Reconciliation Reports" means the reports as required by Applicable Policy including the Long-term Care Home Annual Report and, the In-Year Revenue/Occupancy Report.

3.0 Provision of Funding.

3.1 In each Funding Year, the LHIN shall advise the HSP of the amount of its Estimated Provincial Subsidy. The amount of the Estimated Provincial Subsidy shall be calculated on both a monthly basis and an annual basis and will be allocated among the Envelopes and other funding streams applicable to the HSP, including the CFS.

3.2 The Estimated Provincial Subsidy shall be provided to the HSP on a monthly basis in accordance with the monthly calculation described in 3.1. Payments will be made to the HSP on or about the twenty-second (22nd) day of each month of the Term.

3.3 CFS will be provided as part of the Estimated Provincial Subsidy and in accordance with the terms of the Development Agreement and Applicable Policy. This obligation survives any termination of the Agreement.

4.0 Use of Funding.

4.1 The HSP shall use the funding allocated for an Envelope for the use set out in the Applicable

Policy.

4.2 The HSP shall not transfer any such portion of the Estimated Provincial Subsidy in the "Raw Food" envelope, to any other Envelope:

4.3 The HSP may transfer all or any of the part of the Estimated Provincial Subsidy for the Other Accommodation Envelope to any other Envelope without the prior written approval of the LHIN, provided that the HSP has complied with the standards and criteria for the "Other Accommodation" Envelope as set out in Applicable Policy.

4.4 The HSP may transfer any part of the Estimated Provincial Subsidy in the (a) Nursing and Personal Care" envelope; or (b) the "Program and Support Services envelope; to any Envelope other than the Other Accommodation Envelope without the prior written approval of the LHIN provided that the transfer is done in accordance with Applicable Policy.

4.5 In the event that a financial reduction is determined by the LHIN, the financial reduction will be applied against the portion of the Estimated Provincial Subsidy in the "Other Accommodation" Envelope.

5.0 Construction Funding Subsidies.

5.1 Subject to 5.2 and 5.3 the HSP is required to continue to fulfill all commitments identified in Schedule A of the service agreement in effect between the HSP and the LHIN on June 30, 2010 (the "CFS Commitments") and the CFS Commitments are hereby incorporated into and deemed part of this Agreement.

5.2 The HSP is not required to continue to fulfill those CFS Commitments that the Ministry has agreed in writing: (i) have been satisfactorily fulfilled; or (ii) are no longer required to be fulfilled; and the HSP is able to provide the LHIN with a copy of such written agreement.

5.3 Where this Agreement establishes or requires a service requirement that surpasses the service commitment set out in the CFS Commitments, the HSP is required to comply with the service requirements in this Agreement.

5.4 The MOHLTC will be responsible for monitoring the HSP's on-going compliance with the CFS Commitments. Notwithstanding the foregoing, the HSP agrees to certify its compliance with the CFS Commitments when requested to do so by the LHIN.

6.0 Reconciliation.

6.1 The HSP shall complete the Reconciliation Reports and submit them to the LHIN in accordance with Schedule C. The Reconciliation Reports shall be in such form and containing such information as required by Applicable Policy or as otherwise required by the LHIN pursuant to Article 8 of the Agreement.

6.2 The Estimated Provincial Subsidy provided by the LHIN under section 3.0 of this Schedule shall be reconciled by the LHIN in accordance with Applicable Law and Applicable Policy to produce the Approved Funding.

6.3 In accordance with the Applicable Law and Applicable Policy, if the Estimated Provincial Subsidy paid to the HSP exceeds the Approved Funding for any period, the excess is a debt due and owing by the HSP to the Crown in right of Ontario which shall be paid by the HSP to the Crown in right of Ontario and, in addition to any other methods available to recover the debt, the LHIN may deduct the amount of the debt from any subsequent amounts to be provided by the LHIN to the HSP. If the Estimated Provincial Subsidy paid for any period is less than the Approved Funding, the LHIN shall provide the difference to the HSP.

Schedule C – Reporting Requirements

1. In-Year Revenue/Occupancy Report	
Reporting Period	**Estimated Due Dates**[11]
2013 – Jan 01-13 to Sept 30-13	By October 15, 2013
2014 – Jan 01-14 to Sept 30-14	By October 15, 2014
2015 – Jan 01-15 to Sept 30-15	By October 15, 2015
2. Long-Term Care Home Annual Report	
Reporting Period	**Estimated Due Dates**[1]
2013 - Jan 01-13 to Dec 31-13	By September 30, 2014
2014 – Jan 01-14 to Dec 31-14	By September 30, 2015
2015 – Jan 01-15 to Dec 31-15	By September 30, 2016
3. Performance Report	
2013-2014	**Due Dates**
Q2 – Apr 01-13- to Sept 30-13	October 31, 2013
Q3 – Apr 01-13- to Dec 31-13	January 31, 2014
Q4 – Apr 01-13- to March 31-14	April 30, 2014
2014-2015	**Due Dates**
Q2 – Apr 01-14- to Sept 30-14	October 31, 2014
Q3 – Apr 01-14- to Dec 31-14	January 31, 2015
Q4 – Apr 01-14- to March 31-15	April 30, 2015
2015-2016	**Due Dates**
Q2 – Apr 01-15- to Sept 30-15	October 30, 2015
Q3 – Apr 01-15- to Dec 31-15	January 29, 2016
Q4 – Apr 01-15- to March 31-16	April 29, 2016
4. French Language Services Report	
Fiscal Year	**Due Dates**
2013-14 – Apr 01-13 to March 31-14	April 30, 2014
2014-15 – Apr 01-14 to March 31-15	April 30, 2015
2015-16 – Apr 01-15 to March 31-16	April 29, 2016
5. OHRS/MIS Trial Balance Submission	
2013-2014	**Due Dates (Must pass 3c Edits)**
Q2 – Apr 01-13- to Sept 30-13 (Fiscal Year) Q2 – Jan 01-13 to Jun 30-13 (Calendar Year)	October 31, 2013
Q3 – Apr 01-13- to Dec 31-13 (Fiscal Year) Q3 – Jan 01-13 to Sept 30-13 (Calendar Year)	January 31, 2014 Optional Submission
Q4 – Apr 01-13- to March 31-14 (Fiscal Year) Q4 – Jan 01-13 to Dec 31-13 (Calendar Year)	May 30, 2014

[11] These are estimated dates from the Ministry and are subject to change.

Schedule C – Reporting Requirements Cont'd/

5. OHRS/MIS Trial Balance Submission Cont'd	
2014-2015	**Due Dates (Must pass 3c Edits)**
Q2 - Apr 01-14 to Sept 30 -14 (Fiscal Year) Q2- Jan 01-14 to June 30-14 (Calendar Year)	October 31, 2014
Q3 - Apr 01-14 to Dec 31-14 (Fiscal Year) Q3 Jan 01-14 to Sept 30-14 (Calendar Year)	January 31, 2015 Optional Submission
Q4 - Apr 01-14 to March 31-15 (Fiscal Year) Q4 Jan 01-14 to Dec 31-14 (Calendar Year)	May 30, 2015
2015-2016	**Due Dates (Must pass 3c Edits)**
Q2 -Apr 01-15 to Sept 30 – 15 (Fiscal Year) Q2 – Jan 01-15 to June 20-15 (Calendar Year)	October 31, 2015
Q3 -Apr 01-15 to Dec 31-15 (Fiscal Year) Q3 Jan 01-15 to Sep 30-15 (Calendar Year)	January 31, 2016 Optional Submission
Q4 -Apr 01-15 to March 31-16 (Fiscal Year) Q4 Jan 01-15 to Dec 31-15 (Calendar Year)	May 30, 2016
6. Compliance Declaration	
Funding Year	**Due Dates**
January 1, 2013 – December 31, 2013	March 1, 2014
January 1, 2014 – December 31, 2014	March 1, 2015
January 1, 2015 – December 31, 2015	March 1, 2016
7. RAI MDS	
Funding Year	**Due Dates**
At least quarterly during each Funding Year in the term of this Agreement, or otherwise in accordance with the submission guidelines set out by CIHI.	As established and advised by the Ministry on behalf of the LHIN.
8. Staffing Report	
Reporting Period	Estimated Due Dates[1]
January 1, 2013 – December 31, 2013	June 15, 2014
January 1, 2014 – December 31, 2014	June 15, 2015
January 1, 2015 – December 31, 2015	June 15, 2016
9. [Note to LHINS – please insert additional local reporting requirements if any]	

Schedule D – Performance

1.0 Performance Indicators

The HSP's delivery of the Services will be measured by the following Indicators, Targets and where applicable Performance Standards. In the following table:

n/a means 'not-applicable', that there is no defined Performance Standard for the indicator for the applicable year

tbd means a Target, and a Performance Standard, if applicable, will be determined during the applicable year.

PAN-LHIN SYSTEM IMPERATIVES	OUTCOME OBJECTIVES	INDICATORS P=Performance Indicator E=Explanatory Indicator	2013/14		2014/15		2015/16	
			Performance		Performance		Performance	
			Target	Standard	Target	Standard	Target	Standard
1. Enabling Coordination and Transitions of Care for Targeted Populations	To reduce ALC days	Long-stay utilization (P)	97.0%	>=97.0%	97.0%	>=97.0%	97.0%	>=97.0%
2. Maintaining Achievement in Access, Accountability and Safety	To reduce avoidable hospital admission, reduce ED/Utilization visits	Median wait time to placement in LTC home (E)	n/a	n/a	n/a	n/a	n/a	n/a
3. Organizational Health	To ensure the organizational health of the home	Compliance status (P)	Yes	n/a	Yes	n/a	Yes	n/a
		Debt service coverage (DSC) ratio for non-municipal homes, organizations (E)	n/a	n/a	tbd	tbd	tbd	tbd

2.0 LHIN-Specific Performance Obligations.

(a) In recognition of the Developmental Indicators, the LTC Home will contribute to:

- Reduced resident transfers from LTC Home to Emergency Department/hospitals for conditions which can be treated in the LTC Home;
- Reduced hospital admissions for conditions which can be treated in the LTC Home;
- Reduced hospital length of stay (LOS) for Long-Term Care Residents who can be discharged to a LTC Home for their ongoing care with appropriate additional supports.

(b) **Wound Management (WM)**
The LTC Home shall participate in the South West Regional Wound Care Program, as sponsored by the South West Community Care Access Centre (CCAC).

(c) **Behavior Support Organization (BSO)**
The LTC Home shall participate in the Behavioral Supports Ontario (BSO) Program and shall enter into a Memorandum of Agreement (MoA) with St. Joseph's Health Care, London who performs the LHIN-wide project coordination role.

Schedule E – Form of Compliance Declaration

DECLARATION OF COMPLIANCE

Issued pursuant to the Long Term Care Service Accountability Agreement

To: **The Board of Directors** of the [insert name of LHIN] Local Health Integration Network (the "LHIN"). Attn: Board Chair.

From: **The Board of Directors** (the "Board") of the [insert name of License Holder] (the "HSP")

For: [insert name of Home] (the "Home")

Date: [insert date]

Re: [January 1, 201X – December 31, 201X] (the "Applicable Period")

The Board has authorized me, by resolution dated [insert date], to declare to you as follows:

After making inquiries of the [insert name and position of person responsible for managing the Home on a day to day basis, e.g. the Chief Executive Office or the Executive Director] and other appropriate officers of the HSP and subject to any exceptions identified on Appendix 1 to this Declaration of Compliance, to the best of the Board's knowledge and belief, the HSP has fulfilled, its obligations under the long-term care service accountability agreement (the "Agreement") in effect during the Applicable Period.

Without limiting the generality of the foregoing, the HSP confirms that

(i) it has complied with the provisions of the *Local Health System Integration Act, 2006* and with any compensation restraint legislation which applies to the HSP; and

(ii) every Report submitted by the HSP is accurate in all respects and in full compliance with the terms of the Agreement;

Unless otherwise defined in this declaration, capitalized terms have the same meaning as set out in the Agreement between the LHIN and the HSP effective April 1, 2013.

_____

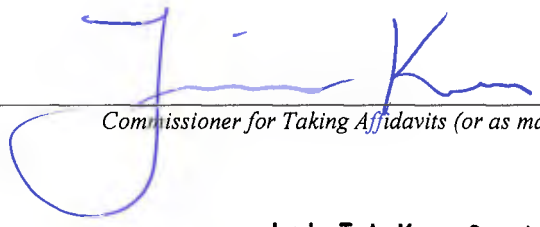
[insert name of individual authorized by the Board to make the Declaration on the Board's behalf], [insert title]

Schedule E – Form of Compliance **Declaration Cont'd.**

Appendix 1 - Exceptions

[Please identify each obligation under the L-SAA that the HSP did not meet during the Applicable Period, together with an explanation as to why the obligation was not met and an estimated date by which the HSP expects to be in compliance.

This is Exhibit "D" referred to in the Affidavit of Dr. Michael Hillmer sworn August 29, 2018



Commissioner for Taking Affidavits (or as may be)

Jessica Taylor Kras, a Commissioner, etc.,
Province of Ontario,
while a Student-at-Law.
Expires May 30, 2020.

Data Sharing Agreement

THIS AGREEMENT dated this 24th day of October, 2016 by the Ministry of Health and Long-Term Care

BETWEEN:

HER MAJESTY THE QUEEN in RIGHT OF ONTARIO as
Represented by the Minister of Health and Long-Term Care
("MOHLTC")

– and –

HER MAJESTY THE QUEEN in RIGHT OF ONTARIO as
Represented by the Minister of Community Safety and Correctional Services
("MCSCS")

Background

The Office of the Chief Coroner for Ontario serves the living through high quality death investigations and inquests to ensure that no death will be overlooked, concealed or ignored. The findings of death investigations are used individually at the case level or more broadly at an aggregate level to inform potential improvements in the health and safety of the public and the prevention of deaths in similar circumstances.

The Ministry of Health and Long-Term Care is working to establish a patient-focused, results-driven, integrated and sustainable publicly funded health system. Its plan for building a sustainable public health care system in Ontario is based on helping people stay healthy, delivering good care when people need it, and protecting the health system for future generations. This role includes monitoring and reporting on the performance of the health system and the health of Ontarians to inform potential opportunities for systemic improvement.

MOHLTC has requested access to Information in the custody or under the control of MCSCS for the Purpose described in Appendix 2, which is a purpose related to monitoring and analyzing all interactions with the health care system leading up to death. This information contains Personal Health Information.

Under clause 4(1)(d) of the *Coroners Act*, RSO 1990, c C37, ("Coroners Act") the Chief Coroner may bring the findings and recommendations of coroners' investigations and coroners' juries to the attention of appropriate persons, agencies and ministries of the government.

Subsection 18(3) of the Coroners Act allows for the disclosure of information where the disclosure is necessary in the interests of public safety and subsection 15(1)(c) of the

Coroners Act provides for the collection and analysis of information about deaths in order to prevent further deaths in similar circumstances.

Clause 36(1)(g) of the *Personal Health Information Protection Act, 2004*, SO 2004, c 3, Schedule A, permits MOHLTC to collect personal health information from a person who is permitted or required by law made under an Act of Ontario to disclose it to MOHLTC.

MCSCS wishes to provide the MOHLTC access to the Information for the Purpose detailed herein.

Consideration

In consideration of the mutual covenants contained in this Agreement, and subject to the terms and conditions set out in this Agreement, the MOHLTC and MCSCS covenant and agree as follows:

ARTICLE 1
DEFINITIONS AND INTERPRETATION

1.1 **Definitions.** In this Data Sharing Agreement including the recitals above, the following words have the following meanings:

"Agreement" means this Data Sharing Agreement between MCSCS and the MOHLTC as it may be amended from time to time in accordance with its terms;

"Applicable Law" means with respect to any person, property, transaction, event or other matter, any rule including any health professional college rule, any law, statute, regulation, order, judgment, decree, treaty or other requirement having the force of law relating or applicable to such person, property, transaction, event or other matter;

"Derived Personal Information" means information that could potentially identify an individual, due to a subset of less than five (5) observations, through a process of elimination, or otherwise;

"Information" means all information including all database elements and databases, if any, as described in Appendix 1 to this Agreement entitled "Information", as may be amended from time to time;

"Party" means MCSCS or the MOHLTC and "**Parties**" means MCSCS and the MOHLTC;

"Personal Health Information" has the same definition as in Section 4 of the *Personal Health Information Protection Act, 2004* SO 2004, c 3 Schedule A;

"Personal Information" has the same definition as in Section 2(1) of the *Freedom of Information and Protection of Privacy Act*, RSO 1990, C F31, as may be amended from time to time;

"Publish" means to make available outside of the MOHLTC and **"Publication"** has a corresponding meaning;

"Purpose" means the purpose for which the Information may be provided to the MOHLTC, as described in Appendix 2 to this Agreement entitled "Purpose"; and

"Report" means the final version of any written material, in any format and on any media, including print, electronic and digital, produced by or on behalf of the MOHLTC, that reports outcomes, results or conclusions relating to the Purpose, and is based on or contains the Information, and **"Reports"** means any two (2) or more of these.

1.2 **Amendment.** No amendment to this Agreement will be binding unless in writing and signed by both Parties;

1.3 **No Waiver.** A waiver of any failure to comply with any term of this Agreement will be in writing and signed by the Party providing the waiver. Every such waiver must refer to a specific failure to comply and will not have the effect of waiving any subsequent or previous failure to comply.

1.4 **Governing Law.** This Agreement, and the rights, obligations and relations of the Parties to this Agreement, will be governed by, and interpreted in accordance with, the laws of the Province of Ontario.

1.5 **Entire Agreement.** This Agreement constitutes the entire agreement between the Parties with respect to the access and use of the Information by the MOHLTC, and supersedes any prior agreements or understandings, collateral, oral or otherwise, existing between the Parties at the time this Agreement is entered into.

ARTICLE 2
TERM

2.1 **Term.** This Agreement is effective from the date it is signed by MOHLTC and will remain in force unless otherwise terminated in accordance with its terms.

ARTICLE 3
INFORMATION TO BE PROVIDED

3.1 **Information Provided.** MCSCS will provide the Information to the MOHLTC at such time or times, and by such means, as may be agreed to by the Parties.

3.2 **Completeness and Accuracy.** MCSCS will use its reasonable efforts to ensure the completeness and accuracy of the Information. However, MOHLTC acknowledges and agrees that MCSCS cannot guarantee the accuracy and completeness of the Information, in whole or in part.

ARTICLE 4
USE AND DISCLOSURE OF INFORMATION

4.1 **Use and Disclosure.** The MOHLTC will not use or disclose the Information for any purpose other than the Purpose, unless authorized by law.

4.2 **Authorized Persons.** The MOHLTC is responsible for the actions of every individual who has access to the Information in connection with carrying out the Purpose for or on behalf of MOHLTC.

4.3 **Applicable Law.** The MOHLTC will only use and disclose the Information in accordance with Applicable Law.

4.4 **Notice of Breach.** The MOHLTC will immediately advise and notify MCSCS as soon as the MOHLTC becomes aware of a potential or actual breach of any term or condition of this Agreement.

ARTICLE 5
REPORTS

5.1 **No Publication of Personal Information**. For certainty, the MOHLTC will not Publish, in any Report or otherwise, any Identifying Information, Personal Information, Personal Health Information or Derived Personal Information, derived from or based on the Information.

ARTICLE 6
DATA AUDIT

6.1 **Records.** MCSCS or an independent auditor may, upon ten (10) days' notice, conduct an audit of the MOHLTC's records relating to the maintenance, use and disclosure of the Information.

6.2 **Auditor Access.** For the purposes of the audit, the MOHLTC will, subject to Applicable Law, give MCSCS and the independent auditor access to the MOHLTC's premises and to the Information, and all such other access as may be reasonably necessary to verify the MOHLTC's compliance with this Agreement.

6.3 **Improvement.** MCSCS may, at any time, require the MOHLTC to improve the methods by which it maintains, uses and discloses the Information to ensure compliance with this Agreement.

6.4 **MCSCS not to Control.** Nothing in this Article or in this Agreement will be construed so as to give MCSCS any control whatsoever over the books, accounts or other records of the MOHLTC.

ARTICLE 7
TERMINATION

7.1 **Termination for Breach.** MCSCS may terminate this Agreement immediately upon notice to the MOHLTC in the event of any breach by the MOHLTC of any material representation, warranty, condition or covenant of this Agreement.

7.2 **Termination for Convenience.** Either Party may terminate this Agreement at any time, without cause, upon at least thirty (30) days prior notice to the other Party.

7.3 **No Further Information Provided.** Upon termination of this Agreement, MCSCS will have no further obligation to provide Information to the MOHLTC.

7.4 **Destruction or Return of Information.** Upon termination of this Agreement, the MOHLTC will:

(a) immediately stop using the Information;
(b) return or destroy the Information, as directed by MCSCS and in a manner approved by MCSCS, without keeping any copies; and
(c) provide written confirmation of the destruction of the Information.

7.5 **Written Approval Required.** Despite section 7.4, the MOHLTC may, if approved in writing by MCSCS, maintain the Information in the form and in accordance with the conditions required by MCSCS for the purposes specified by MCSCS.

7.6 **No Further Publication without Consent.** In addition to the foregoing, if MCSCS terminates this Agreement for breach pursuant to this Article, the MOHLTC will not publish any Reports or any other material that was produced using the Information after the date of termination without the prior written consent of MCSCS, which will not be unreasonably withheld.

ARTICLE 8
NOTICE

8.1 **Notice.** Notices under this Agreement will be in writing and will be delivered by email, postage-prepaid mail, courier, personal delivery or fax and addressed to the other Party as provided below or as either Party will later designate to the other in writing by notice in writing.

To MCSCS:

Dirk Huyer, Chief Coroner
Forensic Services and Coroners Complex
25 Morton Shulman Avenue
Toronto, Ontario M3M 0B1
Phone: 647-329-1814
Fax: 416-314-4030
E-mail: dirk.huyer@ontario.ca

To the MOHLTC:

John R. Hill, Manager
Analytic Reports and Tools,
Health Analytics Branch, HSIM
1075 Bay St. 13th Floor
Phone: 416-327-8683
Fax: 416-326-6560
E-mail: john.r.hill@ontario.ca

8.2 **Effective Notice.** All Notices will be effective:

(a) at the time the delivery is made if the Notice is delivered personally, by e-mail, pre-paid courier or by facsimile; or

(b) three (3) days after the day the Notice was deposited in the mail if the Notice is sent by registered or postage prepaid mail, unless the day the Notice is effective falls on a day when MCSCS is normally closed for business, in which case the Notice will not be effective until the next day that is a day when MCSCS is normally open for business.

ARTICLE 9
GENERAL

9.1 **Assignment and Transfer.** Neither Party will assign or transfer this Agreement, any part of this Agreement, or any benefit or interest in or under this Agreement, without the prior written consent of the other Party

9.2 **Cumulative Rights and Remedies.** Except to the extent otherwise expressly stated in this Agreement, the rights and remedies of the Parties are cumulative and are in addition to, and not in substitution for, any rights and remedies provided by law or equity.

9.3 **Contract Binding.** All rights and obligations contained in the Agreement will extend to and be binding on the Parties' respective heirs, executors, administrators, successors and permitted assigns.

9.4 **MOHLTC Not a Partner, Agent or Employee.** The MOHLTC will have no power or authority to bind MCSCS or to assume or create any obligation or responsibility, express or implied, on behalf of MCSCS.

9.5 **Further Assurances.** The Parties agree to do or cause to be done all acts and things necessary to implement and carry into effect this Agreement to its full extent.

9.6 **Survival.** Section 3.2 (Completeness and Accuracy), Article 5 (Reports), Article 6 (Data Audit), Section 7.4 (Destruction or Return of Information), Section 7.5 (Written Approval Required), Section 7.6 (No Further Publication Without Consent) and this Section 9.7 (Survival) will survive the termination of this Agreement for any reason.

IN WITNESS OF WHICH the Parties have made this Agreement.

Her Majesty the Queen in right of Ontario as represented by the Minister of Health and Long Term Care:

Signature: _____

Name: Michael Hillmer

Title: Executive Director,
Information Management, Data, and Analytics

Date of Signature: _____
I have the authority to bind MOHLTC

Her Majesty the Queen in right of Ontario as represented by the Minister of Community Safety and Correctional Services:

Signature: _____

Name: Dirk Huyer

Title: Chief Coroner

Date of Signature: 28/Oct/2016
I have the authority to bind MCSCS

APPENDIX 1
INFORMATION

MOHLTC requires the following data elements which comprise the Information for the Purpose as follows:

(i) For historical data from 2001 to the effective date of this Agreement, MCSCS shall use best efforts to disclose one complete data set containing the Information in a form, format and manner agreed to by the Parties, as soon as is practicable after the effective date; and

(ii) For data collected by MCSCS after the effective date of this Agreement, MCSCS shall disclose to MOHLTC on a quarterly basis, the newly collected Information in each quarter, in a form, format and manner agreed to by the Parties.

MCSCS will provide MOHLTC with the following data elements:

Personal Health Information Data elements
Coroner file number
Coroner region
Decedent name
Decedent sex
Decedent date of birth
Decedent age
Decedent address
Decedent postal code
Municipality where death occurred
Date of death
Cause of death
Manner of death
Death factor
Opioid drug involvement code(s)

MCSCS will also provide the following aggregate indicators:
1) Total number of drug related deaths per year; and
2) Total number of deaths per year.

APPENDIX 2
PURPOSE

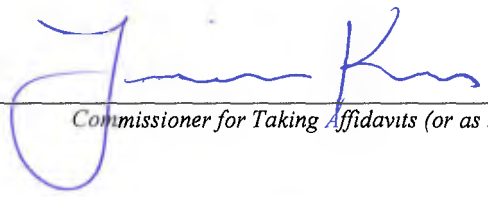
The following is the Purpose:

MOHLTC will use the Information to better understand the incidence and contributing factors to deaths in Ontario.

MOHLTC currently has custody and control of data that quantifies deaths that occur in hospital, emergency rooms, long-term care homes, and other health care settings but not deaths that occur in a non-health care setting –MCSCS collects a significant proportion of this data MOHLTC will use probabilistic linkage to link the Information with MOHLTC data, in order to monitor and analyze all interactions with the health care system leading up to death.

Detailed death investigations are completed by the Office of the Chief Coroner (OCC) identifying information not routinely available to the MOHLTC. The information to be provided by MCSCS relates to persons who were the subject of a coronial death investigation. The information will be used to develop an enhanced understanding of the circumstances of deaths investigated by the OCC. Sharing of coronial death investigation data will support the completeness and robustness of MOHLTC analyses of health care interactions in the period prior to death, including but not limited to deaths occurring outside of health care settings. This is consistent with the approach of the death investigation system in Ontario and will further the work of the Chief Coroner in improving the health and safety of Ontarians.

This is Exhibit "E" referred to in the Affidavit of Dr. Michael Hillmer sworn August 29, 2018



Commissioner for Taking Affidavits (or as may be)

Jessica Taylor Kras, a Commissioner, etc.,
Province of Ontario,
while a Student-at-Law.
Expires May 30, 2020.

AMENDING AGREEMENT NO. 1 TO THE DATA SHARING AGREEMENT

THIS AMENDING AGREEMENT effective as of the 14 day of MAY, 2018

HER MAJESTY THE QUEEN in RIGHT OF ONTARIO as represented by the Minister of Health and Long-Term Care
("Ontario")

- and -

HER MAJESTY THE QUEEN in RIGHT OF ONTARIO as Represented by the Minister of Community Safety and Correctional Services
("MCSCS")

Background

The MOHLTC and MCSCS entered into a Data Sharing Agreement dated the 24th day of October, 2016.

The MOHLTC and MCSCS wish to amend the Original Agreement in the manner set out in this Amending Agreement.

Consideration

In consideration of the mutual covenants contained in this Amending Agreement, the MOHLTC and MCSCS agree as follows:

ARTICLE 1
DEFINITIONS

1.1 **Definitions.** In this Amending Agreement including the recitals above, the following words shall have the following meanings:

"Amending Agreement" means this Amending Agreement between the Parties;

"Original Agreement" means the Data Sharing Agreement made between the MOHLTC and MCSCS signed on October 24th, 2016, as amended or otherwise modified to the date that this Amending Agreement becomes effective.

1.2 **Definitions in Original Agreement.** Capitalized terms in this Amending

Agreement that are not defined above in Section 1.1 (Definitions) shall have the same meaning as in the Original Agreement.

ARTICLE 2
TERM

2.1 **Effective Date.** This Amending Agreement is effective from the date that it is signed by both Parties.

ARTICLE 3
AMENDMENTS

3.1 **Amendments to Original Agreement.** The Original Agreement is amended as follows:

1. Appendix 1 (Information) is deleted and replaced with the Appendix set out in Schedule 1 to this Amending Agreement.

ARTICLE 4
CONFIRMATION

4.1 **Full Force and Effect.** The Parties, in all other respects, confirm that the Original Agreement is in full force and effect, and is not changed or modified except as set out in Article 3 (Amendments to Original Agreement) above.

ARTICLE 6
BINDING EFFECT

6.1 **Amending Agreement Binding.** This Amending Agreement shall enure to the benefit of and be binding upon the Parties, and each of their heirs, executors, administrators, permitted successors and permitted assigns, respectively.

IN WITNESS OF WHICH the parties to this Amending Agreement have executed this Amending Agreement.

HER MAJESTY THE QUEEN in right of Ontario as represented by Minister of Health and Long-Term Care

Signature: M. Hillmer

Name: Michael Hillmer

Title: Executive Director
Information Management, Data and Analytics

Date of Signature: 8 May 2018

HER MAJESTY THE QUEEN in right of Ontario as represented by the Minister of Community Safety and Correctional Services:

Signature: _____

Name: Dr. Dirk Huyer

Title: Chief Coroner

Date of Signature: 14 MAY 2018

I have authority to bind MCSCS

SCHEDULE 1

TO AMENDING AGREEMENT NO. 1 TO THE
DATA SHARING AGREEMENT

APPENDIX 1
INFORMATION

The MOHLTC requires the following data which comprise the Information for the Purpose as follows:

(i) For historical data from 2001 to the effective date of this Agreement, MCSCS shall use best efforts to disclose one complete data set containing the Information in a form, format and manner agreed to by the Parties, as soon as is practicable after the effective date; and

(ii) For data collected by MCSCS after the effective date of this Agreement, MCSCS shall disclose to MOHLTC on a quarterly basis, the newly collected Information in each quarter, in a form, format and manner agreed to by the Parties.

MCSCS will provide the MOHLTC with all data from the following databases:

(a) **Coroner Investigation System (CIS)**; and

(b) **Supplementary Opioid investigation Aid (OIA) database**

Notes
MCSCS will also provide the following aggregate indicators:

1. Total number of drug related deaths per year; and

2. Total number of deaths per year.

This is Exhibit "F" referred to in the Affidavit of Dr. Michael Hillmer sworn August 29, 2018

Commissioner for Taking Affidavits (or as may be)

Jessica Taylor Kras, a Commissioner, etc.,
Province of Ontario,
while a Student-at-Law.
Expires May 30, 2020.

Ontario Ministry of Health and Long-Term Care

Detecting LTC Homes with Excessive Rate of Mortality

September 13, 2017

Health Analytics Branch

Ontario

In this deck we will...

- Present two approaches of modeling to risk adjust or predict death in LTC home
- Present preliminary findings of homes identified as having excessive rate of mortality after risk adjustment

And at the end

- Gather feedback about the approaches and methodologies, and next steps

Purposes of Project

- Develop a risk adjusted model of mortality rate at LHTC level and use it as a quality control technique to develop a monitoring system and flag homes with excessive deaths for further investigation
- Explore approaches to model development and variable selection
  - Traditional Statistical approach
  - Machine Learning approach (Random Forest , Decision Tree, XGBoost)

Background

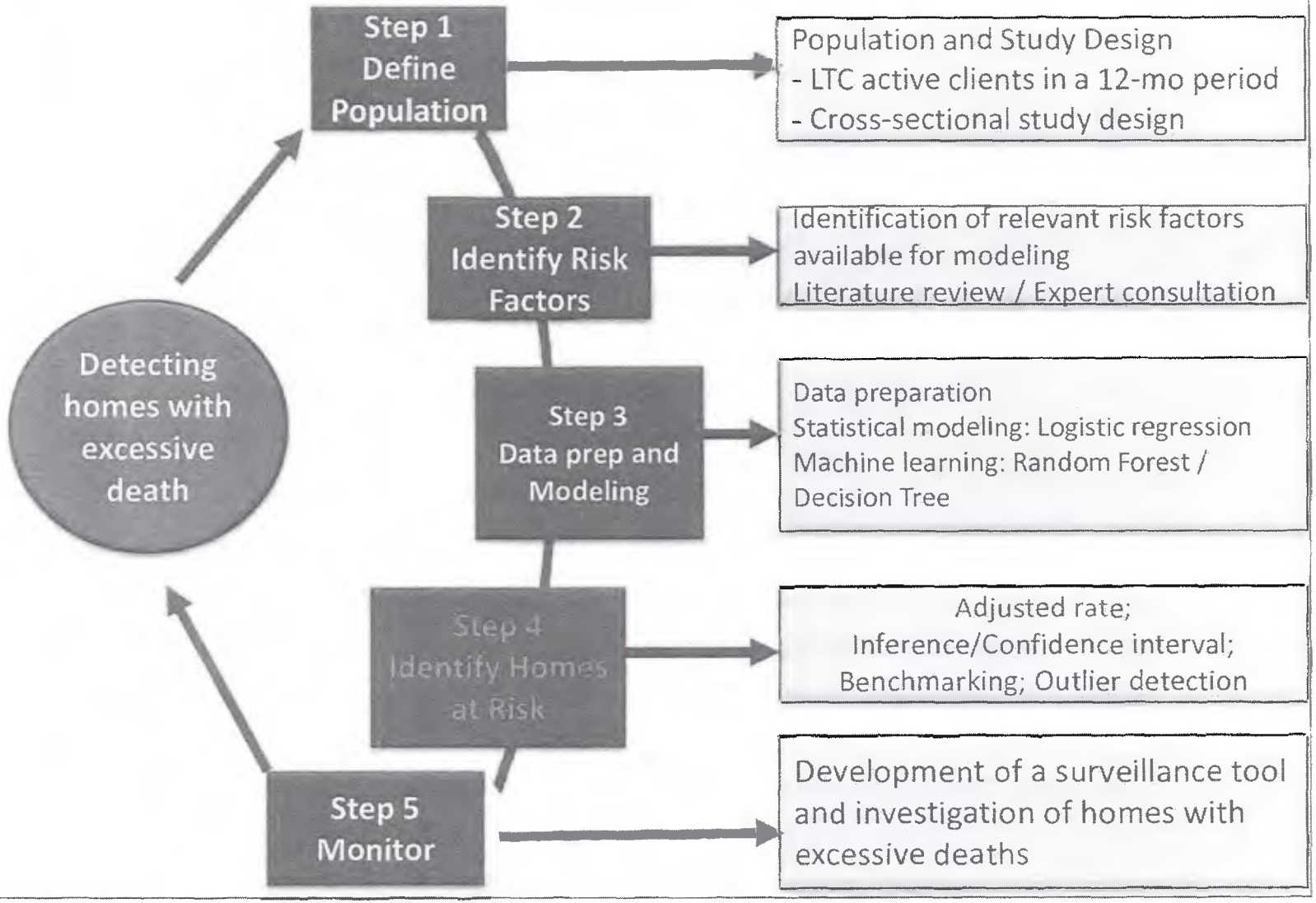
- LTC homes death vary significantly by homes. The excessively high death rate of a home could reflect
  - the acuity level of residents in the home,
  - poor quality of care provided by the home,

    OR

  - actions of health-care professionals in the home
- Ex-nurse Elizabeth Wettlaufer is charged with murder of 8 residents (7 of which in Caressant Care, Woodstock)
  - FY2007: Aug 17, 2007; Dec 23, 2007 (Caressant Care, Woodstock)
  - **FY2011:** Oct 14, 2011; Oct 27, 2011; Nov 7, 2011 (Caressant Care, Woodstock)
  - **FY2013:** July 14, 2013; Mar 28, 2014 (Caressant Care, Woodstock)
  - FY2014: Aug 31, 2014 (Meadow Park, London)

  (Other attempted murder charges and aggravated assault charges related to residents of Caressant Care took place in 2007-2009)

Study Design



Study Design and Steps

- A **snapshot** approach on people residing in LTCH in a predefined period of time (e.g. 12 months)
- **Active clients** were modelled for the event of death after controlling for socio-demographics, various prevalent conditions related to aging and chronic disease
    - Active clients that have no assessments are removed
- **Conditions and status** from the **latest assessment** were used for risk adjustment
- **An indirect standardization in risk adjustment**
    - Modeling
        - Statistical modeling of logistic regression, and
        - Machine Learning algorithms
    - Individuals' expected chances of death after risk adjustment from the modeling were aggregated to the LTC home level
    - Expected deaths were compared against observed deaths, to assess if a LTC home's deaths are higher than what it should have, given its resident composition
- **Outlier detection**: Ranking of adjusted rate, confidence intervals and benchmarks were used to help outlier detection
- **Data source**: The Continuing Care Reporting System (CCRS) and HAB enhanced death database

Proposed Methodologies

Statistical modeling

- Use a predefined set of risk factors associated with death of LTC residents, based on literature and expert consultation
- Run Regression modeling, estimating resident's expected chance of death after risk adjustment
  - low-risk individuals => low expectancy of death
  - Home with low-risk residents => low risk-adjusted death rate

Proposed Methodologies

Machine Learning

- It is a combination of methodologies from multiple realms including inferential statistical methods and computer-science algorithms, where the model/algorithm goes through multiple steps of iterations using *fit–predict–feedback* loop. Mainly of two types: supervised and unsupervised.
  - *Fit:* Use of selected variables to build the model
  - *Prediction: Prediction* of response and comparison with actual value
  - *Feedback*: parameter tuning, variable re-selection
- Random Forests, Decision Trees and XGBoost were explored

Crude Rate, Adjusted Rate & Confidence Interval

Total active clients: Number of people that resided in LTC homes over a defined period

Observed deaths (Observed):
Number of reported deaths in a home

Expected deaths (Expected):
Number of deaths a home is expected to have, after risk adjustment, based on the statistical modeling/machine leaning algorithms

Crude rate: $\frac{Observed}{Total\ active\ clients}$ x 100

Adjusted rate: $\frac{Observed}{Expeted}$ x Provincial Rate

- Confidence limits of adjusted rate: Byar's approximation

  LCL = Provincial rate $* \frac{Observed}{Expected} * \left(1 - \frac{1}{9*\text{Observed}} - \frac{1.96}{3\sqrt{\text{Observed}}}\right)^3$

  UCL = Provincial rate $* \frac{Observed+1}{Expected} * \left(1 - \frac{1}{9*(\text{Observed}+1)} + \frac{1.96}{3\sqrt{(Observed+1)}}\right)^3$

  Where LCL = Lower confidence limit; UCL = Upper confidence limit

Confidence limits of expected deaths

- Use bootstrapping to generate

Pre-defined List of Risk Factors for Adjustment:

Used in Statistical Modeling Approach

Category	Measurements		
	Core Set		
Socio-demographics	Sex; Age (at start of the study period)		
Health conditions	CHF; Dementia; Renal failure; Cancer		
Conditions in RAI at the latest assessment	Cognitive Perform Scale Depression scale Pain Scale Weight loss	Dehydration Edema Shortness of Breath	Delusions Leave Food Uneaten Vomiting
Acuity Level	ADL difficulties (ADL Self-Performance Hierarchy Scale) Previous hospital admissions in the past 30 days ED visits within 365 days ADL decline (compared to 90 days ago) Cognitive status deteriorated (compared to 90 days ago)		
Discharge bed type	Four types: long-stay (including unknown), interim, convalescent, or respite		
	Additional Variables		
Acuity Level	Changes in Health, End-Stage Disease and Symptoms and Signs Scale (CHESS) Personal severity index (PSI) End-Stage Disease: 6 months or less to live		
Offset variables (to adjust for study design effects)	Years of exposure to LTC (years admitted to LTC) Assessment interval variations (days between latest assessment and censored date – exist date such as death, home transfer, or last date of study period, march 31)		

Select Risk Factors – Time Span of Measurement

	Span/window of variables measured			
Scales / Items	In 7 days	In 14 or 30 days	Compared to 90 days ago	Other
CHESS Scale	•Dehydration •Edema •Shortness of Breath •Vomiting •Leaving food uneaten		•Decline in Cognition •Decline in ADL	•**Weight loss**: 5% or more in 30 days or 10% in last 180 days) •**End-Stage Disease**: 6 months or less to live
Personal Severity index(PSI) (for age>90)	•Cognitive skills impaired •Lethargy •Ability to understand •ADL difficulties •Incontinence •Conditions or disease make cognition, ADL or behavior unstable •Experience an acute episode or a flair-up •Pressure/stasis ulcer	•Repetitive verbalizations (30 days) •Recurrent statements (30 days)	•Changes or deterioration in care needed	•**Weight loss**: 5% or more in 30 days or 10% in last 180 days) •**End-Stage Disease**: 6 months or less to live
Pain Scale	Presence of intense pain			
Single assess-ment items	Days received antidepressant	Use of oxygen therapy (14 days) Days doctor changed order (14 days)		

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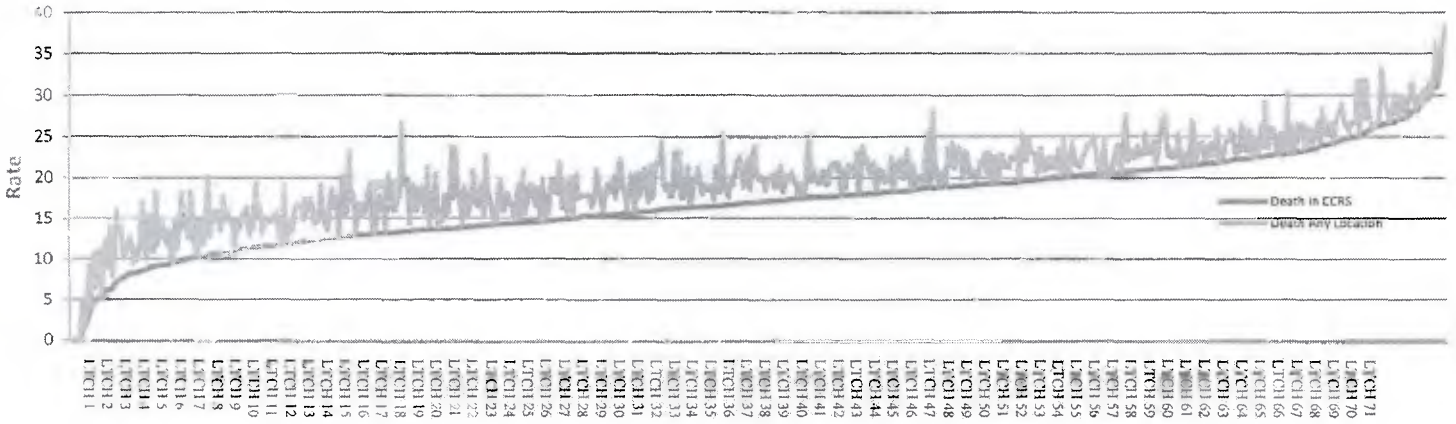
Risk factors: Issues to be considered in Statistical and Machine Approaches

- **Did we miss any important risk factors?**
- **Are we over-adjusting? Are we risk adjusting home variations in resident acuity or predicting mortality?**
  - Including risk factors based on measurements on status within past 7 days
  - Including risk factors that may be manifestation of the symptom of impending death, such as
    - over-sleeping, loss of diet, personal severity index , end of life stage disease, use of oxygen therapy, pain scale, CHESS

See Slides 41-42 for the completed list of variables included in all approaches of modeling
See Appendix C for association between some of the risk factors and death

Outcome: Death

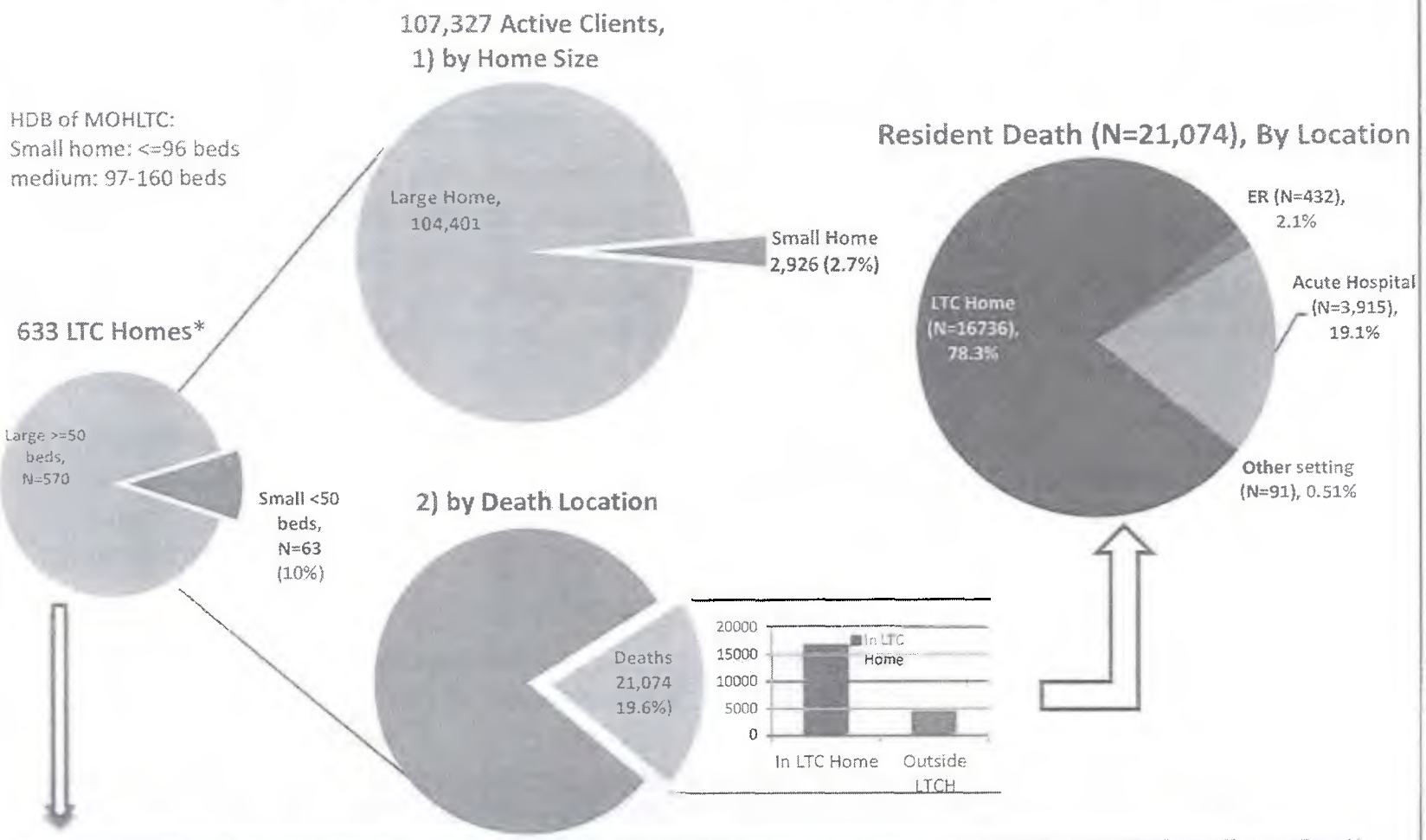
- **Defined as death in LTC home or in other institutions within 30 days of discharge from LTC**
  - LTC homes vary in their practice of temporary discharges of residents to ER or acute hospital (in anticipation of resident's return)
    - Some discharge residents right away or a few days after residents' acute admission
    - Some keep the beds while residents were admitted to acute hospital
  - 18% of resident deaths in FY2015/16 are not recorded in CCRS but in DAD, ER or other care settings while residents were temporarily discharged



Data Descriptive, FY2015/16

- 107,373 active clients (with assessment info)
- 21,074 deaths, or 19.6% of active clients die in the year
- Bed type: 99.2% in long-stay bed, remaining (0.8%) interim, convalescent or respite bed
- Death rate by bed type
  - Interim (22.4%),
  - Long-stay (20.7%)
  - Respite (4.9%)
  - Convalescent (0.9%)

LTC Active Clients, FY2015/16



Largest homes still small in comparison with the acute hospital sector or in statistical sense.

- Baycrest, with most beds: 472 beds / 590 active clients;
- St. Joseph's Villa Dundas, with most active clients: 378 beds / 787 active clients.

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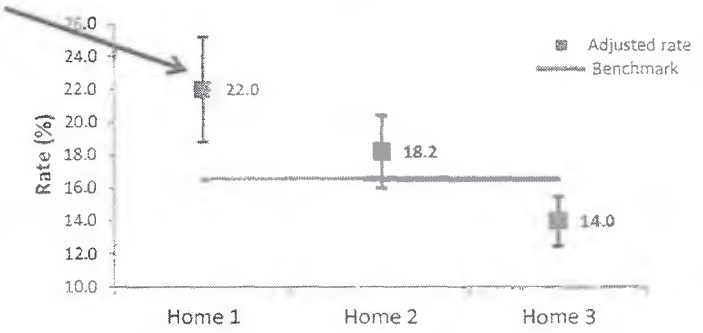
Possible Approaches to Identify Homes with Excessive Deaths/Death Rates (1)

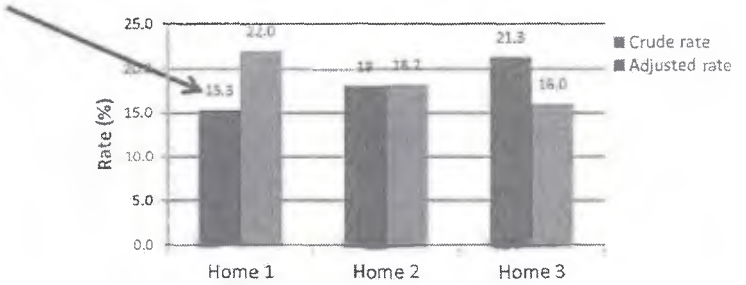
Measure	How to interpret
Ranking of Adjusted Rate • Rank adjusted rates to identify top-ranked LTC homes (with highest adjusted rate)	• Homes with top ranks (1,2….) have the highest adjusted death rates or ratio of observed to expected deaths (more deaths than expected)
Ranking Disparities • Rank crude rates and adjusted rates and identify homes with the biggest disparity in ranking between crude rate and adjusted rate	• Homes with low ranking in crude rate but top ranking in adjusted rate are homes with excessive deaths
Benchmarking • Apply ABC (Achievable Benchmarks of Care) methodology calculating rates based on top-ranked (on risk adjusted rate) LTC homes that represent at least 5% of residents (removing bias from rates based on small homes)	• Homes with rates above the benchmarks are homes with the excessive death rates
Expected Deaths vs. Observed Deaths • Compare confidence intervals of the expected deaths with the observed number of deaths	• Homes with confidence interval of expected deaths below the observed number of deaths have more deaths than expected

Methods to Identify Homes with Excessive Deaths/Death Rates (2)

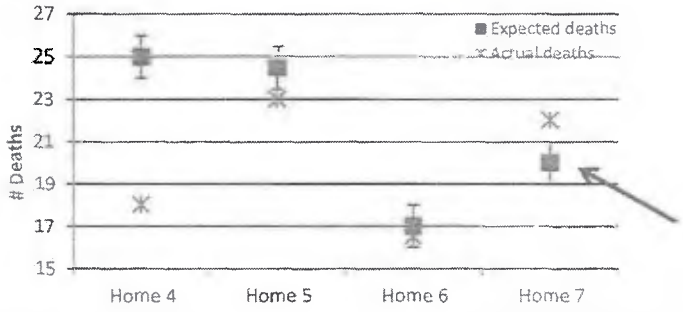
- Homes with adjusted rates above benchmark are homes with the excessive death rates (Adjusted Rate Ranking/Benchmark)



- Home with low ranking in crude rate but high ranking in adjusted rate (i.e. home with widest rank difference between adjusted rate crude-rate) (Ranking Disparities)



- Homes with confidence limits of expected deaths below observed number of deaths (Expected vs. Observed Death)



Statistical Results

Coefficient Estimates of Risk Factors from Statistical Modeling, FY2011/12: Using Different Variable Sets

	Core set	Plus EndStage	Plus CHESS/PSI	Plus EndStage/ CHESS/PSI
Intercept	-7.208***	-7.155***	-6.555***	-6.598***
sex Female Vs. Male	-0.399***	-0.399***	-0.381***	-0.382***
Age	0.041***	0.041***	0.036***	0.037***
Years since 1st LTC Admission	0.017***	0.018***	0.011***	0.013***
Days since last assessment	-0.001***	0.000*	-0.001**	0.000 n.s.
ADL hierarchy	0.322***	0.300***	0.151***	0.166***
Pain scale	0.188***	0.152***	0.146***	0.134***
ADL decline	0.425***	0.310***	-0.475***	0.103*
Cognition decline	0.393***	0.280***	-0.474***	0.098 n.s.
Shortness of breath	0.506***	0.411***	-0.068 n.s.	0.305***
Leaves food uneaten	0.719***	0.677***	-0.003 n.s.	0.547***
Dehydrated	0.934***	0.555***	0.370***	0.447***
Weight loss	0.559***	0.524***	-0.220***	0.272***
Vomiting	0.213***	0.147**	-0.326***	0.037 n.s.
Cognitive performance scale	0.173***	0.160***	0.079***	0.086***
Delusions	-0.181***	-0.183***	-0.241***	-0.231***
Dementia	-0.434***	-0.409***	-0.395***	-0.389***
CHF	0.145***	0.148***	0.151***	0.153***
Cancer	0.066**	-0.010 n.s.	0.038 n.s.	-0.002 n.s.
Renal failure	-0.069**	-0.081**	-0.068*	-0.079**
Depression scale	-0.009*	-0.002 n.s.	-0.018***	-0.012**
Edema	0.093***	0.089***	-0.523***	-0.032 n.s.
AIP admission in previous 30 days	0.780***	0.764***	0.740***	0.741***
Previous ER visit Index 1 vs. 0	-0.030 n.s.	-0.026 n.s.	-0.035 n.s.	-0.028 n.s.
Previous ER visit Index 2 vs. 0	0.132**	0.153***	0.121***	0.137**
Previous ER visit Index 3 vs. 0	0.498***	0.529***	0.495***	0.517***
Previous ER visit Index 4 vs. 0	1.644***	1.695***	1.667***	1.694***
Bed type Interim vs. Long-stay	0.079 n.s.	0.058 n.s.	0.062 n.s.	0.063 n.s.
Convalescent vs. Long-stay	-3.319***	-3.252***	-3.290***	-3.246***
Respite vs. Long-stay	-1.556***	-1.575***	-1.522***	-1.548***
End-stage disease		1.790***		1.500***
CHESS Scale			0.734***	0.119**
Personal severity index (PSI)			0.152***	0.128***

(C statistics ~.85 for all models)

Stat. Significance
*: p <.05,
**: p<0.01,
***: p<.001,
n.s not significant

Assessing of using different risk factors sets on Caressant Care, Woodstock

Three Periods: 2011Apr – 2012Mar 2011Jul – 2012June 2013Apr – 2014Mar (Coincided with the nurse killing)	Ranking of Adjusted Rate (Lower ranks = higher adjusted rate = Observed/Expected Ratio) All homes (633)	Observed vs expected death ratio	Adjusted Rate vs. Benchmark: 95%LCL – Adjusted rate + 95%UCL	Adjusted Rate vs. Benchmark: Benchmark
Core set	130	55/43.8: 1.26	22.73 (17.1,29.6)	29.43
	140	50/40.6: 1.23	22.11 (16.4,29.2)	29.97
	145	53/44.5: 1.19	22.94 (17.2,30.0)	32.30
+ End-stage disease	98	55/41.8: 1.32	23.83 (18.0,31.0)	29.71
	107	50/38.8: 1.29	23.19 (17.2,30.6)	29.59
	105	53/42 2: 1.26	24.21 (18 1,31 7)	32.02
+ CHESS, PSI	74	55/39.6: 1.39	22.84 (18.8, 32.3)	30.22
	70	50/36.1: 1.39	24.55 (18.3, 32.3)	30.21
	69	53/39.3: 1.35	26.01 (19.6, 33.8)	32.37
+ CHESS, PSI, End-stage disease	64	**55/38.9: 1.41**	25.57 (19.3,33.3)	30.12
	61	**50/35.6: 1.40**	25.24 (18.7,33.3)	30.14
	64	**53/38.7: 1.37**	26.38 (19.8,34.5)	32.43
+ CHESS, PSI, End-stage disease, PSI individual items	90	55/40.6: 1.36	24.54 (18.5,31.9)	29.82
	88	50/37.1: 1.35	24.23 (18.0,31.9)	29.70
	68	53/39.3: 1.35	25.98 (19.5,34.0)	32.12

- **Higher observed-to-expected-death ratio = more deaths than expected**
- **Higher rank: higher adjusted rate and more deaths than expected**

163 beds	Active Clients	Observed death	Crude rate	Provincial rate
2011Apr-Mar	231	55	23.81	18.10
2011June-Jul	232	50	21.55	17.98
2013	237	53	22.36	19.26

Reminder: Crude & adjusted rates not comparable:

Crude rate $= \frac{Oobserved\ Death}{Active\ Clients} \times 100$

Adjusted rate $= \frac{Observed\ Death}{Expected\ Death} \times$ Provincial rate

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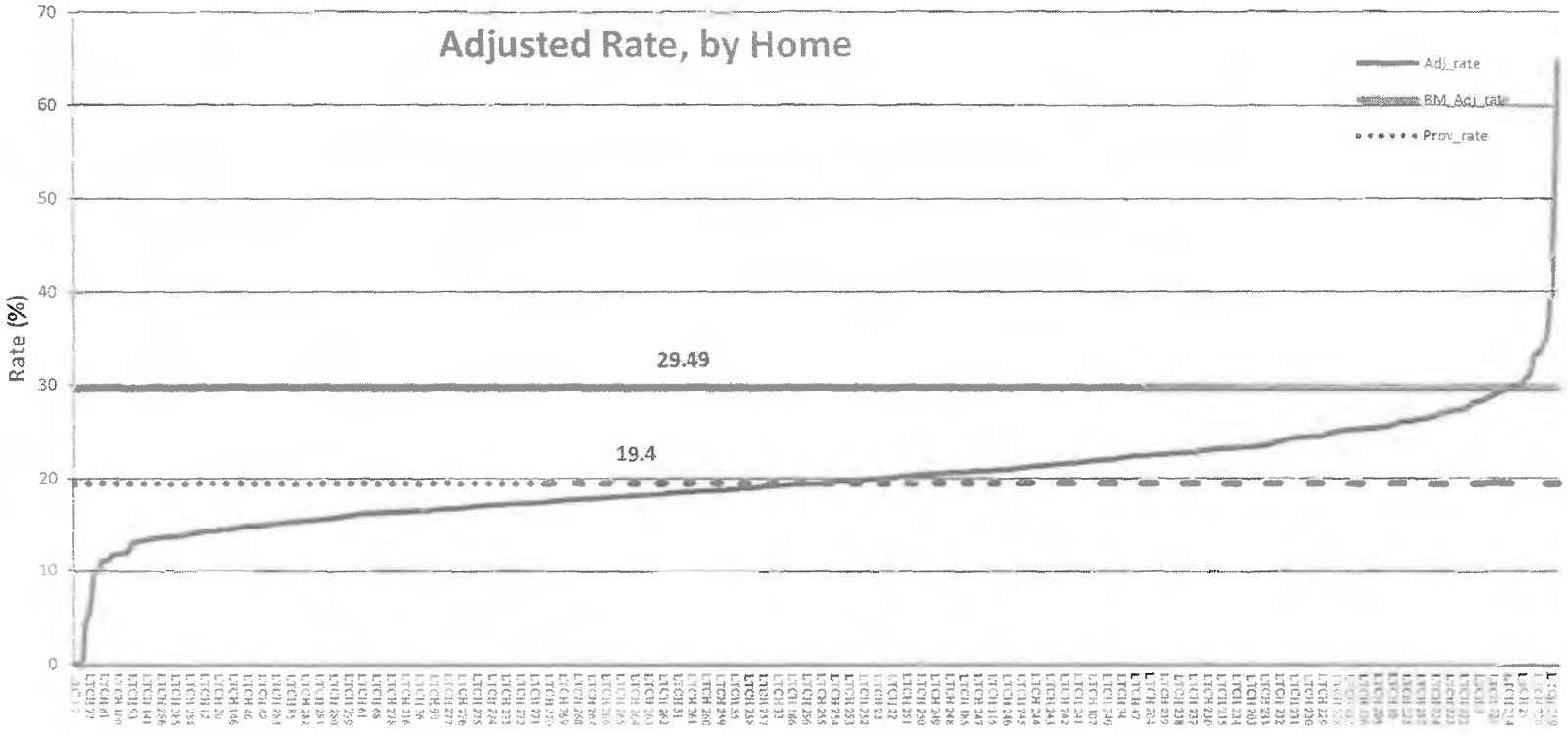
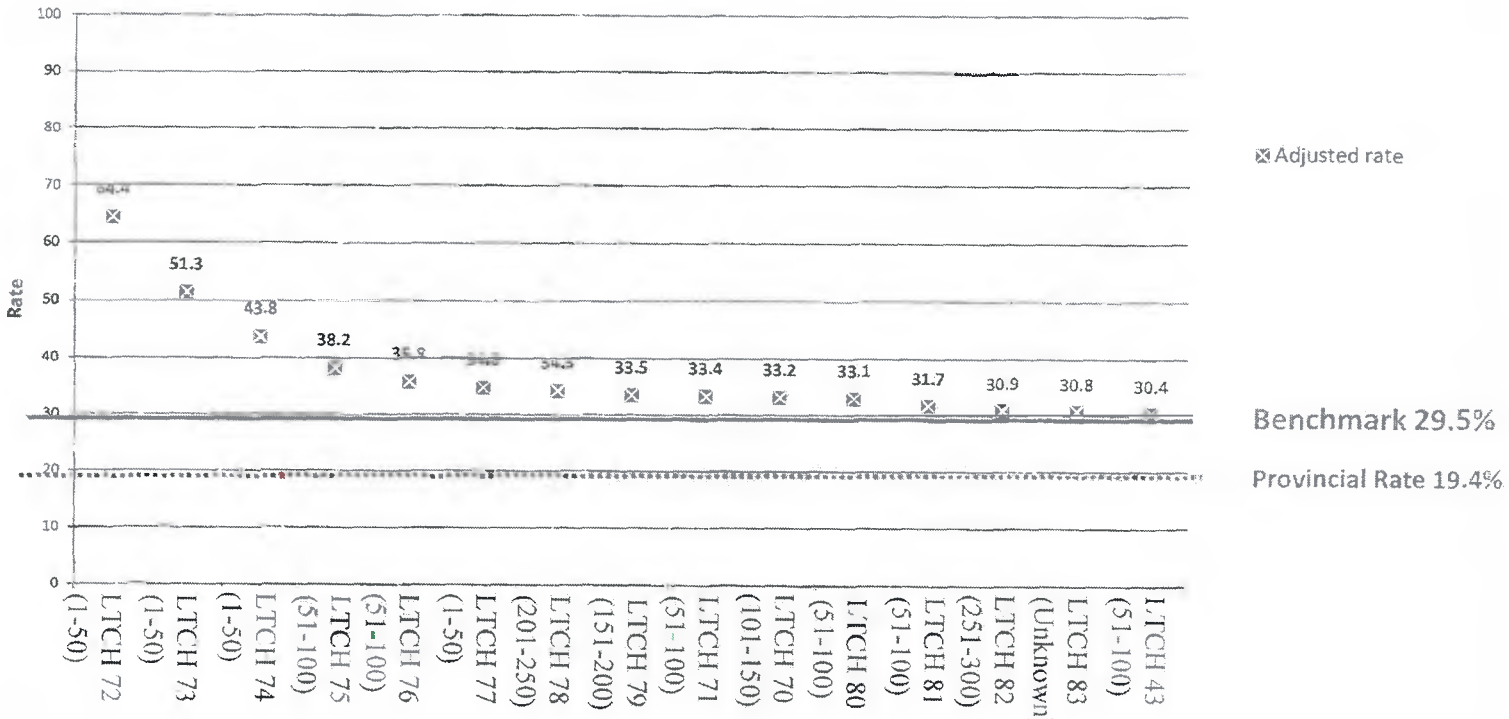
Risk Adjusted Rate, by LTC Home (N=630), FY2015/2016



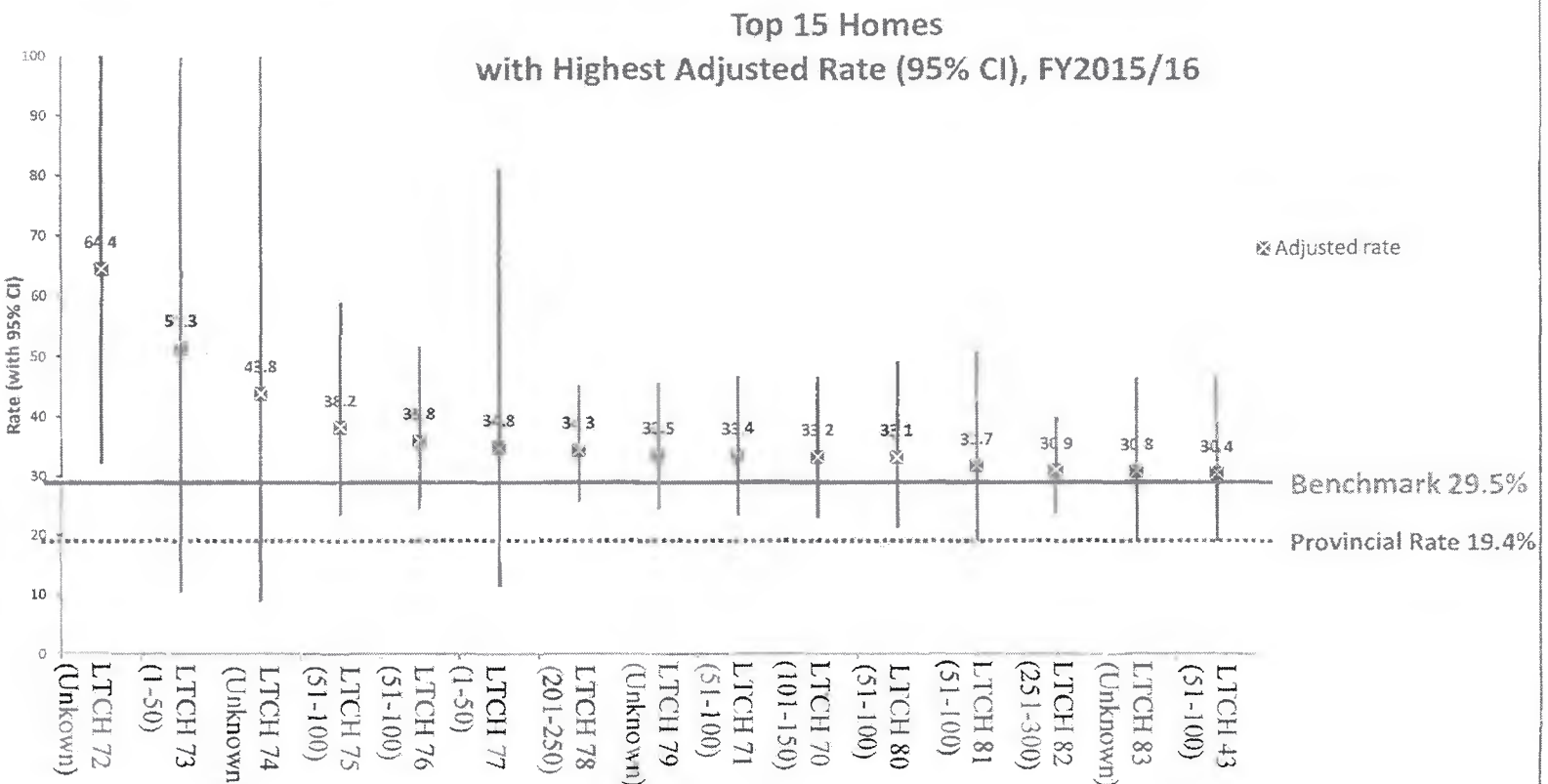
22 LTC homes with rates above benchmark and 313 homes with rates above provincial rate

Homes for Monitoring (1)
Based on Adjusted Rate Ranking & Benchmark

Top 15 Homes
with Highest Adjusted Rate, FY2015/16

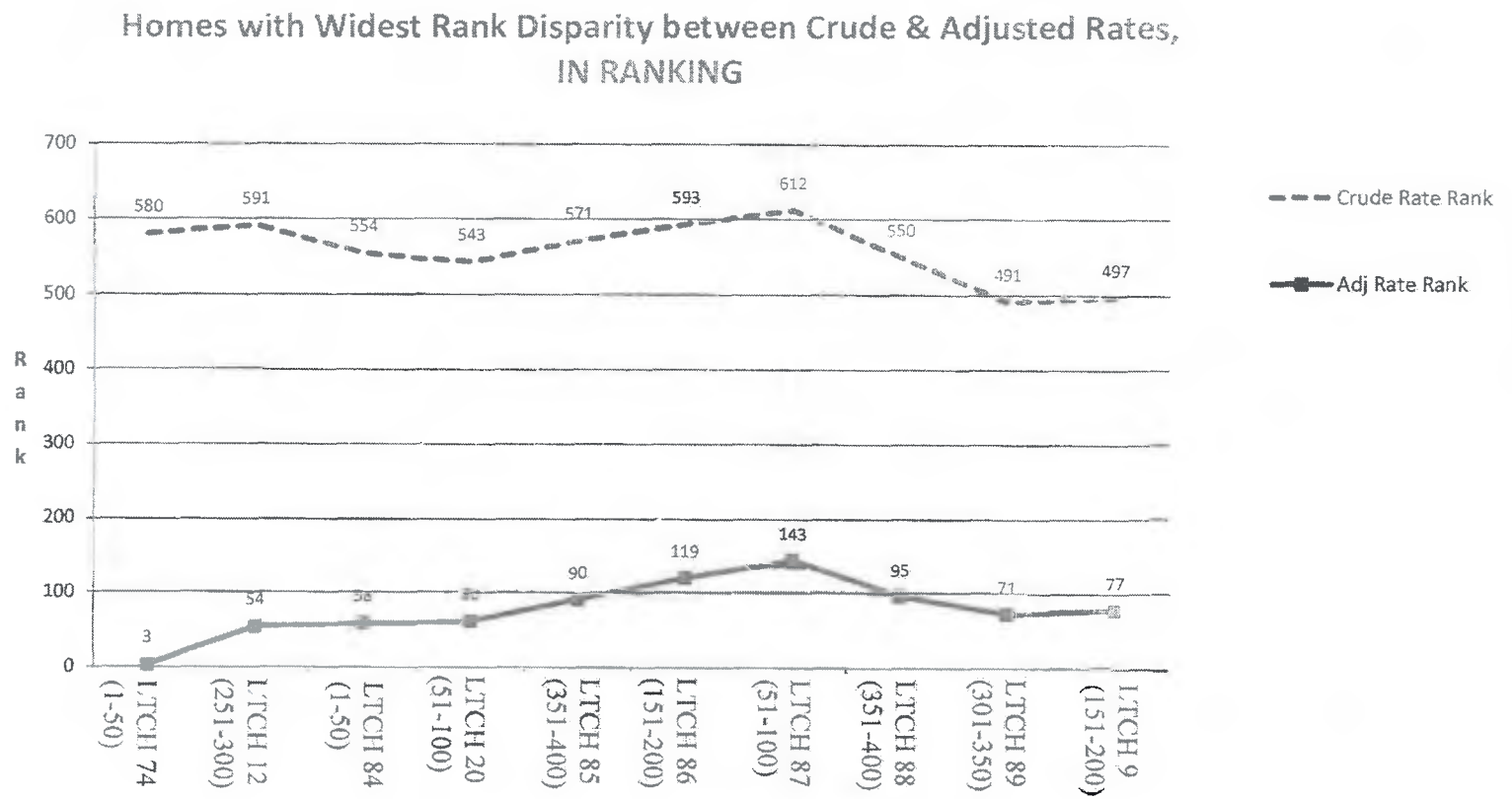


Homes for Monitoring (1)
Based on Adjusted Rate Ranking & Benchmark



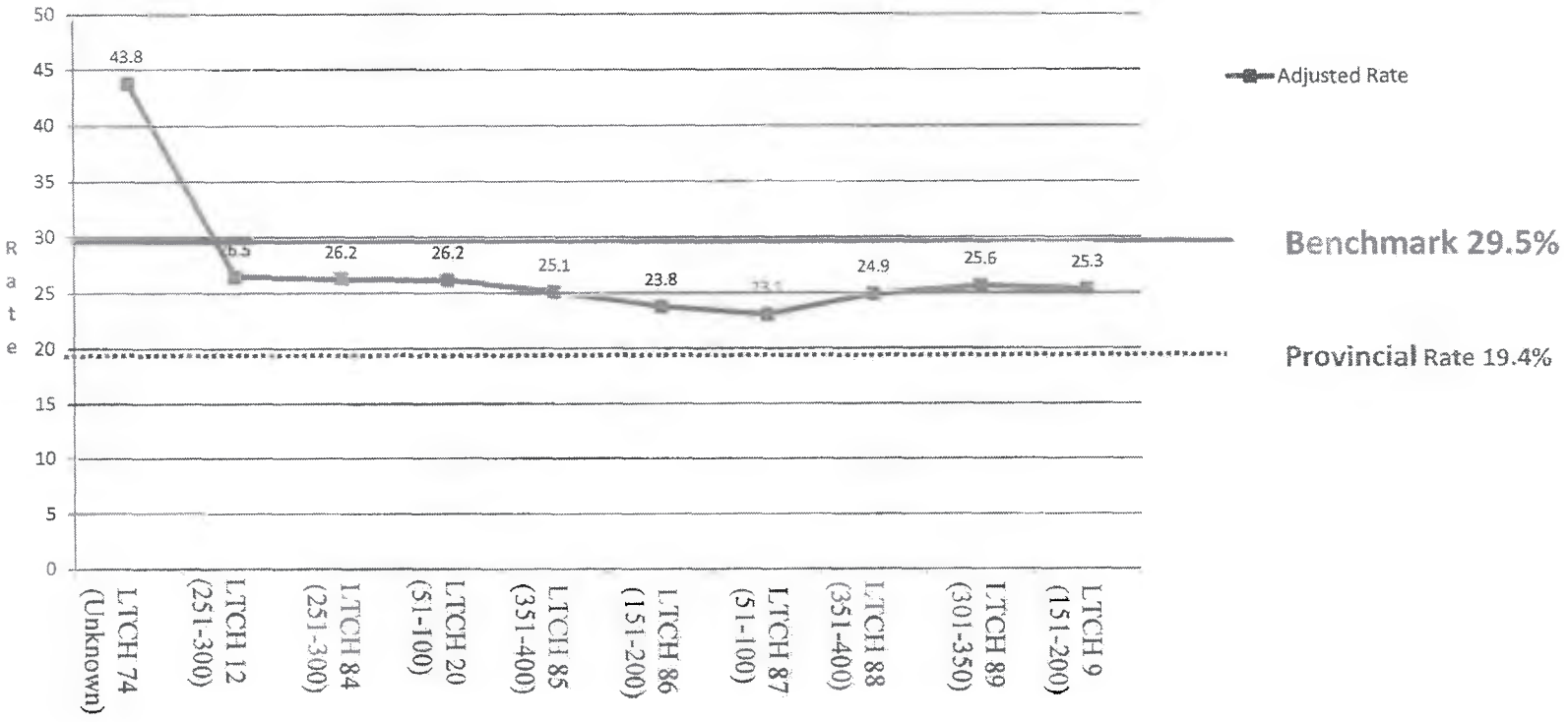
- All homes but one have confidence interval overlapped with the benchmark
- 37 homes have LCL above provincial rate (with adjusted rate rank up to 87)

Homes for Monitoring (2)
Based on Ranking Disparity



Homes for Monitoring (2)
Based on Ranking Disparity

Homes with Widest Rank Disparity between Crude & Adjusted Rates, in RATES



A concordance measure on Residuals

		Truth	
		Died	**Alive**
PREDICTED	**Died**	True Positive	False Positive
	Alive	False Negative	True Negative

- Predicted probability continuous [0,1]
- Cut-point of 0.5 can create bias (unbalanced data)
- Possible solutions
  - Average of Pearson's Residual
    - $R_c = \frac{\sum_i^{n_c} \frac{y_i - p_i}{\sqrt{p_i(1-p_i)}}}{n_c}$
  - Average of Deviance Residual
    - $R_c = \frac{\sum_i^{n_c} \sqrt{\left[y_i * log\left(\frac{y_i}{p_i}\right) + (n_i - y_i) * log\left(\frac{n_i - y_i}{n_i + p_i}\right)\right]}}{n_c}$

$n_c = number\ of\ patient\ in\ home\ c$
$y_i = i^{th}\ resident\ 1: died; 0: alive$
$p_i = prediction\ [0,1]$

- *Positive Residuals => False Negative*
- Ranking homes : sort R_c high to low

Other concordance measure

- Kendall's Tau
  - based on the ranking
  - robust
- Cohen's Kappa
  - Evaluates the agreement over and above the chance.
  - Needs a threshold value (default=0.5)

Both are commutative:

- *kendall(y,p) = kendall(1-y,1-p) ; cohen(p,y) = cohen(1-y,1-p)*
- Cannot differentiate between False Negatives and False positives

Comparison of ranks* … top 20

Facility Name	Rank on Deviance	Adjusted Rate Rank
LTCH 72	1	1
LTCH 71	2	9
LTCH 76	3	5
LTCH 90	4	26
LTCH 91	5	23
LTCH 73	6	2
LTCH 70	7	10
LTCH 92	8	16
LTCH 75	9	4
LTCH 80	10	11
LTCH 93	11	24
LTCH 94	12	19
LTCH 95	13	17
LTCH 96	14	20
LTCH 78	15	7
LTCH 66	16	28
LTCH 97	17	96
LTCH 98	18	22
LTCH 77	19	6
LTCH 79	20	8

* - Logistic regression model.

Machine Learning

Random Forest , Decision Tree and Gradient Boosting

Random Forest

Data Preparation – Random Forest

1. Read in the big list of data (593 variables)
2. Using this file as basis, removed all dates, and any variable which isn't numeric
3. Dropped any irrelevant variables (ex: Disposition, Facility type, flags)
4. Dropped all columns that have any missing values. At this point, 269 variables remain.
5. Converted some of the variables to categorical features (many binary columns)
   - Total of 625 features
   - All of the variables in the statistical analysis are included
   - Features are scaled to zero mean and unit variance before continuing
   - Death as reported in CCRS and other care settings as target.

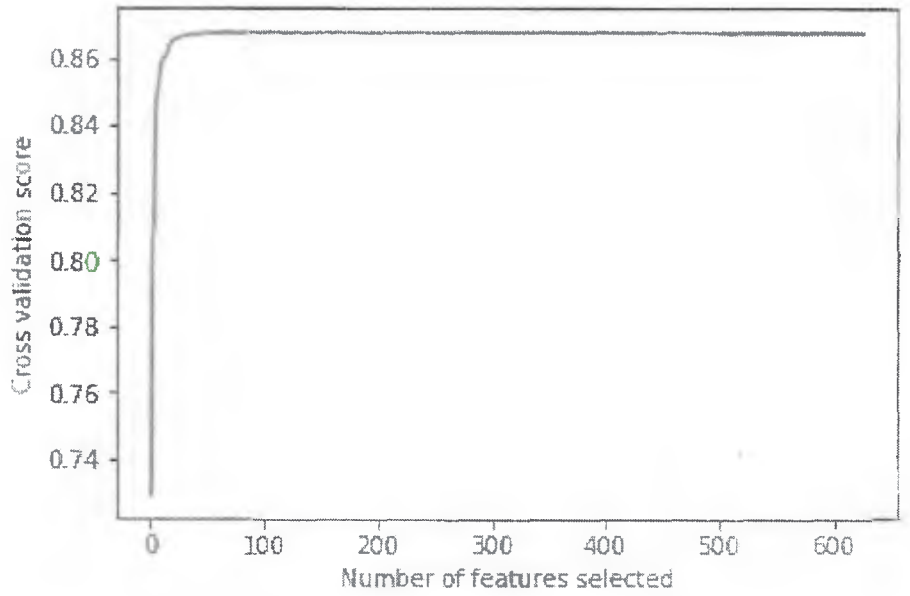
Random Forest

- An ensemble learning method that uses many decision trees
- Used for both feature elimination and final modelling
- Has a feature importance attribute
- Parameters used (from grid search):
  - 50 estimators
  - Max feature that is 75% of the total number of features
  - Max depth of 10
  - Minimum sample at a leaf node of 75
  - Minimum of 10 samples to split an internal node

Recursive Feature Elimination

- Select features by recursively considering smaller and smaller sets of features
- Algorithm:
  1. Train on the whole feature set for 4 stratified k-folds
  2. Obtain the average of those 4 scores obtained (C statistic), store this number
  3. Remove the feature that is deemed least important
  4. Train on this reduced set
  5. Repeat steps 2-4 until there are no features left

Recursive Feature Elimination - Results



- After taking approximately the first 50 most important features, adding any more features does not increase the performance of the model

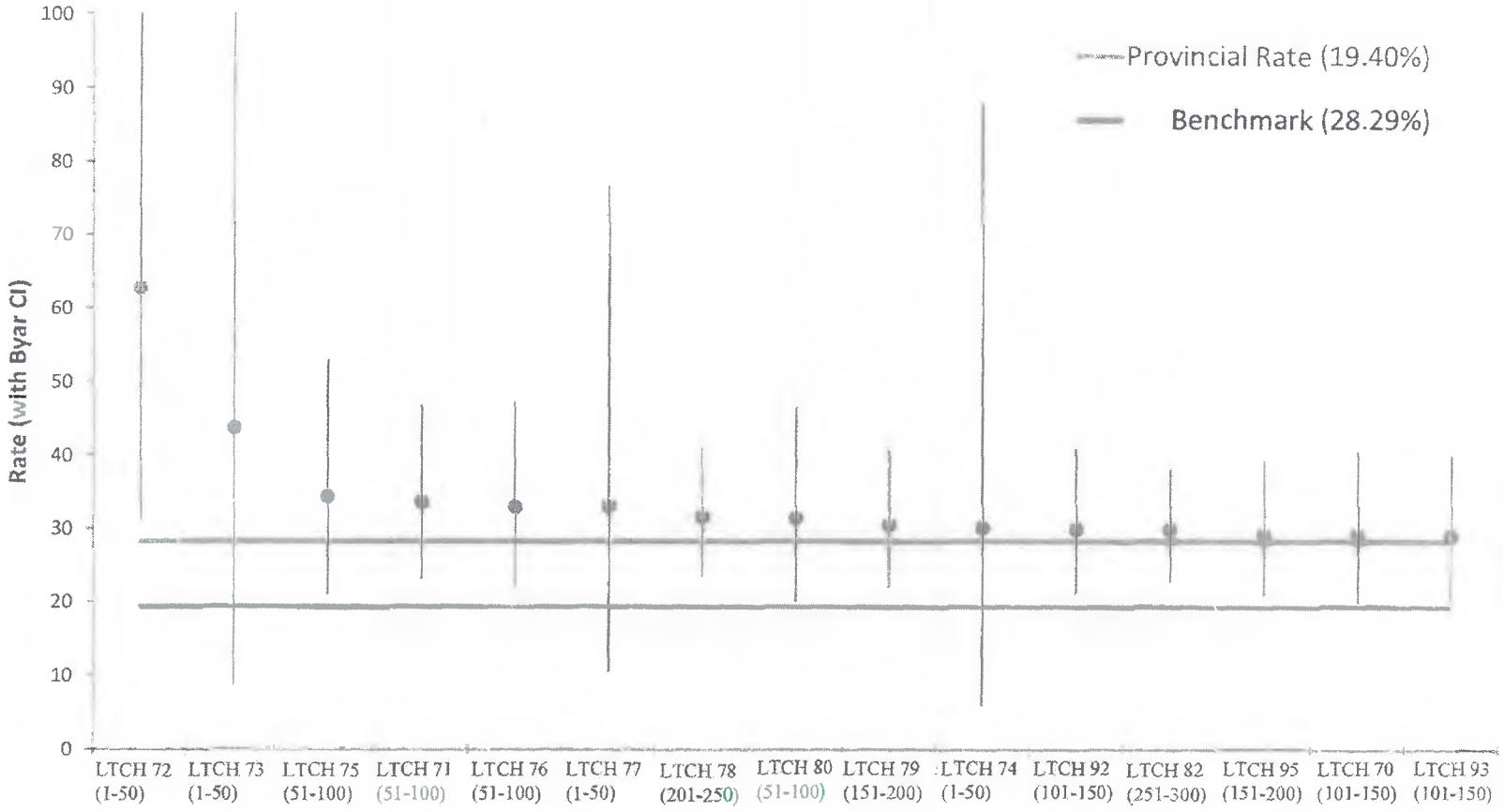
Recursive Feature Elimination - Features

- 65 features selected in total (C-statistic 0.867)*
- 15 most important features:

Feature Importance	Feature
0.330717	J5C_End_Stage_Disease
0.153854	Previous ER visit within 30 days_sum score
0.098553	Previous ER visit _Index_4
0.090195	PSI (Personal Severity Index)
0.055547	Days_since_last assessment
0.035042	Leaves_food_uneaten
0.018788	Convalescent bed
0.017751	ADL_Short_Form
0.015717	Age_at_FYstart_date
0.015449	P1AG_Oxygen_Therapy
0.013316	Previous ER visit _SumScale
0.011231	ADL_Long_Form
0.010827	K2B_Weight
0.009871	Previous AIP admission _Index_4
0.009809	Q2_Change_In_Care_Needs

* For a complete list, see Appendix C

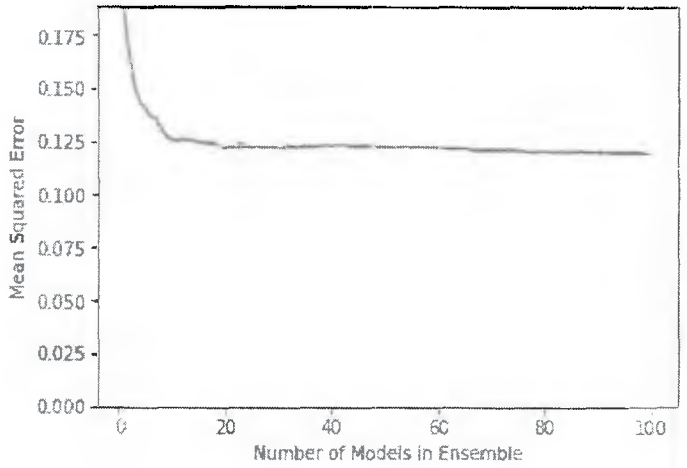
Homes for Monitoring – Random Forest



Decision Tree

General approach – Decision Tree algorithm

- Starting with a dataset of 258 relevant variables
- Tree model was utilized using following parameters:
  - Number of trees models : 100
  - Build cumulative prediction
  - Number of variables of importance: 19
  - Maximum tree depth: 5



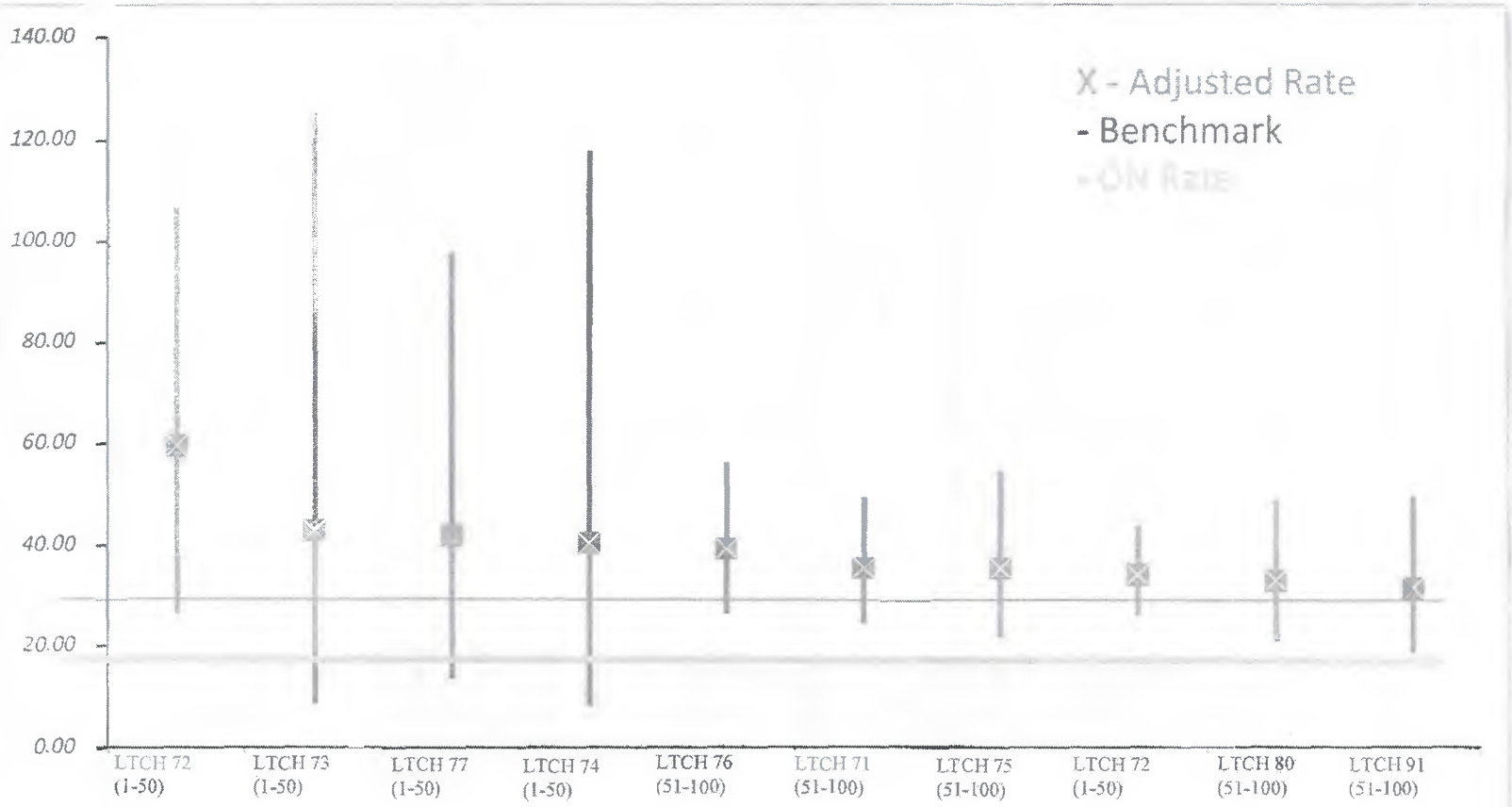
List of selected features

- C-statistic 0.856
- 19 most important features:

Feature Importance	Feature
0.402521506	J5C_END_STAGE_DISEASE
0.259906589	prevER30
0.114645997	PSI (Personal Severity Index)
0.059516717	disch_bedtype
0.055406783	CHESS
0.042782576	Days_since_lastassess
0.023059122	prevAIP30
0.010381948	ADL_hierarchy
0.00792764	PrevAIP30_sum
0.006371226	Leaves_food_uneaten
0.005562775	P1AG_OXYGEN_THERAPY
0.002980782	Years_in_LTC
0.0026611	PrevER_Index
0.001756746	Q2_CHANGE_IN_CARE_NEEDS
0.001359297	age_at_fystart
0.001245765	O4C_DAYS_ANTIDEPRESSANTS
0.000955315	ADL_Short_Form_cc
0.000712054	ISE_cc (Index of Social Engagement)
0.000246062	P8_DAYS_DOCTOR_ORDERS_CHANGED

Homes for Monitoring – Decision Tree

Top 10 Homes (with Lower/Upper Bounds of Confidence Limits) with the Highest Adjusted Rate, FY2015/16



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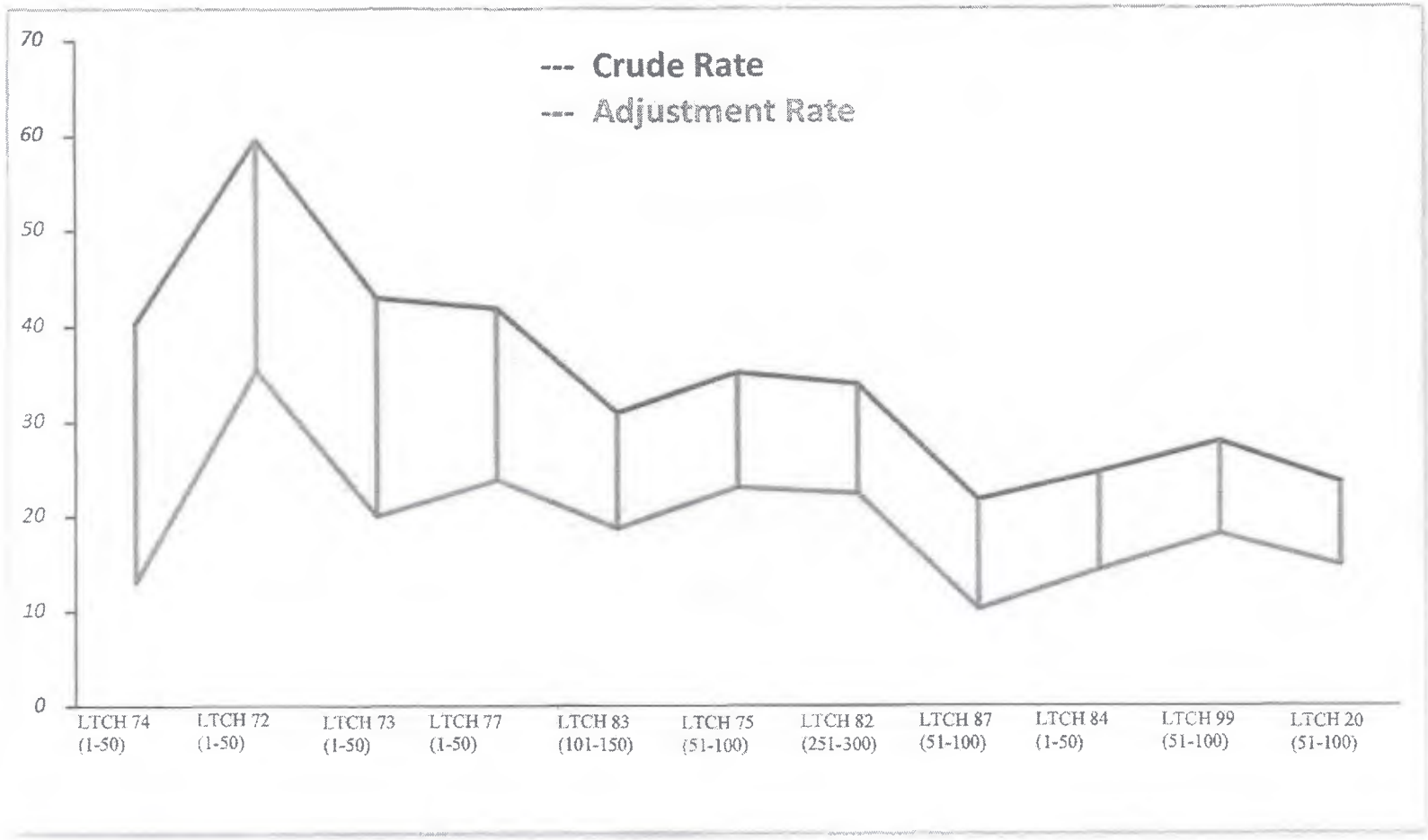
Homes for Monitoring –Decision Tree

Homes with Widest Rank Disparity between Crude and Adjusted Rates, FY2015/16



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eXtreme Gradient Boosting (XGBoost)

General approach – Gradient Boosting algorithm

- Difference from Random Forest- build one tree at a time to correct error of the previous tree. Random Forest builds each tree independently

- **XGBoost python package**
  - Use regularization to reduce over-fitting
  - Support parallel processing
  - Cross-validation built-in

- Combine features from Standard approach and Decision Tree (37 variables)

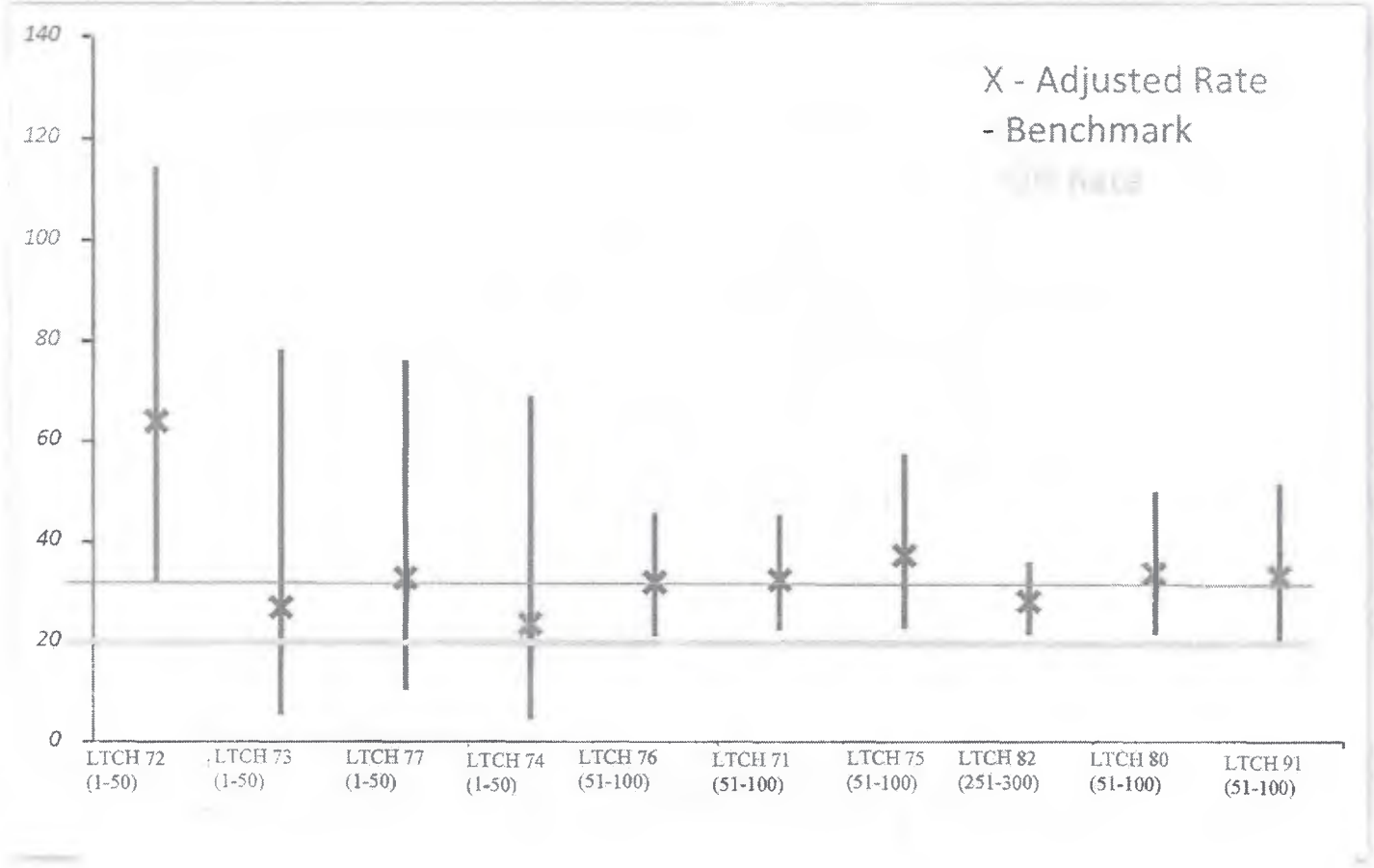
List of selected features

- C-statistic 0.899

Feature Importance	Feature
0.149621	Days_since_lastassess
0.10912	Years_in_LTC
0.103293	Years_since_1stAdm
0.0782343	age_at_fystart
0.0490967	PSI
0.0474942	PrevER_Index
0.0407925	P8_DAYS_DOCTOR_ORDERS_CHANGED
0.037296	depression_scale
0.036859	ADL_Short_Form_cc
0.0285548	ISE_cc
0.0269522	CP_scale
0.0218531	disch_bedtype2
0.020542	ADL_hierarchy
0.0202506	Pain_scale
0.0155886	Leaves_food_uneaten
0.0150058	P1AG_OXYGEN_THERAPY
0.0145688	O4C_DAYS_ANTIDEPRESSANTS
0.0144231	J5C_END_STAGE_DISEASE
0.013549	Q2_CHANGE_IN_CARE_NEEDS

Homes for Monitoring – XGBoost

- Top 10 Homes (with Lower/Upper Bounds of Confidence Limits)
  - with the Highest Adjusted Rate, FY2015/16



Machine Learning: Decision Tree vs. Random Forest

	Pros	Cons
Decision Tree	• Easy to interpret and implement • Easy to generate rules • Reduce modeling complexity • Simple decision boundaries • No distributional assumptions	• Hard to handle complicated relationships • Greedy approach, chances of getting stuck into local optima vis-à-vis sub-optimal tree • Does not handle continuous variable well with wider range and numerous distinct values • May suffer from over-fitting
Random Forest	• Better at addressing over-fitting • No distributional assumptions • Sub-optimality due to greedy approach is reduced by the ensemble approach.	• Ensemble method many tree using sampling, computation intensive • Sensitive to tuning parameters • Decision rules can get pretty complex
eXtreme Gradient Boosting (XGBoost)	• Use regularization for over-fitting • Parallel processing • Built-in cross-validation • Remove tree when there is no gain	• Sensitive to outliers • Complex and hard to explain • Hard to tune parameters

Result Validation

Variable Comparisons Across Approaches

	Statistical Approach	Random Forest	Decision Tree	XGBoost
Var # Start/End	27 /27	269 / 60 (or 65 features)	258/19	
Facility Nature	Bed type	Beds Bed type (Convalescent bed)	Bed type	Bed type
Study design	Years_since_1stAdm; Days_since_last assessment	Years_in_LTC Days_since_last assessment Days_since_1stAdm	Years_in_LTC Days_since_last assessment	Years_in_LTC Days_since_last assessment
Demographic	Sex; Age_at_FYstart	Sex; Age_at_FYstart	Age_at_FYstart	Age_at_Fystart
Medical cond.	CHF;Cancer;Renal failure;Dementia	CHF		CHF; Cancer; Renal failure; Dementia
ADL	ADL_hierarchy	ADL_Hierarchy; ADL_RUGIII ADL_Short_Form; ADL_Long_Form G1Da_Walk_In_Corridor_Self G1Db_Walk_In_Corridor_Support G1Ea_Locomot_On_Unit_Self G1Fa_Locomot_Off_Unit_Self G1Ha_Eating_Self ADL_CAP2_cc	ADL_hierarchy ADL_Short_Form_cc	ADL_hierarchy
Previous AIP admission (30, 90, 365 days)	prevAIP30	PrevAIP_Index_4 PrevAIP_SumScale prevAIP30 PrevAIP30_sum	PrevAIP30 PrevAIP30_sum	prevAIP30 PrevAIP30_sum
Previous ER visit (30, 90, 365 days)	PrevER_Index	PrevER_Index (3,4) PrevER_SumScale PrevER30_sum	PrevER30 PrevER_index	PrevER_Index PrevER_index
Deteriorated condition	ADL_decline (G9) Cognition_decline (B6)	G9_Change_ADL_Function Q2_Change_In_Care_Needs P8_Days_Doctor_Orders_Changed	Q2_Change_In_Care_Needs	ADL_decline (G9) Cognition_decline (B6)
End of Stage	CHESS EndStage_6mo_tolive	CHESS J5C_End_Stage_Disease	CHESS J5C_End_Stage_Disease	CHESS EndStage_6mo_tolive
Acuity Level	Pain_scale PSI	J2A_Pain_Symptons_Freq PSI	PSI	Pain_scale PSI
Other outcome scale	Cognitive performance (CPS)	Index of Social Engagement (ISE) Cognitive performance (CPS)	Index of Social Engagement (ISE)	Cognitive performance (CPS)

Variable Comparisons (Continued)

	Statistical Approach	Random Forest	Decision Tree	XGboost
RAI assessment	Leaves_food_uneaten	Leaves_food_uneaten	Leaves_food_uneaten	Leaves_food_uneaten
	Shortness_of_breath			Shortness_of_breath
	Weight_loss	K3A_Weight_Loss		Weight_loss
	Vomiting			Vomiting
	Delusions			Delusions
	Depression_scale			Depression_scale
	Edema			Edema
	Dehydrated	Dehydration_CAP2_cc		Dehydrated

Variables used in Random Forest or Decision Tree or XGBoost

Random Forest

Ulcer related
M2a_stage_of_pressure_ulcer
M5E_Ulcer_Care

Test for Balance
G3A_Balance_While_Standing
G3B_Balance_While_Sitting
G4Da_Leg_Range_Of_Motion

Oral/Nutrition Status
K1A_Chewing_Problem
K1B_Swallowing_Problem
K2A_Height; K2B_Weight
K5F_Dietary_Supplement

Skin Problem/Treatment
M4F_Skin_Tears_Or_Cuts
M5D_Nutrition_Intervention
M5G_Apply_Dressings_Not_Feet

Medication
O1_Num_Of_Medications
O4C_Days_Antidepressants
O4E_Days_Diuretic

Special treatment
P1Ag_Oxygen_Therapy
P1Bca_Days_Physical_Therapy
P1Bcb_Mins_Physical_Therapy

Other
G6A_Bedfast
N1B_Time_Awake_Afternoon
N1C_Time_Awake_Evening
Activities_CAP2_cc

Decision Tree

Special treatment
P1AG_Oxygen_Therapy

Other
Days received antidepressant (O4C_Days_Antidepressants)
Days physician changed order (P8_Days_doctor_orders_changed)

XGBoost

Oral/Nutrition Status
Weight Loss

Medication
O4C_Days_Antidepressants

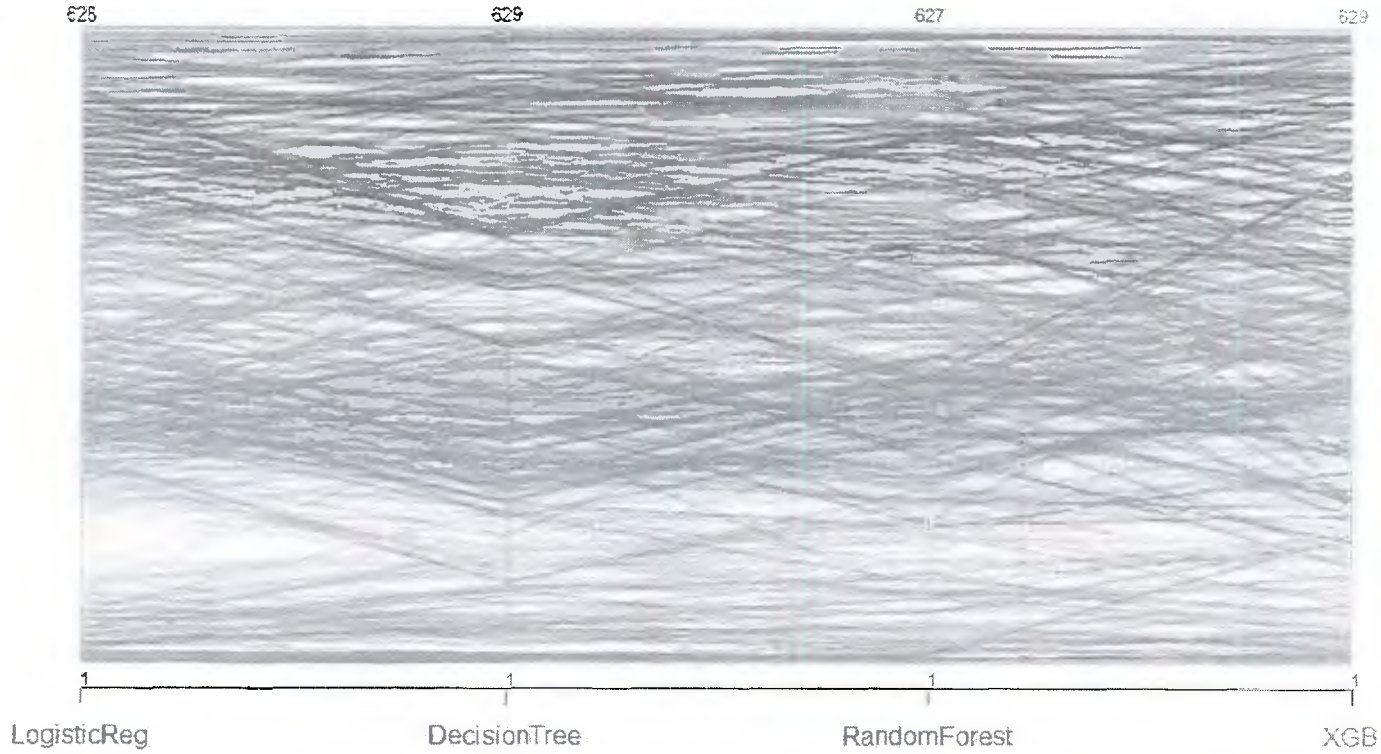
Special treatment
P1Ag_Oxygen_Therapy

Special treatment
P1AG_Oxygen_Therapy

Other
Days received antidepressant (O4C_Days_Antidepressants)
Days physician changed order (P8_Days_doctor_orders_changed)

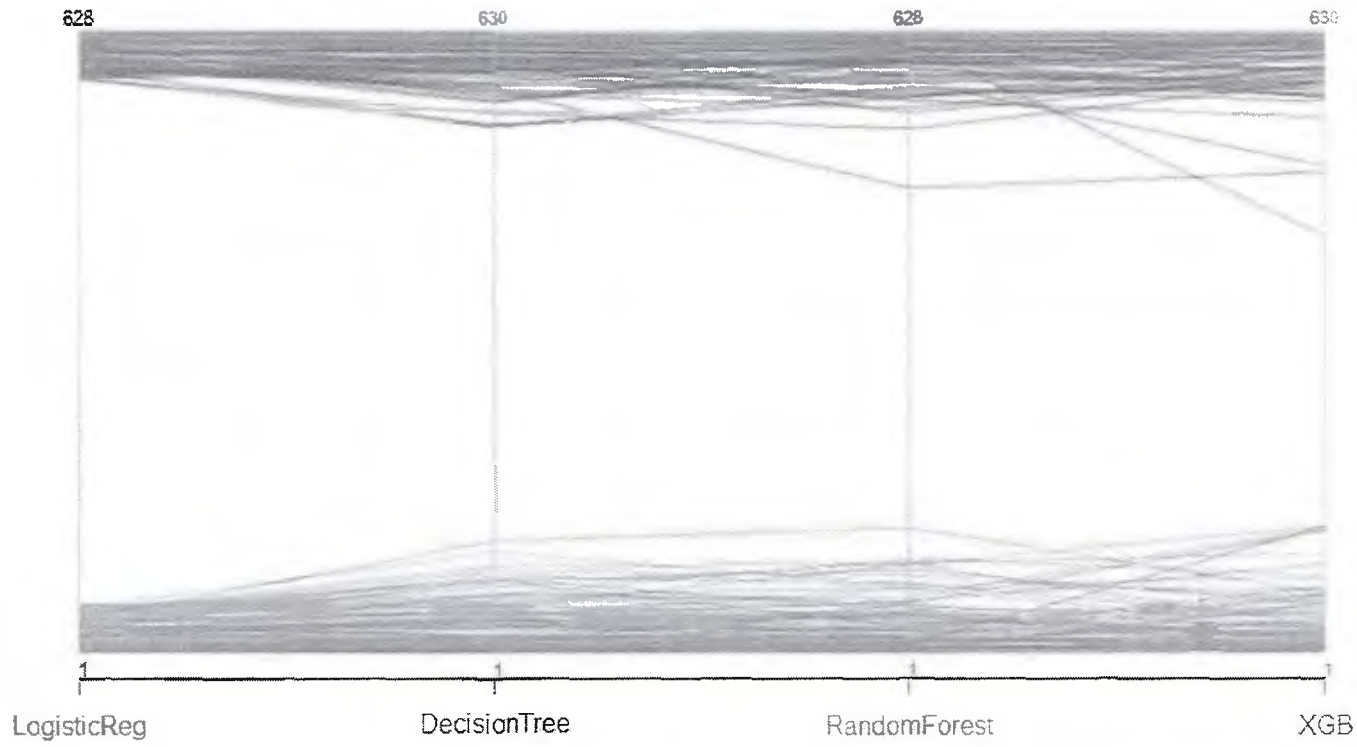
Compare Lists of Homes Across Approaches

Ranking by Approaches for A Random Selection of 300 Homes, FY2015/16



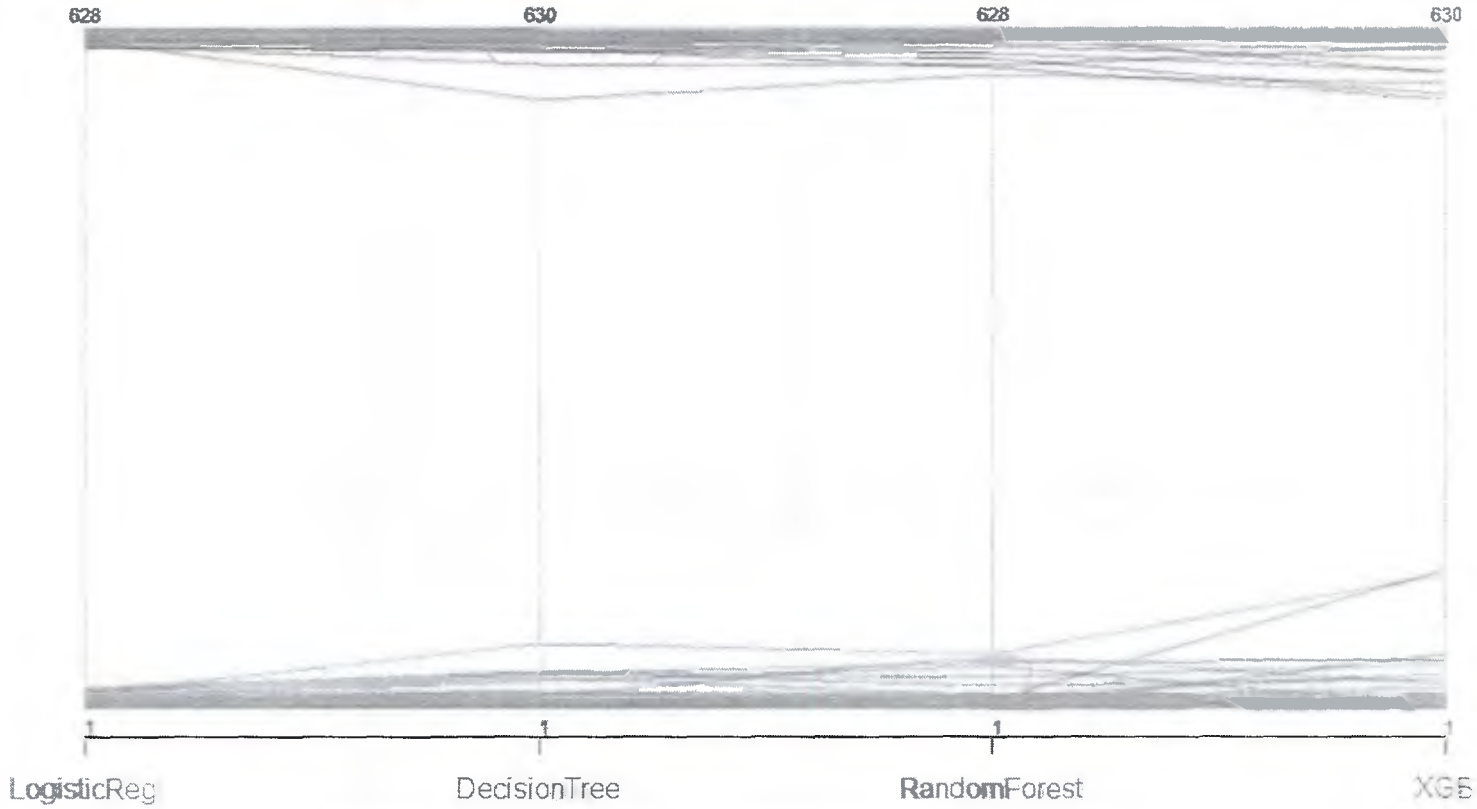
Compare Lists of Homes Across Approaches

Ranking by Approaches For Top 50 & Bottom 50 Homes, FY2015/16



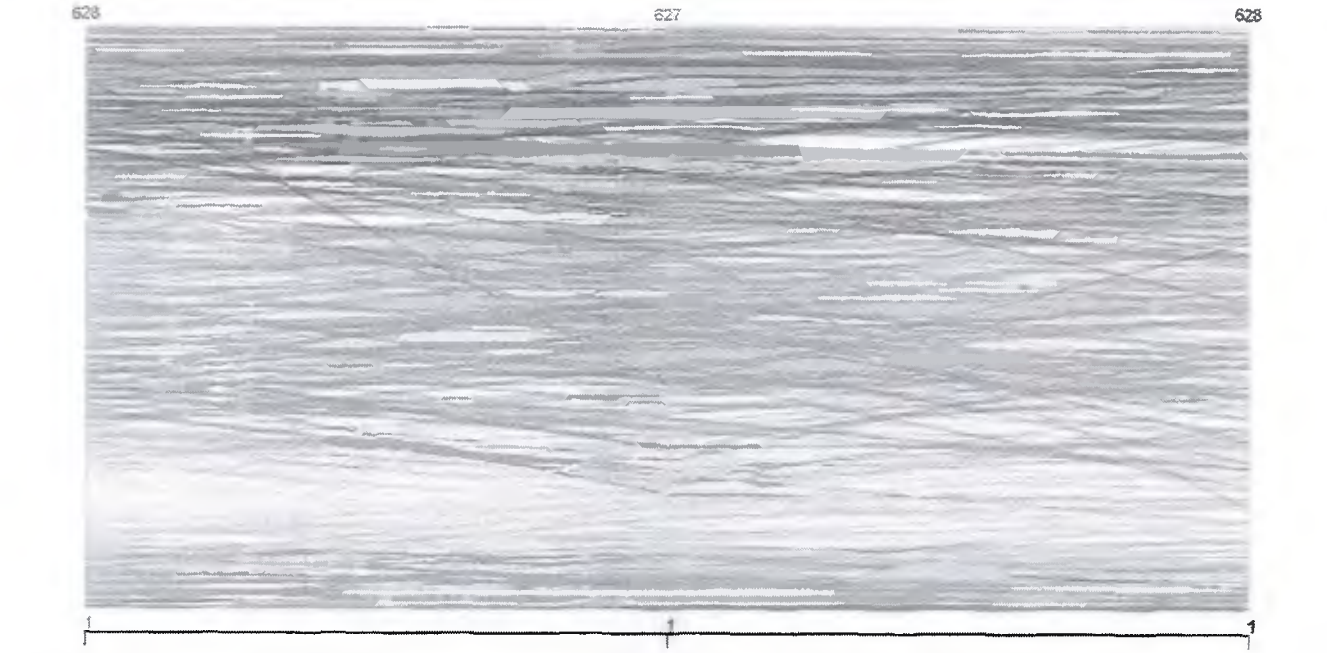
Compare Lists of Homes Across Approaches

Ranking by Approaches For Top 20 & Bottom 20 Homes, FY2015/16



For the list of Top 20 Homes, see Appendix A

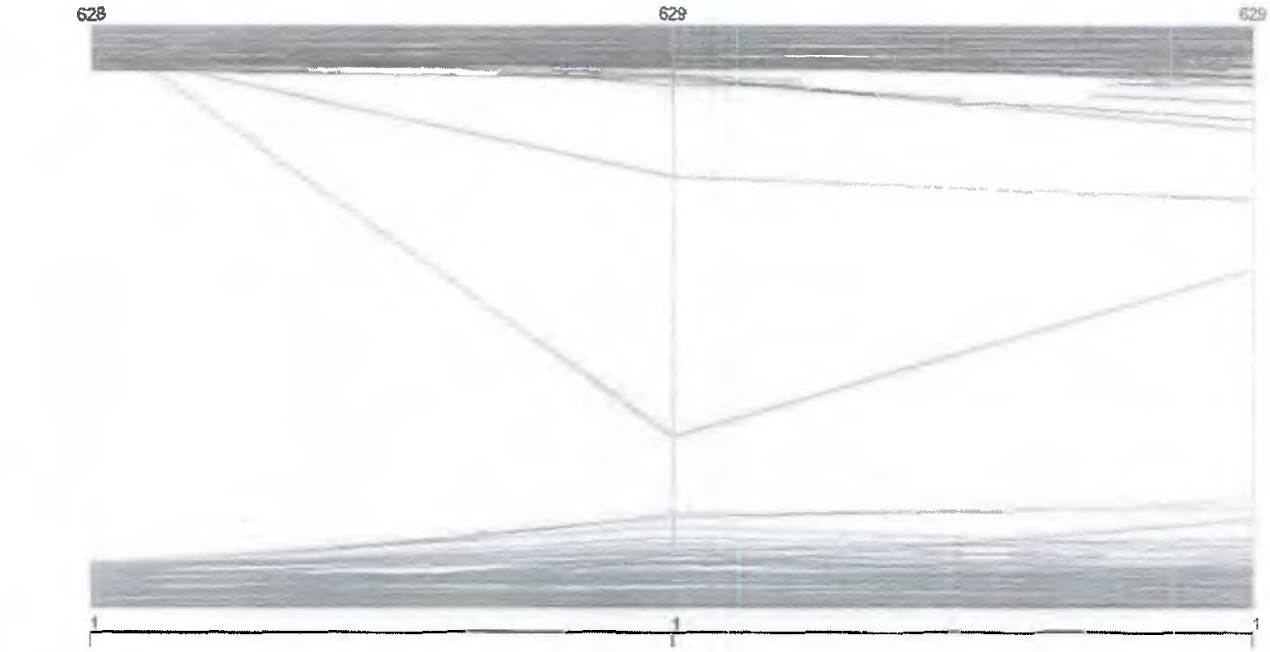
Sensitivity of Concordance measures*



300 odd ranked LTC homes

* - Logistic regression.

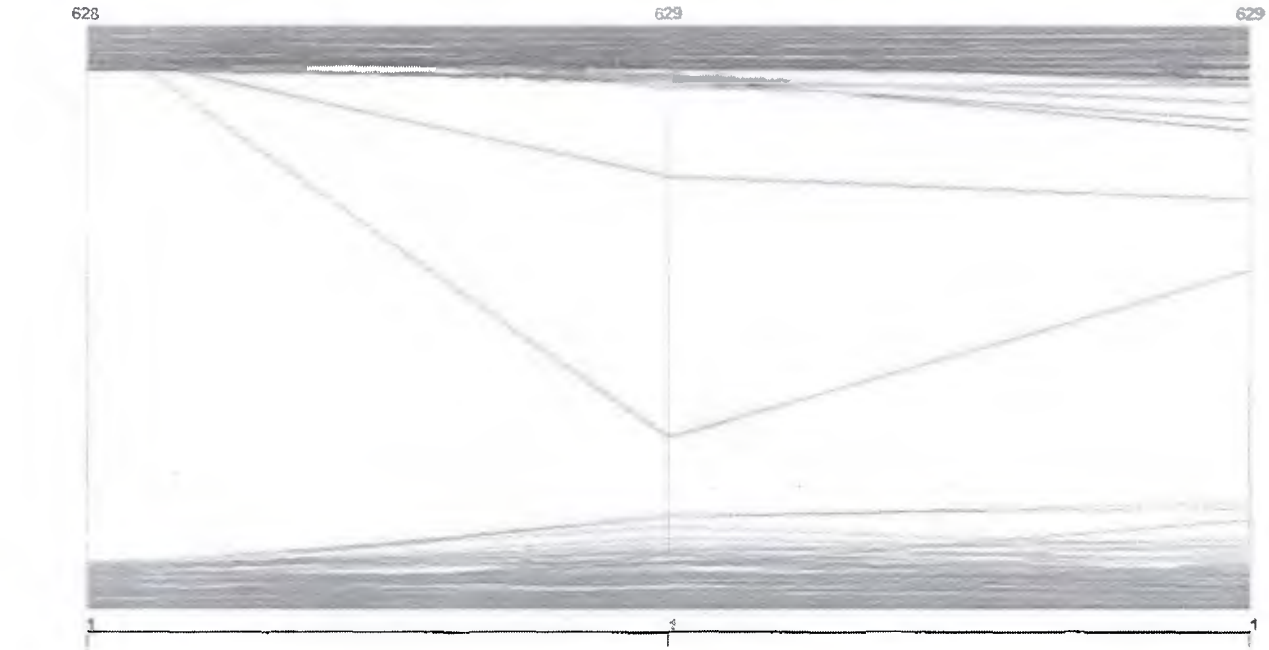
Sensitivity of Concordance measures*



Top and bottom 50 LTC homes

* - Logistic regression

Sensitivity of Concordance measures*



Top and bottom 20 LTC homes

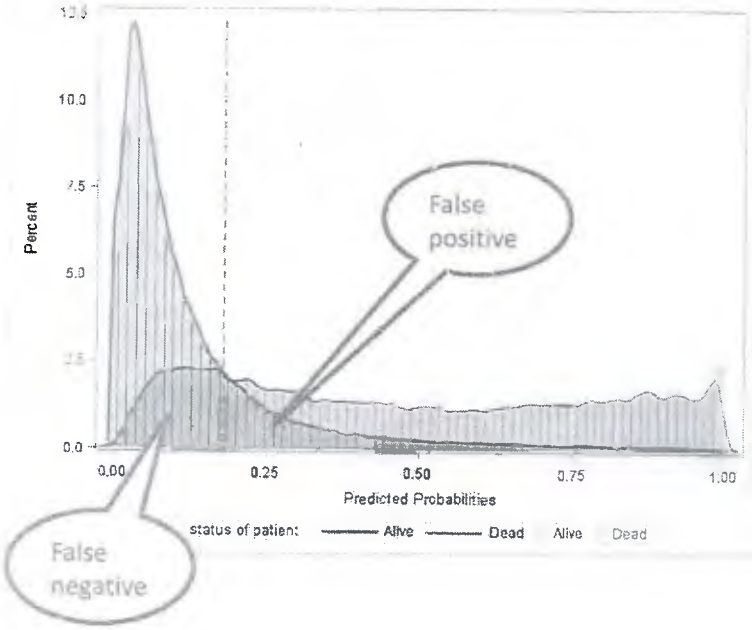
* - Logistic regression

Data imbalance and decision Sensitivity

Equally weighted

Dead : 1 Alive : 0

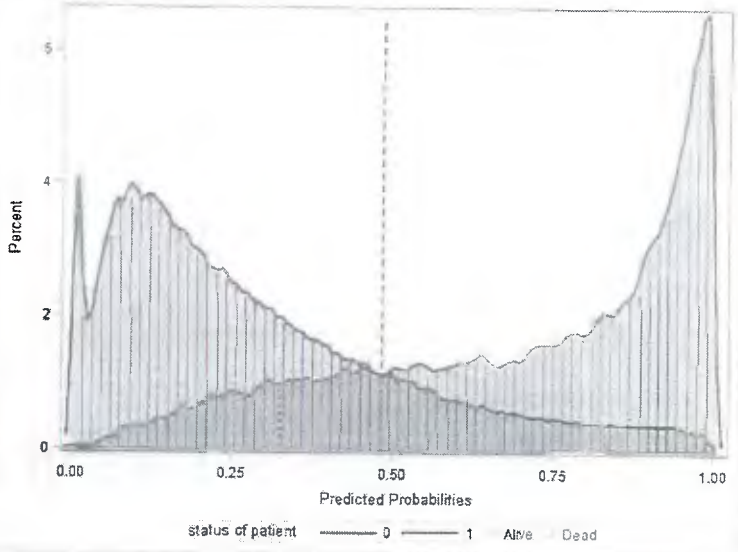
50% 50%



weights inversely prop. to class freq.

Dead :1 Alive : 0

80% 20%



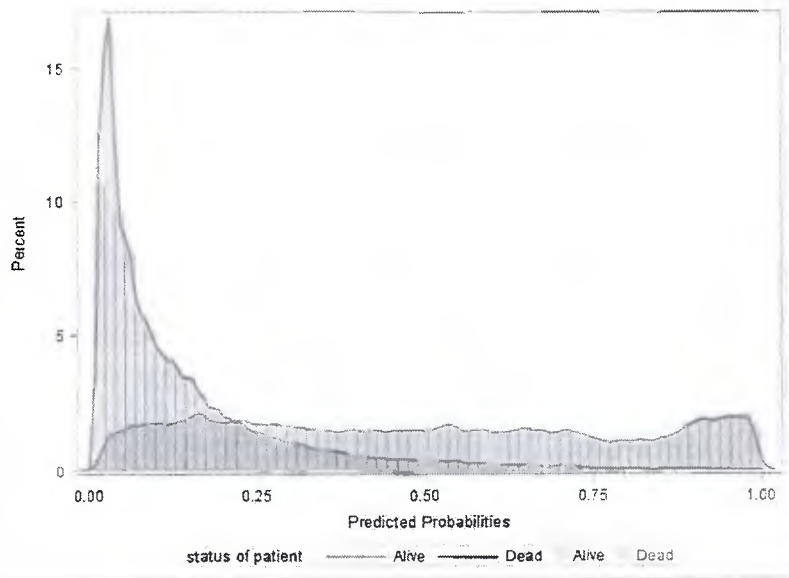
** Logistic model

Data imbalance and decision Sensitivity

Equally weighted

Dead : 1 Alive : 0

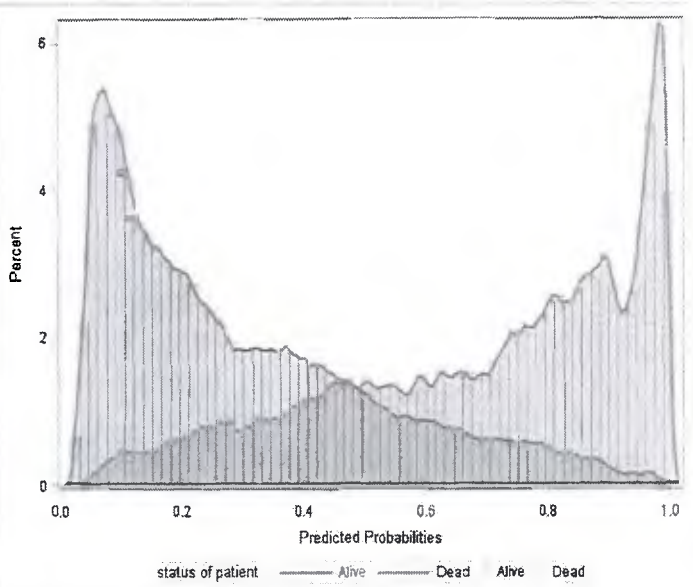
50% 50%



weights inversely prop. to class freq.

Dead : 1 Alive : 0

80% 20%



** Random Forest

Summary

- All approaches of modeling had a similar set of risk factors or predictors
- All approaches identified a similar set of homes with excessive rate of mortality
- We can use results from ML approaches as validation – homes identified across all approaches as having top ranked risk adjusted rate should be flagged for auditing or inspection to identify reasons for excess mortality over expected rate.

Summary: Statistical Modeling vs. Machine Learning

	Pros	Cons
Statistical (Logistic)	• Logistic modelling technique fairly reliable • Well developed and established methodology • Efficient and fast • Emphasis on inference	• Collinearity can be an issue • Cannot handle non-linear relationship • Restricted to literature and experts for variable selection
Machine Learning	• Multi-collinearity is not an issue due to underlying trees approach • Faster algorithms in handling large datasets • Flexible in building linear and/or non-linear relationship • No distributional assumptions • Emphasis on prediction and predictive accuracy of models	• Pretty much black box approach • Interpretation of the model is difficult • Possibility of suboptimal solution • Tuning parameters can add extra complexity in model building

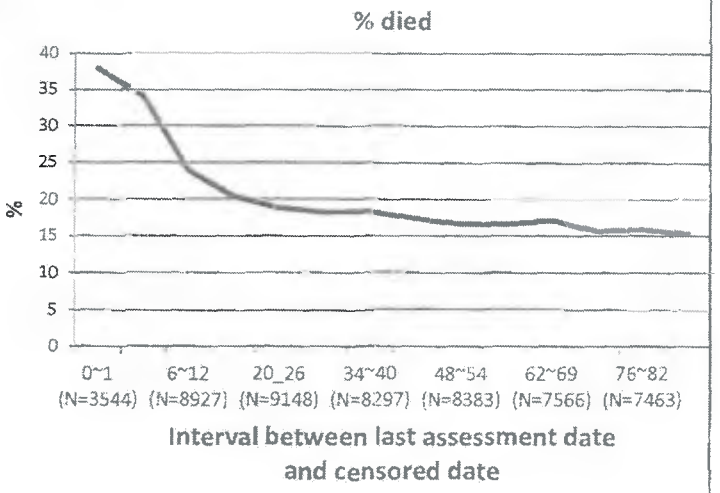
Limitations and Next Steps

Limitations and Challenges (1)

- **Risk adjustment models can and can't do**:
  - Can remove impact of patient acuity due to medical, functional or behavioral status on a home's death rate
  - Cannot isolate death due to intentional killing from death due to poor quality of care provided by LTC home.
- Most homes are small, and confidence interval for adjusted rate or expected deaths are wide; if we **consider confidence interval aside from point estimate**, we'd
  - flag no home, if against Benchmark, and
  - flag homes that may not have the most excessive rates or miss out high-risk homes due to their wide CIs, if against provincial rate
- Small homes rate not stable, so it is difficult to reliably signal small homes, even if we use two years of data

Limitations and Challenges (2)
Which Assessment To Choose for Risk Adjustment

- **Risk factors based on the latest assessment** may reflect the status of dying
  - Sicker patients are assessed more frequently to the extent of within days of death
  - **Current adjustment (A)**: control for days since the last assessment (i.e. interval between last assessment and censored date)



Next Steps

- Model on a 12-month or 24-month rolling period, as soon as new quarterly data becomes available.
- Expand to include adverse events as part of LTC quality of care surveillance, including hospital admissions and ER visits of for fractures, pressure ulcers, pneumonia, and urinary tract infections

Appendices

Appendix A. 20 Top Ranked Homes From Three Approaches Each

LTC_home	Active Clients	Obs deaths	Crude rate	Ranking				Logistic			Random Forest			Decision Tree			XGBoost		
				Log-istic	RF	DT	XGB	Exp'd death	O/E ratio	Adj rate	Exp'd death	O/E ratio	Adj rate	Exp'd death	O/E ratio	Adj rate	Exp'd death	O/E ratio	Adj rate
LCTH 72 (1-50)			35.5	1	1	1	1	3.3	3.32	64.4	3.4	3.24	62.7	3.6	3.07	59.6	3.4	3.24	63.9
LCTH 73 (1-50)			20.0	2	2	2	51	1.1	2.65	51.3	1.3	2.26	43.7	1.4	2.21	42.9	2.2	1.36	26.8
LCTH 74 (1-50)			13.0	3	10	4	130	1.3	2.26	43.8	1.9	1.55	30.1	1.4	2.08	40.3	2.5	1.20	23.6
LCTH 75 (51-100)			23.0	4	3	7	2	10.2	1.97	38.2	11.3	1.77	34.4	11.0	1.81	35.1	10.7	1.87	37.2
LCTH 76 (51-100)			32.2	5	5	5	13	15.7	1.85	35.8	17.1	1.70	33.0	14.4	2.02	39.2	18.1	1.60	31.8
LCTH 77 (1-50)			23.8	6	6	3	9	2.8	1.79	34.8	2.9	1.70	33.0	2.3	2.16	41.8	3.0	1.67	32.7
LCTH 78 (201-250)			24.0	7	7	11	4	28.3	1.77	34.3	30.8	1.62	31.5	31.2	1.60	31.1	28.5	1.75	34.9
LCTH 79 (151-200)			24.0	8	9	14	3	24.3	1.73	33.5	26.8	1.57	30.4	26.5	1.59	30.8	23.6	1.78	35.3
LCTH 71 (51-100)			34.0	9	4	6	11	19.8	1.72	33.4	19.7	1.73	33.5	18.7	1.82	35.3	20.9	1.63	32.3
LCTH 70 (101-150)			29.0	10	14	17	10	19.3	1.71	33.2	22.1	1.50	29.0	21.2	1.56	30.2	20.1	1.64	32.6
LCTH 80 (51-100)			26.7	11	8	9	6	14.1	1.7	33.1	14.8	1.62	31.4	14.3	1.68	32.7	14.2	1.69	33.6
LCTH 81 (51-100)			20.5	12	40	27	5	10.4	1.63	31.7	12.5	1.36	26.5	11.3	1.50	29.1	9.8	1.73	34.4
LCTH 82 (251-300)			22.3	13	12	8	34	38.3	1.59	30.9	39.7	1.54	29.8	34.9	1.75	33.9	43.9	1.39	28.0
LCTH 83 (101-150)			18.6	14	49	13	24	13.9	1.59	30.8	16.6	1.33	25.7	13.8	1.59	30.9	15.6	1.41	29.3
LCTH 43 (51-100)			22.6	15	51	62	125	13.4	1.57	30.4	15.9	1.32	25.6	15.4	1.37	26.5	16.7	1.26	23.7
LCTH 92 (1-50)			29.7	16	11	15	20	24.4	1.56	30.2	24.7	1.54	29.9	24.0	1.58	30.7	25.2	1.51	30.0
LCTH 95 (151-200)			26.9	17	13	31	15	27.2	1.54	30.0	28.0	1.50	29.1	28.5	1.48	28.6	26.5	1.58	31.5
LCTH 100 (101-150)			23.1	18	44	33	46	20.1	1.54	29.9	23.1	1.34	26.0	21.1	1.47	28.4	23.6	1.31	27.0
LCTH 94 (51-100)			27.4	19	22	36	28	16.9	1.54	29.9	17.8	1.46	28.4	17.9	1.45	28.2	18.0	1.44	28.6
LCTH 96 (51-100)			27.3	20	30	35	41	17.6	1.54	29.8	19.0	1.42	27.5	18.6	1.45	28.2	19.7	1.37	27.3

Appendix B. Percent of Death, By Assessment Response

% Died by Responding Status

	No	Yes
ADL decline	15.6	40.5
Cognition decline	17.4	48.0
Shortness of breath	17.8	40.8
Leave food uneaten	12.6	32.3
Dehydrated	19.2	77.2
Weight loss	17.3	43.6
Vomiting	19.5	35.8
Clostridium Difficile	19.9	35.8
Fell in past 30 days	19.1	24.0
Delusions	20.0	19.3
Dementia	17.8	20.9
CHF	18.6	28.0
Cancer	18.9	26.8
Renal failure	18.9	26.7
Edema	19.0	25.5
AIP admission in previous 30 day	17.2	61.0
EndStage_6mo_tolive	16.1	73.6
J5A_condition_lead to instable	17.0	24.0
J5B_experiencing_acute_episode	18.0	34.2
P1Ag_Oxygen_Therapy	16.9	50.1

% Died, by assessment responses

PSI	0	3	5	7	9	11	13	14+
	4.5	12.0	20.7	28.2	45.8	74.7	88.9	95.0
ADL Hierarchy Scale	0	1	2	3	4	5	6	
	5.8	5.7	7.8	10.6	20.9	28.6	41.8	
Cognitive Performance Scale	0	1	2	3	4	5	6	
	10.9	14.8	14.8	18.4	23.4	24.1	38.9	
Depression scale	0	1	2	3	5	6	7+	
	17.1	20.5	21.4	20.6	22.0	22.4	26.5	
CHESS	0	1	2	3	4	5		
	9.1	15.9	28.7	49.4	73.5	91.6		
Prior ER visit index	0	1	2	3	4			
	13.6	14.1	18.9	26.6	56.8			
Pain scale	0	1	2	3				
	17.2	23.0	28.4	42.2				
B4_cognitive_skills	0	1	2	3				
	11.4	14.9	19.4	31.0				
C6_understands_others	0	1	2	3				
	14.3	19.3	26.1	32.8				
B5e_periods_of_lethargy	0	1	2					
	15.6	29.6	65.2					
E1c_repetitive_verbalizations	0	1	2					
	18.6	22.8	24.5					
E1g_recurrent_statements	0	1	2					
	19.3	26.3	26.8					
Q2_change_in_care_needs	0	1	2					
	16.0	7.7	43.8					
H1a_bowel_continence_self	0	1	2	3	4			
	10.1	16.6	18.0	22.1	30.7			
M2a_stage_of_pressure_ulcer	0	1	2	3	4			
	17.3	32.8	41.4	44.7	50.7			
M2b_stage_of_stasis_ulcer	0	1	2	3	4			
	19.7	29.1	30.6	33.9	48.4			
P8_Days_doctor_orders_changed	0	1	2	3	4	5+		
	13.3	18.7	24.8	34.0	38.7	49.6		

Appendix C. – Random Forest Recursive Feature Elimination (65 features)

Importance	Feature	Importance	Feature
0.3307	J5C_END_STAGE_DISEASE	0.0018	M4F_SKIN_TEARS_OR_CUTS
0.1539	PrevER30_sum	0.0017	O4E_DAYS_DIURETIC
0.0986	PrevER_Index_4	0.0016	K1B_SWALLOWING_PROBLEM
0.0902	PSI	0.0016	Dehydration_CAP2_cc
0.0555	Days_since_lastassess	0.0015	O1_NUM_OF_MEDICATIONS
0.035	Leaves_food_uneaten	0.0015	G1HA_EATING_SELF
0.0188	Convalescent	0.0015	CHESS_4
0.0178	ADL_Short_Form	0.0015	N1B_TIME_AWAKE_AFTERNOON
0.0157	age_at_fystart	0.0014	PrevAIP_SumScale
0.0154	P1AG_OXYGEN_THERAPY	0.0014	G1DA_WALK_IN_CORRIDOR_SELF
0.0133	PrevER_SumScale	0.0014	M5G_APPLY_DRESSINGS_NOT_FEET
0.0112	ADL_Long_Form	0.0013	K5F_DIETARY_SUPPLEMENT
0.0108	K2B_WEIGHT	0.0012	G1FA_LOCOMOT_OFF_UNIT_SELF
0.0099	PrevAIP_Index_4	0.0012	G1EA_LOCOMOT_ON_UNIT_SELF
0.0098	Q2_CHANGE_IN_CARE_NEEDS	0.0011	O4C_DAYS_ANTIDEPRESSANTS
0.0085	CHESS_1	0.0011	CHESS_3
0.0083	PrevAIP30_sum	0.0009	J2A_PAIN_SYMPTONS_FREQ
0.0073	G9_CHANGE_ADL_FUNCTION	0.0009	CP_scale
0.0069	M2A_STAGE_OF_PRESSURE_ULCER	0.0008	P1BCA_DAYS_PHYSICAL_THERAPY
0.0067	prevAIP30	0.0007	G4DA_LEG_RANGE_OF_MOTION
0.0051	Years_in_LTC	0.0007	G1DB_WALK_IN_CORRIDOR_SUPPORT
0.0043	P8_DAYS_DOCTOR_ORDERS_CHANGED	0.0006	Activities_CAP2_cc
0.004	Days_since_1stAdm	0.0006	N1C_TIME_AWAKE_EVENING
0.004	Beds	0.0006	ADL_Hierarchy
0.0036	K2A_HEIGHT	0.0006	K1A_CHEWING_PROBLEM
0.0034	M5E_ULCER_CARE	0.0005	CHF
0.0034	K3A_WEIGHT_LOSS	0.0005	PrevER_Index_3
0.0032	ADL_RUGIII	0.0004	ADL_CAP2_cc
0.0029	ISE	0.0004	M5D_NUTRITION_INTERVENTION
0.0029	CHESS_2	0.0004	G3A_BALANCE_WHILE_STANDING
0.0028	P1BCB_MINS_PHYSICAL_THERAPY	0.0003	G6A_BEDFAST
0.0023	female	0.0001	CHESS_5
0.0019	G3B_BALANCE_WHILE_SITTING		

Appendix D. Data Challenges

Issues	Solutions
Death date in CCRS is not necessarily the actual death date	• Death is recorded under the disposition reason field and disposition date is simply the date the LTC home discharged the resident due to death, which may not be the actual date of death and home may not be the location of death • We fixed some of them
Multiple deaths	• A resident died in multiple occasions or multiple homes Death is not necessarily the last record in CCRS • We fixed them.
Not all LTC residents' death is recorded in CCRS	• **Varying by LTC home's** practice of their temporary discharges of residents to ER, hospitalization or other care setting "**A discharge record may also be completed when the discharge is temporary (that is, when the resident's return is anticipated).** It should be noted that any absences from the facility where the resident is not formally discharged (such as a **medical** or social leave of absence) are not recorded within CCRS." • We include death outside of home in our analysis
Residents assigned a new episode ID after return to the same home	• We treated them as same active clients
Missing discharge dates	• A person is already discharged to home B but it is still an open discharge date at home A. • We fixed.

This is Exhibit "G" referred to in the Affidavit of Dr. Michael Hillmer sworn August 29, 2018

Commissioner for Taking Affidavits (or as may be)

Jessica Taylor Kras, a Commissioner, etc.,
Province of Ontario,
while a Student-at-Law.
Expires May 30, 2020.

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Predicting Death in the Nursing Home: Development and Validation of the 6-Month Minimum Data Set Mortality Risk Index

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Background. Currently, 24% of all deaths nationally occur in nursing homes making this an important focus of care. However, many residents are not identified as dying and thus do not receive appropriate care in the last weeks and months of life. The aim of our study was to develop and validate a predictive model of 6-month mortality risk using functional, emotional, cognitive, and disease variables found in the Minimum Data Set.

Methods. This retrospective cohort study developed and validated a clinical prediction model using stepwise logistic regression analysis. Our study sample included all Missouri long-term-care residents (43,510) who had a full Minimum Data Set assessment transmitted to the Federal database in calendar year 1999. Death was confirmed by death certificate data.

Results. The validated predictive model with a c-statistic of .75 included the following predictors: a) demographics (age and male sex); b) diseases (cancer, congestive heart failure, renal failure, and dementia/Alzheimer's disease); c) clinical signs and symptoms (shortness of breath, deteriorating condition, weight loss, poor appetite, dehydration, increasing number of activities of daily living requiring assistance, and poor score on the cognitive performance scale); and d) adverse events (recent admission to the nursing home). A simple point system derived from the regression equation can be totaled to aid in predicting mortality.

Conclusions. A reasonably accurate, validated model has been produced, with clinical application through a scored point system, to assist clinicians, residents, and family members in defining good goals of care around end-of-life care.

TWENTY-FOUR percent of Americans die in nursing homes (1). Accordingly, dying in the nursing home has received an increasing amount of attention and scrutiny (2–4). Somewhat contradictory, the major focus of care in nursing homes has been restorative and rehabilitative to meet regulatory requirements and to generate greater reimbursement (4). Despite the number of deaths that occur in nursing homes, there is much research and clinical evidence to suggest that the care of residents at the end of their life is commonly unsatisfactory (5–7).

There are multiple potential benefits in recognizing nursing home residents at great risk of dying. This recognition should precipitate a thorough discussion of prognosis and goals of care. For those residents or family members choosing a palliative course, the focus of care might be on settling issues with family members and symptom management, perhaps foregoing surgical procedures or uncomfortable hospitalizations. For those choosing length of life as the highest priority, this serious prognosis recommends intensive investigation and attempted reversal of underlying problems. Knowing that a resident is at the end of life is fundamental to ensuring that their wishes are known and respected and that the quality of their life and death reflects their choices.

Every nursing home in the United States that receives Medicare or Medicaid funding for its residents is required to complete a full Minimum Data Set (MDS) assessment of functional, emotional, cognitive, and disease status on each resident a) within 14 days of admission, b) annually, and c) when any significant event or change in condition occurs. Further, a shortened assessment is completed every 90 days following admission. A recent study (8) found that just 4.5% of new admissions were designated as being at the end of life (expected to die within 6 months) as recorded on the MDS. Almost 1 in 5 residents not designated as near the end of life also died within 6 months of admission, thus demonstrating that (at least up to 6 months ahead of time) we do not recognize a substantial number of residents as dying.

The purpose of this study was to identify the MDS indicators that best predict 6-month mortality in nursing home residents to coincide with the Medicare hospice benefit timeframe. The predictive model was developed to inform research and practice with the goal of facilitating end-of-life planning and medical decision making.

Methods

The study was a secondary analysis involving linked MDS and death certificate data from the State of Missouri. Approval from the University of Missouri Health Sciences

Institutional Review Board at the University of Missouri-Columbia was obtained. The MDS provided the demographic and clinical variables to be considered as predictors of mortality, whereas the death certificates provided the most precise information about the date and place of death. The sample consisted of all Missouri long-term-care residents in nonhospital-based facilities who were over the age of 65 at the time of their first full assessment in 1999 and had a full MDS assessment transmitted to the Federal database in calendar year 1999.

Instrument

The MDS is a comprehensive standardized assessment instrument of more than 400 items for all long-term-care residents in facilities that receive Medicare or Medicaid funding (9). A full assessment is required within 14 days of admission, annually, and after significant change in resident status There is growing evidence in the literature of the reliability and validity of many of the items of the MDS instrument and data (9–15).

Study Variables

The dependent variable in all analyses was death at 6 months following the first full assessment in 1999. The potential predictors of mortality were items from the MDS survey that represented factors from previous research and clinical experience associated with the dying process. The team, consisting of experienced researchers and clinicians, identified 50 individual MDS items as having a potential relationship with prognosis and/or mortality; these fell into four main categories: 1) demographics (e.g., age, sex), 2) diseases (e.g., cancer, chronic obstructive pulmonary disease, congestive heart failure), 3) clinical signs and symptoms (pain, shortness of breath, weight loss, activities of daily living [ADLs], cognitive function), and 4) adverse events (e.g., falls, infections, hospitalizations, loss of a spouse). The cognitive performance scale (CPS) was used to assess cognitive function as devised by Morris and colleagues (12). Independence in ADLs was assessed using a composite score of seven ADLs from the self-performance items from the MDS as devised by Morris and colleagues (16). These seven ADLs were bed mobility, transfer between surfaces (e.g., bed to chair), locomotion on unit, dressing, eating, personal hygiene, and toilet use.

Data Set Creation

The data from the MDS assessments from the 1999 calendar year were matched with Missouri death certificate data from January 1999 through December 2000 to definitively identify residents who died. Records from residents in hospital-based nursing facilities were excluded from the analyses, as were resident records with missing last name, sex, or Social Security Number. Details of this matching procedure can be found in the Appendix.

Data Analysis

There were 43,510 residents in the data set. Seventy-five percent of the data was randomly selected to become the developmental data set with the remaining 25% set aside for validation. From this developmental data set, 20 randomly selected independent subsamples of about 11,000 residents (one third of the developmental set) were created. One reason for doing this was to avoid having so much power that we were observing statistically significant differences that were so small as to be of no clinical relevance. A second reason for looking at multiple subsets of the developmental set was to avoid problems associated with using stepwise selection of predictor variables. Variables that appear to be significant in one subset of the data may not appear to be significant in other subsets. By looking for predictor variables that were consistently selected from one subset to another, it is more likely that a model based on these predictors will be predictive in the validation data.

Many of the 50 variables listed as potential predictors were simple dichotomous variables. For those variables that were not dichotomous, but were at least ordinal, we investigated the form of the relationship of the predictor, using residual plots from generalized additive models to help determine the best form (17). Next we considered all variables univariately to determine if any one, by itself, was a useful predictor of 6-month mortality. In view of the relatively large power when dealing with 11,000 residents, only variables significant at the .01 level were retained for further consideration in the multiple-predictor models. The remaining steps of the analysis are described with the resulting findings.

Of the 50 variables selected from the MDS for analysis, an initial screening showed that 26 had a significant relationship with 6-month mortality. Using all variables that passed the initial screening, we used a stepwise logistic regression procedure to find which variables would be retained in a multivariable predictor model. Due to sampling variation, a variable in one model might not be retained in a subsequent fitting of a model based on a different sample. For that reason, we tested the variables in the 20 randomly selected subsamples to find which variables were retained every time, all but one time, and so forth.

To determine which variables to include in a final model, we considered two factors: how often a variable was selected by the stepwise procedure, and the step at which the variable was selected. To this end, each variable received a score based on the frequency and order with which they entered each model, i.e., the first variable selected by stepwise regression received the score of 20 points, the second variable 19 points, and so on. A total score was the sum of points for each variable across the 20 models. Table 1 details the frequency with which each variable entered the models and the total points scored.

The cutoff point to determine whether a variable could be considered a reliable predictor was decided on the basis of the frequency that it appeared in the 20 subsamples as well as the total score. A break clearly appeared after the 14th variable, so the first 14 variables were kept for further fitting of the model.

After the set of variables to be kept had been determined, all possible two-way interaction terms were defined for possible inclusion in the final model. A stepwise procedure again was used on each developmental subsample with the condition that all main effects be forced into the model before the interactions were considered. Two interactions

Table 1. Frequency and Scores for Variable Entry Into 20 Subsamples of the Development Data Set

Variable Ranking	Variable Name	Frequency of Model Entry	Total Score of Ordered Entry
1	Activities of daily living (ADLs) requiring assistance (0–7)	20	379
2	Shortness of breath	20	338
3	Cancer diagnosis	20	328
4	Recent admission to nursing home	20	322
5	Poor appetite	20	287
6	Male sex	20	277
7	Deteriorating condition	20	274
8	Weight loss	20	249
9	Chronic heart failure	20	236
10	Age	20	190
11	Renal failure	20	180
12	Cognitive Performance Scale score (0–6)	19	119
13	Alzheimer's disease or dementia	18	97
14	Dehydrated, definition	17	129
15	Pain, moderate to severe nearly every day	13	76
16	Infection, pneumonia	13	56
17	Pain, excruciating every day	11	52
18	Sleep, definition	9	49
19	Parkinson's disease	6	30
20	Infection, tuberculosis	5	15
21	Affect change	4	14
22	No. of times hospitalized in the past 90 days	2	10
23	Infection, *Clostridium difficile*	2	7
24	Communication problems	1	7
25	Edema	1	6
26	Infection, antibiotic-resistant infection	1	5

consistently appeared in these analyses: "cancer and age" and "admission to the nursing home and deterioration." With a diagnosis of cancer, the risk of dying was greater the younger the resident was. The interaction between admission and deterioration suggested that the effect of these two variables was not simply additive. Thus we had 14 variables and 2 interactions to fit the model.

After deciding on the variables to be entered into the predictive model, we used all of those variables with the entire developmental set (32,484 observations) to estimate the final parameters and validate the model. To account for possible dependence of outcomes within the same home, we used the Generalized Estimating Equations (GEE) (18) approach, and modeled the covariance using an exchangeable (or compound symmetry) model.

We compared the ordinary coefficients and the GEE coefficients and found them to be quite close. Table 2 shows the c-statistics for four cases. Using coefficients from the model found using the developmental data, we found the

Table 2. Summary Table of Developmental Validation Data Sets

Data Set	Method	c-Statistic
Development	Ordinary	0.762
Development	Generalized Estimating Equations	0.762
Validation	Ordinary	0.753
Validation	Generalized Estimating Equations	0.753

Table 3. Comparison of the 1999 Missouri Minimum Data Set Data (Including Developmental and Validation Subsets) With National Data on Selected Demographics

Variable	Total Sample (N = 43,510)	Developmental Data (N = 32,599)	Validation Data (N = 10,911)	National Data*
Age, y				
65–74	13.00%	13.00%	12.77%	12.00%
75–84	36.48%	36.38%	36.79%	32.00%
85+	50.51%	50.53%	50.44%	46.00%
Sex				
Male	26.44%	26.31%	26.84%	28.00%
Female	73.56%	73.69%	73.16%	72.00%
Race				
White (non-Hispanic)	91.85%	91.86%	91.84%	87.10%
Black (non-Hispanic)	7.60%	7.58%	7.64%	10.40%
Other/unknown	0.50%	0.50%	0.50%	2.50%

Note: *Gabrel CS, Jones A. The National Nursing Home Survey: 1997 summary. Vital and Health Statistics-Series 13: Data from National Health Survey. 2000:147.1–21.

c-statistic when the model was fit to the developmental data and when the same model was used with the validation data. The c-statistic is a measure of the predictive value of the logistic regression model with values ranging from 0 to 1, with large values indicative of better predictive value. This comparison was repeated for the model using the ordinary coefficients and the model using GEE coefficients. The relatively small change when fitting the models to the validation data indicates that the model validates quite well.

Other measures of model fit related to measures of discrimination and calibration (19). Discrimination is the ability to separate the successes from the failures, i.e., for higher values of estimated probability, there should be

Table 4. Validated Logistic Regression Model of 6-Month Mortality in Nursing Home Residents

Variable	*df*	Estimate	Odds Ratio Estimates	95% Wald Confidence Limits	
Intercept	1	−5.8475			
Activities of daily living	1	0.2467	1.280	1.254	1.306
Shortness of birth	1	0.7849	2.192	2.019	2.381
Loss of appetite	1	0.4634	1.589	1.496	1.668
Sex	1	0.5885	1.801	1.689	1.921
Weight loss	1	0.4366	1.547	1.428	1.676
Chronic heart failure	1	0.3771	1.458	1.367	1.555
Renal disease/failure	1	0.6183	1.856	1.632	2.110
Cognitive performance scale	1	0.0907	1.095	1.073	1.117
Alzheimer's disease or dementia	1	−0.2399	0.787	0.737	0.840
Dehydrated	1	0.4603	1.585	1.416	1.774
Cancer†	1	5.2889			
Age†	1	0.0269			
Cancer * Age‡	1	−0.0523			
Admission†	1	0.8379			
Deteriorated†	1	0.6904			
Admission * Deterioration†	1	−0.5057			

Note: †Odds ratios cannot be calculated for variables included in interaction terms.

‡Interaction.

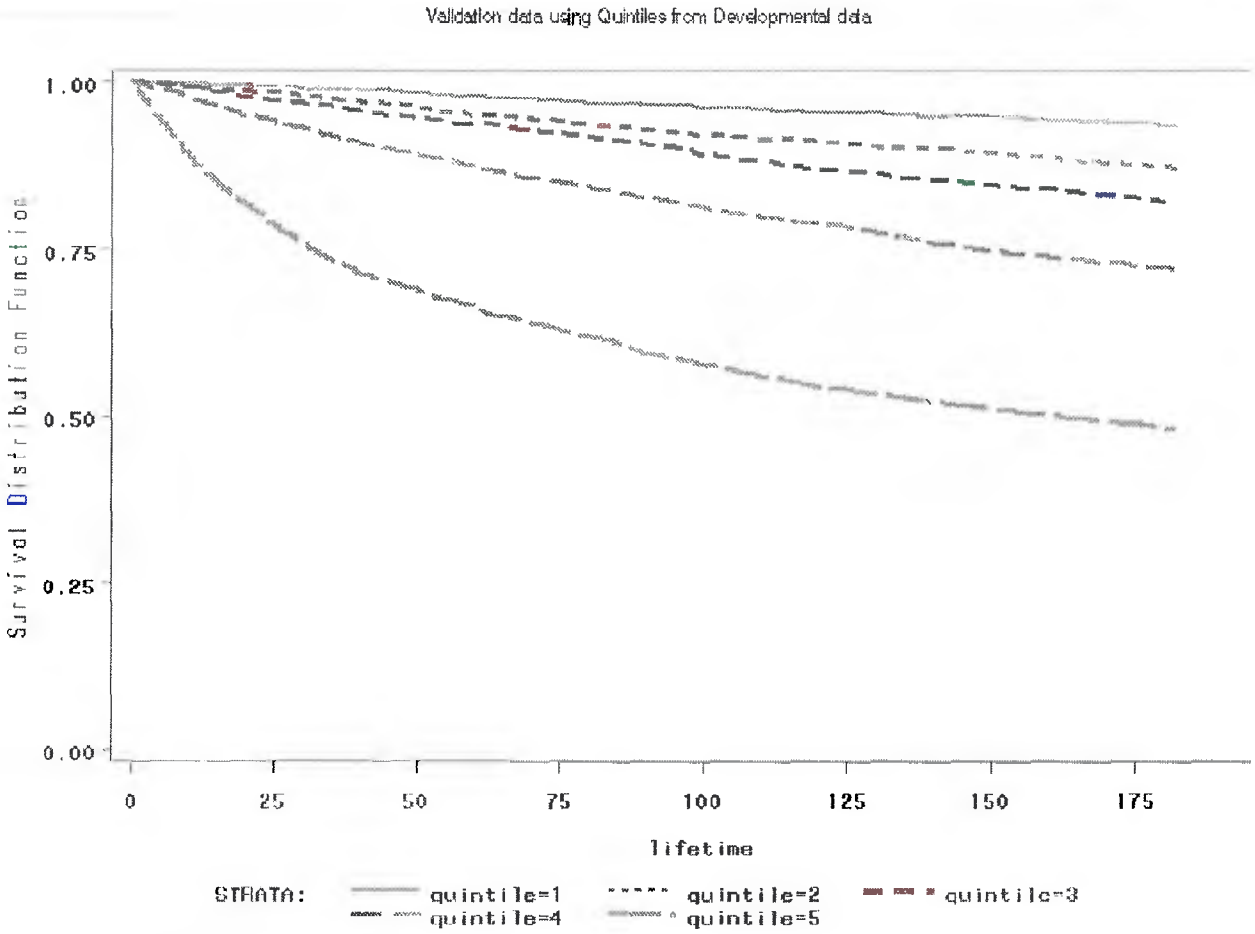

Figure 1. Kaplan–Meier survival curves for each quintile of risk of dying using the developmental data set.

a very high proportion of residents who die, whereas for lower values of estimated probability, a low proportion should die. We then compared the proportion of deaths in the highest quintile of the estimated probabilities relative to the proportion in the lowest quintile. For the developmental set, the ratio is 8.91; for the validation set, this drops only to 8.12. Calibration, which determines whether the predicted and observed mortality are similar over the range of predicted risk, was checked by looking at the observed and expected proportions of death within each decile of probability values. This was summarized by a Hosmer–Lemeshow statistic and, even with the large sample size and associated power, the results were satisfactory. For the developmental set, the p value for the Hosmer–Lemeshow test was .58 and for the validation set it was .16.

Results

Demographics

Demographics of the total sample of 43,510 residents and the development and validation subsets were compared with national statistics to determine the generalizability of the findings. Table 3 summarizes those findings. Overall, 23% of the residents died in the 6 months following their first full assessment of 1999/2000. The final validated 16-item model for predicting the risk of death within 6 months is presented in Table 4.

To illustrate how well the quintiles of the estimated probability of dying (or the risk of dying) relate to survival, we made Kaplan–Meier survival curves for each quintile within the validation set. The plot shown in Figure 1 illustrates how the estimated survival curves are successively lower as the quintiles of risk get higher.

Implications for Practice–The 6-Month MDS Mortality Risk Index

Having identified an optimal set of predictors, we derived a 6-month mortality risk index from the final logistic model. The 6-month MDS Mortality Risk Index (MMRI) is a simple algorithm that assists in using selected MDS items to determine a resident's risk of dying within the next 6 months. The algorithm was guided by the results of the logistic regression analysis but is not identical to the regression model, and is an additive scale with weights

6-Month MDS Mortality Risk Index Point System

Age Without Cancer		Age With Cancer	
≤69	1 pt		
70–78	2 pts	≤74	8 pts
79–88	3 pts	75–84	7 pts
89–98	4 pts	85–94	6 pts
99+	5 pts	≥95	5 pts

Age points _____

CPS score	
0–1	0 pts
2–4	1 pt
5–6	2 pts

CPS points _____

Admission and/or deteriorating score	
Admission only	3 pts
Deteriorating	3 pts
Both admission and deteriorating	4 pts

Admission/deteriorating points _____

ADL score _____

Shortness of breath (3 pts) _____

Poor appetite (2 pts) _____

Male (2 pts) _____

Weight loss (2 pts) _____

Chronic heart failure (2 pts) _____

Renal failure (2 pts) _____

Dehydrated (2 pts) _____

Subtotal number of points _____

Alzheimer's (subtract 1) _____

Grand total number of points _____

Figure 2. Algorithm for calculating individual risk based on points derived from the logistic regression analysis–Minimum Data Set Mortality Risk Index.

being assigned by rounding the regression coefficients from the final logistic model. The MMRI point system can be found in Figure 2. Figure 3 compares the actual deaths with the predicted deaths using the point system, and demonstrates the validity of the system. To illustrate the utility of the MMRI, Table 5 presents the mean proportion of deaths that occurred in the 6 months following assessment.

The following examples illustrate how the MMRI could work. A 90-year-old man with Alzheimer's disease who has a score of 6 on the CPS (reflecting advanced cognitive impairment) and a score of 5 on the ADL scale would have a total 14 points. Table 5 indicates that, in this point range, about 20% of residents would be expected to die in the following 6 months. Whereas, an 82-year-old man with a CPS score of 6, poor appetite, weight loss, a "totally dependent" score on the ADL scale, and assessed to be deteriorating would receive a total score of 22, and would have a nearly 75% chance of dying within the next 6 months. If these conditions were judged irreversible, it would certainly be appropriate to plan for end-of-life care.

Discussion

The validated predictive model of 6-month mortality in nursing home residents included variables that are not surprising to those working in this area. It is possible that some predictors are potentially reversible, for example,

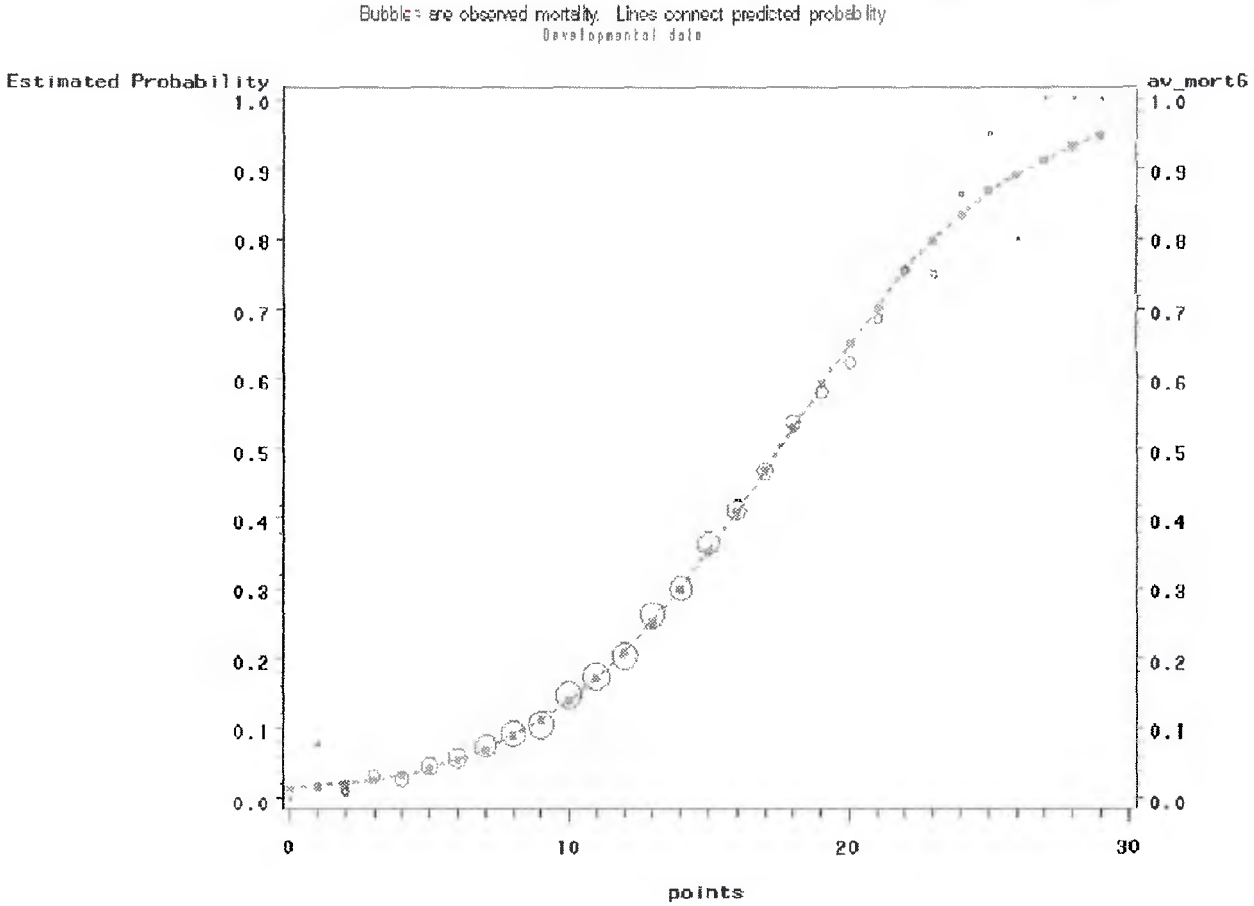

Figure 3. Comparison between actual mortality and predicted mortality using the point system.

artificial feeding and/or fluids for weight loss and hydration. However, the potential for reversibility must be considered in the light of whether such intervention would in fact be futile, what the risk of causing harm (e.g., to dignity or risk of infection) might be, and the wishes of the resident (20). The finding that Alzheimer's disease was protective in terms of the risk for death in 6 months at first seems counter-intuitive. However, people with dementia are more likely to enter a nursing home because of problems in behavior, wandering, and incontinence rather than through loss of function due to serious medical illness such as cancer or heart disease. Therefore, on admission or at any given time during the course of their stay in the nursing home, they might be less likely to die of an immediately life-threatening illness. That being said, those persons with advanced dementia will eventually die of diseases that result from that chronic neurodegenerative condition—failure to thrive with resulting malnutrition, falls, fractures, and infections.

Table 5. Proportion of Mortality Within 6 Months Based on Minimum Data Set Mortality Risk Index Point Score Ranges

Set	Points	*N*	% Died	Sensitivity, %*	Specificity, %	False-Positive	False-Negative
Development	0–10	14,239	9.1	100.0	0.0	76.9	—
	11–14	10,743	23.0	82.6	51.8	66.1	9.1
	15–18	5438	42.8	49.7	84.9	50.4	15.1
	19–21	1466	61.9	18.6	97.3	32.5	20.0
	22+	598	81.3	6.5	99.6	18.7	22.0
Validation	0–10	4710	10.1	100.0	0.0	76.3	—
	11–14	3589	22.9	81.6	51.0	66.0	10.1
	15–18	1854	43.4	49.6	84.3	50.6	15.6
	19–21	520	58.1	18.4	96.9	35.1	20.7
	22+	209	81.8	6.6	99.5	18.2	22.5

Note: *Sensitivity, specificity, false-positive, and false-negative rates are given for a rule that "predicts" that a person with a point score in this category or higher would die within 6 months. For example, if a person was categorized based on a score of 11 or higher, the sensitivity would be 82.6%.

Several attempts using the MDS to predict mortality in nursing home residents have been published in recent years. Abicht-Swensen and Debner (21) conducted a retrospective study of 199 residents who had been referred to hospice from 24 Minnesota nursing homes. The main finding of their study was the strength of the relationship between short-term mortality and a decline in functional status in the areas of cognitive functioning, communication, ADLs, incontinence, and nutrition. These findings corroborate with

ours but, unfortunately, their study focused on residents already referred to hospice and, therefore, already recognized as dying.

Hirdes, Frijters, and Teare (22) created the MDS-CHESS (Changes in Health, End-stage and Symptoms and Signs) Scale. Their scale included items from three sections of the MDS: declining health status, end-stage disease, and symptoms and signs of medical problems. Many similarities are found between this model and ours even though the population studied was Complex Continuing Care hospital patients rather than long-term-care residents. The main limitation noted by Hirdes and colleagues was their inability to verify death after discharge from the Complex Continuing Care hospital.

The linking of the MDS and death certificate data is a particular strength of our study. Furthermore, the transformation of the logistic regression model to a point system provides greater clinical utility for decision making. Unlike Hirdes and colleagues, we decided not to use the end-stage disease item of the MDS although it has excellent prognostic value for those who are so designated (8). What our analysis found was that, despite the validity of the item when it is used, it was not used reliably in the MDS. It is fair to say that there are many complex and varied reasons why a physician or an MDS nurse would not choose to document that a resident has "six or fewer months to live," even if it were suspected.

In a study of 1-year survival in nursing home residents (2003), Flacker and Kiely (23) linked MDS data with the National Death Index to overcome the problems in tracking deaths, and also used developmental and validation data sets. The principal difference (other than time) between Flacker and Kiely's model and ours was the stratification of long-stay residents and new admissions producing two models, whereas we incorporated the predictor "recent admission" into our model.

We chose a 6-month timeframe to calculate risk for mortality because it has clinically useful application in identifying residents who may benefit from specialist palliative care or hospice services. In our study, we found that many residents were at high risk of dying in 6 months. Overall, 23% of the residents died within 6 months of their first full assessment in 1999–2000. Included in that group were many residents who were most at risk. Identifying those most at risk of death—in other words, making the diagnosis of dying—is the first step in ensuring that the goals of care are appropriate and the wishes of the resident are known, documented, and respected.

Several aspects of our work support the validity of the MMRI. First is the use of state death certificate data to confirm the outcome variable of death and the strong linkage of these outcomes with the MDS data. Second, the model development was rigorous with the use of multiple development data sets and reserved data for validation of the final model, thus producing a reliable and valid method of prediction.

One particular limitation of our study is the lack of ethnic diversity in the sample; specifically, the proportion of African American and Hispanic elderly persons in Missouri nursing homes is not as high as in national statistics. Bearing in mind these strengths and limitations, future research needs to focus on multi-state studies using the MMRI, the transferability of the MMRI to non-MDS settings, the inclusion of predictors not currently found on the MDS (for example, social cues), and the impact that prediction makes on decision making and goal setting in the nursing home.

High quality end-of-life care cannot be achieved if the diagnosis of dying occurs only hours or days before death. Therefore, the ability to predict accurately the transition to the end of life is vital. The particular significance of this work was that it focused on MDS data that are routinely collected by nursing homes and are, therefore, already part of the workload, not an additional imposed expectation. The heightened awareness of a resident's transition to the end of their life may in itself create the impetus for a change in goals of care.

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Appendix

Details of Linking Missouri Minimum Data Set (MDS) Records With Death Certificate Data

Three methods were used to determine whether residents were alive or dead at 6 months after the first full assessment in 1999. First, we determined that deaths recorded in the MDS were accurate, and assigned those residents as dead. Second, we assigned residents with continued MDS assessments as alive. Finally, we linked the remaining MDS assessments with Missouri death certificate data for 1999 and 2000. The overwhelming majority of MDS records and the death certificate data contain the individual's Social Security Number (SSN), date of birth, sex, and first and last names. Thus, the SSN provided the primary link between the two data sets. To simplify the problem of positively matching long-term care residents to the death certificates, we excluded resident records with missing or invalid SSN, missing or incorrectly coded sex variable, or missing last name. This process resulted in the exclusion of 128 residents from the analysis. In the 1999 and 2000 data, 0.2% of death certificates had missing or invalid SSNs. The need to positively determine the date of death dictated that these records could not be excluded. Thus, when the death certificate SSN was missing, matching was based on name, date of birth, and sex. All potential computer matches for these cases were finally reviewed "by hand." From the MDS–death certificate record linkage, each resident's date of death and, therefore, survival time from their first full assessment in 1999 was determined. When the linkage failed, we deduced that the resident was still alive at the close of calendar year 2000. Thus, we determined whether each of these residents survived at least 6 months beyond the assessment date. An additional 552 long-term-care residents were excluded from the analysis because the first full assessment of 1999 coincided with their date of death, thus yielding zero survival times.

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An overview of risk-adjusted charts

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Summary. The paper provides an overview of risk-adjusted charts, with examples based on two data sets: the first consisting of outcomes following cardiac surgery and patient factors contributing to the Parsonnet score; the second being age–sex-adjusted death-rates per year under a single general practitioner. Charts presented include the cumulative sum (CUSUM), resetting sequential probability ratio test, the sets method and Shewhart chart. Comparisons between the charts are made. Estimation of the process parameter and two-sided charts are also discussed. The CUSUM is found to be the least efficient, under the average run length (ARL) criterion, of the resetting sequential probability ratio test class of charts, but the ARL criterion is thought not to be sensible for comparisons within that class. An empirical comparison of the sets method and CUSUM, for binary data, shows that the sets method is more efficient when the in-control ARL is small and more efficient for a slightly larger range of in-control ARLs when the change in parameter being tested for is larger. The Shewart p-chart is found to be less efficient than the CUSUM even when the change in parameter being tested for is large.

Keywords: Average run length; Cumulative sum; Performance; Resetting sequential probability ratio test; Risk-adjusted control charts; Sets method; Shewhart

1. Introduction

Quality control originated in the industrial context, where quick detection of problems is essential for efficiency. Control charts, such as the Shewhart chart and cumulative sum (CUSUM) chart, are a primary statistical tool of the methodology and have been used to monitor automated processes since the 1920s. Recently, it has been suggested that such monitoring schemes could be used to monitor the performance of clinical practitioners, such as surgeons and general practitioners (DeLeval *et al.*, 1994; Lovegrove *et al.*, 1997, 1999; Poloniecki *et al.*, 1998; Steiner *et al.*, 2000; Spiegelhalter *et al.*, 2003).

Unlike in industrial processes, where the 'subjects' (raw material) may be relatively homogeneous in nature, for medical applications the subjects (patients) will often vary greatly in terms of base-line risk. If the heterogeneity of the base-line patient risk is not taken into account when monitoring the surgeon's performance, then the additional variability in outcome due to that heterogeneity may mask the effect of the underlying performance of the surgeon and cause the chart either to produce false alarms or not to respond quickly to changes in performance. Such risk adjustment (adjustment for patient case mix) has been implemented for cumulative observed–expected (O–E) plots by Lovegrove *et al.* (1997, 1999) and Poloniecki *et al.* (1998), CUSUM charts (Steiner *et al.*, 2000; Spiegelhalter *et al.*, 2003), resetting sequential probability ratio test (RSPRT) charts (Spiegelhalter *et al.*, 2003), Shewhart charts (Cook *et al.*, 2003) and the sets method (Grigg and Farewell, 2004).

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1.1. Example data

Two example data sets are used throughout. The first is based on data from a centre for cardiac surgery, collected over the period 1992–1998. The data consist of 30-day mortality following surgery, age, sex, type of operation performed, diabetes status and Parsonnet score calculated from the first four variables plus others (see Parsonnet *et al.* (1989)). Monitoring the data by using risk-adjusted CUSUMs is discussed in detail by Steiner *et al.* (2000).

Here, the data that relate to patients of just one of the surgeons are discussed. Patient risk is taken into account by using a logistic regression model relating the probability of surgical failure to patient factors, i.e. a model is used to predict a patient's risk of dying within 30 days of their operation, given their characteristics. As in Steiner *et al.* (2000), a model fitted to the data from 1992–1993 is used to set up charts to monitor the data (retrospectively) from 1994–1998. The average failure rate, from the start of 1994, is assumed to be 0.066. The choice of the model by use of backward elimination resulted in the Parsonnet score being the only factor included. Since the Parsonnet score is a measure that is based on the other factors, and so is highly correlated with them, this is unsurprising.

For this example, since the data are binary, the natural parameter on which to base monitoring is the odds of failure. An acceptable level of performance is taken to be that reflected by the logistic regression model. Departures from this performance level are defined, relative to the model, by a common increase, or decrease, in the odds of death for all patients. Because the early detection of a problem is crucial in this instance, monitoring patient by patient is illustrated, except the Shewhart p-chart which updates every 79 patients (approximately 6 months of surgery for a typical surgeon, on the basis of the training data).

The second example is based on the number of deaths per year, in the period 1987–1998, of the patients of a single general practitioner, Harold Shipman. A public inquiry concluded that Shipman killed at least 215 of his patients over 23 years, a rate of over nine patients a year (Shipman Inquiry, 2002).

Monitoring charts are based on the assumption that the number of deaths per year is Poisson distributed. The acceptable level of 'risk' for a specific patient of type t (male or female; aged under 45, 45–64, 65–74, 75–84 or over 84 years) is taken to be the England and Wales average rate of deaths per year for that type of patient, as given by Baker (2001). This is multiplied by the number of patients of type t in Shipman's practice to give an expected count for the assumed Poisson distribution. A chart that is unadjusted for risk would assume that the risk for each patient is equal to a weighted average over all types of patient of the average rates for England and Wales. It is assumed that the acceptable rates remain the same over the period 1987–1998. In principle, though, we could forecast the trend in rates and allow the expected rate to change over time.

For example 2, since the data are counts, the natural parameter for monitoring is the rate per year (or risk). The null rates are taken to be the rates for England and Wales adjusted for the age–sex distribution of patients under Shipman's care. Departures from this level are defined to be an increase, or decrease, in the risk of death for all patients. Since the rates are assumed to be Poisson distributed, they can be combined into a single rate.

2. Departure from the model: observed–expected plot

Risk-adjusted O–E plots were developed by both Poloniecki *et al.* (1998) (who named them cumulative-risk-adjusted mortality charts) and Lovegrove *et al.* (1997) (who referred to them as variable-life-adjusted display plots).

Fig. 1 compares an unadjusted O–E plot with a risk-adjusted O–E plot. This chart is based on example data set 1, where the patients' outcome is a binary indicator Y_t of whether patient t

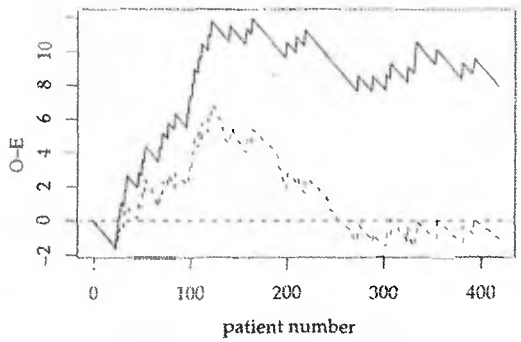

Fig. 1. O–E plot of surgical outcomes (1994–1998) for a cardiac surgeon: ———, unadjusted; - - - - - - -, risk adjusted

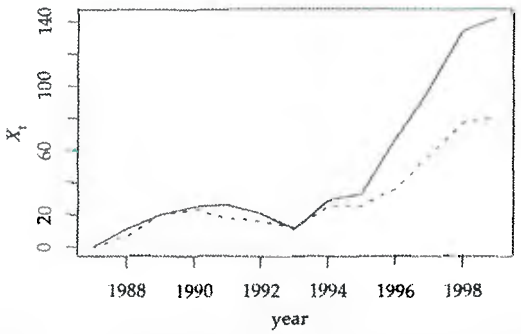

Fig. 2. O–E plot of deaths under Harold Shipman (1987–1998), where the expected value is based on the average for England and Wales: ———, all patients; - - - - - - -, females aged 75 years and over

survived 30 days after cardiac surgery. The unadjusted plot assumes that the risk of death for all patients is the same value p (the risk averaged over the type of patient) and plots the cumulative sum, over time, of $y_t - p$. In contrast, the adjusted O–E plot presents the cumulative sum, over time, of $y_t - p_t$, where p_t is the estimated risk of death from the logistic regression model.

The plot that is unadjusted for risk suggests that the surgeon is performing much more poorly than the risk-adjusted version suggests. This is because many of these operations were on high risk patients. Only by taking this into account can we accurately assess the surgeon's performance.

Fig. 2 shows a risk-adjusted O–E plot for the example 2 data over the period 1987–1998. Also shown is a comparable plot for females aged 75 years and over. Here risk adjustment means a comparison of the observed rates under Shipman *for each category of patient* with the corresponding expected rate based on rates for England and Wales. In this plot this corresponds to a simple adjustment which is made by calculating, for each year, the age and sex adjusted rate for the patient mix in Harold Shipman's practice and then averaging over the years to give a single rate which is used throughout the chart. For the all-patient chart this is 35 deaths per year and for the females over 75 years chart it is 12 deaths per year. The rapid rise in the death-rate in the latter years is clear. The increase in the overall death-rate appears to be mainly attributable to the rise in rate for females who were over 75 years old; in 1989 and 1993, in particular, the calculated overall excess is wholly due to an excess in deaths of females over 75 years of age.

The cumulative O–E statistic represents an intuitively useful way to represent performance over time. However, this type of plot is not the most natural from which to determine if and

when an alarm should be raised. The CUSUM and RSPRT charts, which are similar to the O–E plot, are designed with this purpose in mind.

3. Resetting sequential probability ratio test and cumulative sum charts

The RSPRT and CUSUM charts are both derived from the Wald sequential probability ratio test (SPRT) (Wald, 1945). The SPRT is a sequential test of a hypothesis H_0 *versus* an alternative H_1. The test statistic is the log-likelihood ratio X_t in favour of H_1 of the cumulative data up to and including time t. The value of X_t can be expressed as

$$X_t = X_{t-1} + L_t, \qquad t = 1, 2, 3, \ldots \tag{1}$$

where $X_0 = 0$ and L_t is the log-likelihood ratio for the single data point at time t.

The SPRT terminates in favour of hypothesis H_0 if the lower boundary a is crossed with approximate type I error rate α and in favour of H_1 if the upper boundary b is crossed with approximate type II error rate β, where

$$\begin{aligned} a &= \log\left(\frac{\beta}{1-\alpha}\right), \\ b &= \log\left(\frac{1-\beta}{\alpha}\right). \end{aligned} \tag{2}$$

If the data contain risk information, this can be taken into account in the test through the likelihood. For example 1, the risk model relating 30-day mortality to Parsonnet score V_t was taken to be

$$\text{logit}(p_r) = -3.67 + 0.077 V_r, \qquad r = 1, 2, \ldots, m, \tag{3}$$

where p_r is the probability of a patient of type r failing within 30 days of surgery. Consider the hypotheses to be H_0: $p_{r0} = p_r$ and H_1: $p_{r1} = R p_r / \{1 + (R-1)p_r\}$, $r = 1, 2, \ldots, m$. If the data are assumed to be Bernoulli distributed, then the log-likelihood ratio for the SPRT would be taken to be

$$L_t = \log\left\{\frac{p_{r1}^{y_t}(1-p_{r1})^{1-y_t}}{p_{r0}^{y_t}(1-p_{r0})^{1-y_t}}\right\} \tag{4}$$

where y_t is the outcome for the tth patient.

For example 2, if we let $\lambda = \sum_{s=1}^{10} \lambda_s$ be the combined death-rate for all types of patient (where λ_s is the rate for a patient of type s, $s = 1, 2, \ldots, 10$) and define the hypotheses to be H_0: $\lambda_0 = \lambda$ and H_1: $\lambda_1 = R\lambda$, then (under the assumption that the data are Poisson distributed), the log-likelihood ratio for the SPRT would be

$$L_t = \log\left\{\frac{\lambda_1^{y_t}\exp(-\lambda_1)}{\lambda_0^{y_t}\exp(-\lambda_0)}\right\}. \tag{5}$$

3.1. Cumulative sum chart

The CUSUM (strictly, the *tabular* CUSUM) was developed by Page (1954). As with the Wald SPRT, the cumulative log-likelihood ratio is plotted, but in this case H_0 is viewed as a null hypothesis. Because the chart's intended purpose is on-going monitoring and not a single significance test, acceptance of the null hypothesis makes little sense. The chart is prevented from

crossing the lower boundary and accepting hypothesis H_0 by replacing the lower absorbing barrier at a with a holding barrier at 0.

For the CUSUM, the cumulative log-likelihood ratio for data up to and including time t can be written as

$$X_t = \max(0, X_{t-1} + L_t), \qquad t = 1, 2, 3, \ldots. \tag{6}$$

where, as for the SPRT, $X_0 = 0$ and L_t is the log-likelihood ratio for the single data point at time t. The chart is said to 'signal' when $X_t > h$, where h defines an upper boundary for the plot. At this point, it is expected that monitoring will stop and remedial action will be taken.

The performance of an SPRT is determined by its nominal error rates α and β, whereas the efficiency of a CUSUM chart is quantified in terms of the length of time before an alarm, false or true, is raised. The average run length (ARL) to detection of an alarm is a convenient and common criterion that is used to assess a CUSUM's performance. The ARL to detection when the process is in state H_0 is termed the in-control ARL and this is analogous to the type I error rate of an SPRT. The out-of-control ARL is analogous to the type II error rate of an SPRT. Typically, the in-control ARL is fixed by setting the boundary h and then the out-of-control ARL is measured for a chart with that same boundary.

3.2. *Resetting sequential probability ratio test chart*

A more flexible class of charts, which includes the CUSUM as a special case, is the RSPRT chart, suggested by Spiegelhalter *et al.* (2003) and discussed in detail by Grigg *et al.* (2003). These, like the CUSUM, are also based on the SPRT, but rather than having a lower holding barrier at 0 have a lower highly elastic (or resetting) barrier at a, i.e., when the lower boundary a is reached, the chart resets to 0 and monitoring continues. So, where the CUSUM can be viewed as a sequence of SPRTs with lower boundary at 0 and upper boundary at h, an RSPRT can be viewed as a sequence of SPRTs with lower boundary at a and upper boundary at b. Hence the CUSUM is an RSPRT with $a = 0$.

Note that the barriers (a, b) can be defined by parameters (α^*, β^*) through equations (2), replacing α and β with α^* and β^* respectively. The pair (α^*, β^*) are simply parameters and are chosen for convenience, and, unlike for the non-resetting SPRT, have no relationship to the type I and II error rates α and β of the chart. Because the chart resets until the upper boundary is crossed, the actual type I and II error rates for an RSPRT are in fact 1 and 0 respectively.

3.2.1. *Optimizing α^* and β^*, the parameters of the resetting sequential probability ratio test*

There is an infinite number of pairs (α^*, β^*) (defined by equations (2) where $a \approx 0$ and $b \approx h$) that give the same in-control ARL as a CUSUM with control limit h, but only a small number of those (giving boundaries close to $(0, h)$) have the same out-of-control ARL. Note, however, that there are RSPRT charts that have a smaller out-of-control ARL than the CUSUM with the same in-control ARL. Essentially, a small out-of-control ARL can be achieved by having a relatively low upper boundary b which is smaller in absolute value than the lower boundary a. This characteristic is achieved when β^* is chosen to be very small compared with α^*.

Considering example data 1, Fig. 3 shows, for risk-adjusted RSPRTs that are designed to detect a doubling of the odds of 30-day mortality, how the out-of-control ARL varies for various choices of (α^*, β^*) which give the same in-control ARL. The in-control ARL for all pairs is approximately 6700 patients, which is equivalent to roughly 6 years of surgery. The out-of-control ARL, given alongside selected points (α^*, β^*), is seen to decrease with increasing α^* and decreasing β^*.

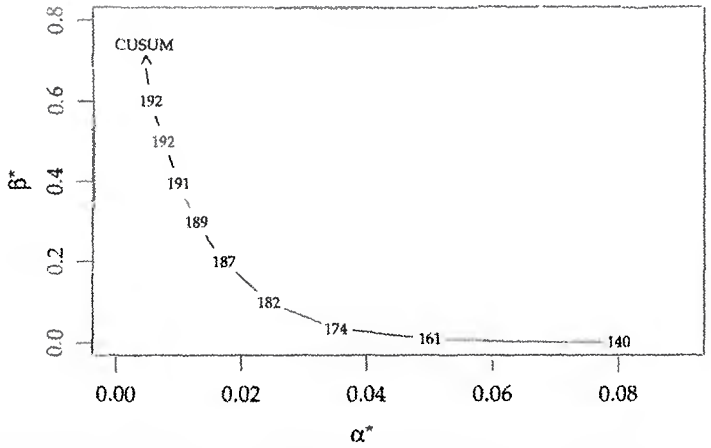

Fig. 3. Change in out-of-control ARL for pairs (α^*,β^*) given an in-control ARL of 6700 patients: RSPRTs monitoring cardiac surgeons (example 1) (α^* and β^* are defining parameters related to a and b via equations (2) and are not connected to the true error rates $\alpha = 1$ and $\beta = 0$ of the charts)

Table 1. Comparison of ARLs and run length standard deviations under hypotheses H_1 (odds = 2) and H_2 (odds = 2 after 1900 observations) for pairs $(\alpha^*,\beta^*) \equiv (a,b)$ and in-control ARL 6700 patients (example 1 data)

α^*	β^*	a	b	*ARL*		*Standard deviation*	
				H_1	H_2	H_1	H_2
CUSUM		0	4.5	193	185	120	129
0.013	0.3	−1.19	3.99	189	189	126	136
0.0352	0.0352	−3.31	3.31	174	210	121	145
0.05	0.009	−4.66	2.99	161	217	135	159
0.08	0.00045	−7.62	2.53	140	274	134	197

The problem with having α^* set high relative to β^*, i.e. having the lower boundary a more extreme than the upper boundary b is that this makes it possible for substantial 'credit' to be built up in the chart. Thus, unlike the CUSUM which has a holding barrier at 0, an RSPRT chart may accumulate credit up to the amount that is needed to cross the lower boundary.

This credit is a problem if the process is not out of control from the start of monitoring, as it would be if the alternative hypothesis H_1 were true, but, rather, it goes out of control after monitoring has been in place for a period of time. Assume, for example, that in the cardiac surgery example the odds of 30-day mortality double after 1900 patients (the lower quartile of the in-control run length distribution). Call this hypothesis H_2. Table 1 gives the out-of-control ARLs after the change in odds under H_1, when the change is immediate, and under H_2, for various pairs $(\alpha^*,\beta^* \equiv (a,b))$. The corresponding standard deviations are also given. The results were obtained from simulations of 1000 runs. Table 1 shows that the ARL under H_2 is greater for the chart with high α^* and low β^* than for that with low α^* and high β^*, although under H_1 this is the other way round (as demonstrated by Fig. 3). The increase in standard deviation under H_2, and also (less noticeably) H_1, as α^* increases shows that charts with a higher α^*

have more variability in run length than those with a low α^*. In view of this, minimization of the out-of-control ARL is not a sensible optimality criterion when RSPRT charts are used for routine monitoring.

In general, the criteria by which charts are compared in any given situation should be chosen with the properties of the process being monitored in mind. For example, the process may be prone to drift out of control, or to change radically at any stage or may fluctuate. Some criteria may be completely inappropriate for choosing optimal charts under such changes.

4. The Shewhart chart

The Shewhart chart, which was developed by Walter Shewhart in the 1920s, simply charts the actual observations (sometimes standardized) of a process. The process is deemed to be out of control when prespecified probability limits are crossed. Usually 99% limits are set (3σ limits on a standard Shewhart chart for normal data) so that only large changes in the process will be detected and the false alarm rate is reduced. Often two-sided control limits are implemented, but a one-sided limit can also be used.

Since the run length is a discrete waiting time, the run length distribution can be assumed to be geometric with mean equal to 1 over the probability that an outcome falls outside the control limits.

For binary data, it is nonsensical to observe whether single observations in isolation cross probability limits. To use a Shewhart chart, the data must be grouped and assumed, for example, to be binomial or normal. Shewhart charts for binomial data are termed p-charts.

For count data, the data can be charted as they are and assumed to be Poisson or negative binomial distributed, for example.

A risk-adjusted version of the Shewhart p-chart for binomial data has been developed by Cook *et al.* (2003) to track grouped binary outcomes in intensive care. There, they simply allow the probability of failure at each group of observations of size n_t to depend on the case mix and calculate the probability limits for that group under the assumption that the distribution of the number of failures at each time point t may be adequately modelled as $\mathcal{N}\{\Sigma_{i=1}^{n_t} p_{it}, \Sigma_{i=1}^{n_t} p_{it}(1-p_{it})\}$, where p_{it} is the expected probability of failure of the ith patient in a group at time t. Here we make a stronger assumption and say that it could be modelled as $\mathcal{B}(n_t, \bar{p}_t)$ where $\bar{p}_t = (1/n_t)\Sigma_{i=1}^{n_t} p_{it}$, as we feel that this may be more accurate for smaller group sizes. Nevertheless, simulations have shown that this binomial approximation performs similarly to the normal approximation for the case mix and group size that were examined in the examples here.

To apply a risk-adjusted Shewhart chart in the case of count data, we make the assumption that the number of failures in a group at time t of size n_t follows $\mathcal{P}(\lambda_t)$ where $\lambda_t = \Sigma_{i=1}^{n_t} \lambda_{it}$, the sum of the individual rates of failure. This result is exact, as long as the data are Poisson distributed. For the binomial case, it is thought that, as long as the distribution of patient type probabilities is tight and non-skew, the approximation is reasonable, but that where the distribution is flat or highly skewed the ARL should perhaps be checked by simulation.

4.1. Example

For the example 1 data set, suppose that we wish to conduct a one-sided test for a doubling in the odds of 30-day mortality, i.e. to test H_0: $p_{r0} = p_r$ *versus* H_1: $p_{r1} = Rp_r/\{1+(R-1)p_r\}$, $r = 1, 2, \ldots, m$. Now, the failure rate averaged over the Parsonnet score (the factor determining case type), $\bar{p}$, can be calculated from the data set and is taken to be 0.066. For a p-chart with groups of size 79 we wish to test whether the number of failures within 30 days under one surgeon follows $\mathcal{B}(79, \Sigma_{j=1}^{79} p_j/79)$ at the α% level. The size of group was chosen to be 79 to correspond

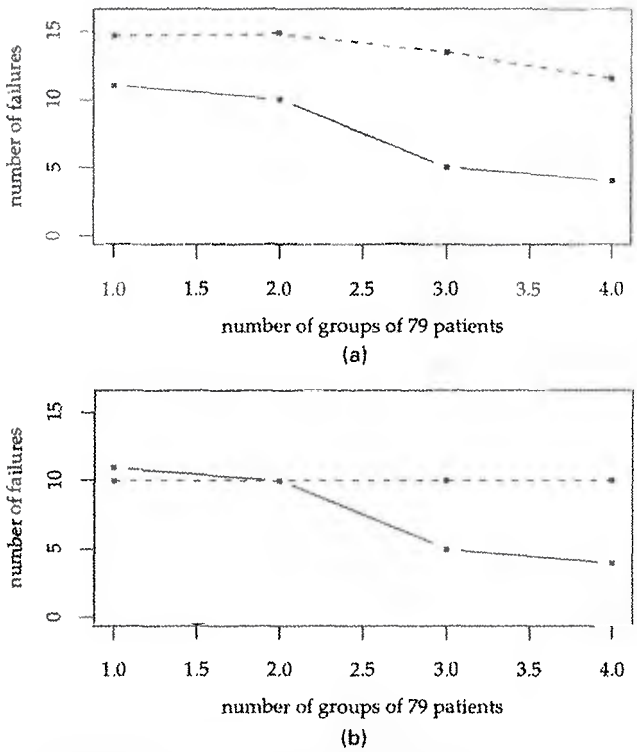

Fig. 4. 6-monthly Shewhart charts testing for a doubling in the odds of 30-day mortality following cardiac surgery (in-control ARL, 84 6-monthly periods): (a) adjusted; (b) unadjusted

roughly to 6 months of surgery for an average surgeon. For the single surgeon considered here, 79 patients correspond more closely to 9 months of surgery.

To achieve an in-control ARL of 6700 (84 sets of 79 patients), α needs to be set at $1/84 = 0.012$. The out-of-control ARL for this chart is 294 (four sets of 79 patients).

Fig. 4 shows a risk-adjusted Shewhart chart for the example 1 data constructed as described. The limit is not crossed, so the odds of 30-day mortality are deemed not to have changed. For comparison, the unadjusted chart is given as well. This has the same in- and out-of-control ARLs as the risk-adjusted chart but has fixed limits calculated under the assumption that the number of failures every 79 patients follows $\mathcal{B}(79, \bar{p} = 0.066)$, where $\bar{p}$ is the failure rate averaged over patient type from the training data. The chart signals at the first group of observations.

5. The sets method and time-between-events Shewhart chart

The sets method for monitoring adverse outcomes was introduced by Chen (1978) as a surveillance system for congenital malformations. Gallus *et al.* (1986) later refined the method. The method was adapted to allow for risk adjustment by Grigg and Farewell (2004).

The risk-adjusted method is based on the 'set' X of *weighted* observations after failure up to and including the next failure, where the weights are dependent on risk. If $X \leqslant T$ on n successive occasions, then an alarm is signalled and the process is deemed to have moved from an initial state H_0 to an out-of-control state H_1. When $n = 1$, the method is equivalent to a one-sided Shewhart-type chart monitoring time between events. The weights that were suggested by Grigg and Farewell (2004) are $p_r/\bar{p}$, where $\bar{p}$ is the probability of failure averaged over the type of risk

and p_r is defined as previously. Using these weights, the weight for an 'average' patient is 1, the weight that is adopted in the unadjusted method.

In the original method, $X \sim$ geometric(π_0) under the null hypothesis, and similarly $X \sim$ geometric(π_1) under the alternative hypothesis. The distribution of X for the risk-adjusted method, however, is intractable and probability calculations involving X must be carried out by using an empirical distribution based on simulations.

Define the event $X \leqslant T$ to be an A-event and a B-event its complement. The probability of an alarm (under either hypothesis) is therefore given by

$$P_i(\text{alarm}) = P_i^n(A) \qquad i = 0, 1. \tag{7}$$

To set the in-control ARL S_0, we require that the probability of an alarm under H_0 satisfies

$$P_i(\text{alarm}) = \lim_{\alpha \to \infty} \left(\frac{\alpha}{\alpha D_i - n + 1} \right) = \frac{1}{D_i} \qquad i = 0, 1 \tag{8}$$

for $i = 0$. For $i = 1$ equation (8) gives the relationship between the probability of a true alarm, P_1(alarm), and the out-of-control ARL S_1. The terms α and $\alpha D_i - n + 1$ correspond to the numbers of actual and possible alarms respectively, and $D_i = \pi_i S_i$ is the number of failures that are expected over S_i patients.

In terms of A-events, P_i(alarm) must also satisfy the relationship

$$P_i(\text{alarm}) = \frac{P_i^n(A)\{1 - P_i(A)\}}{1 - P_i^n(A)} \qquad i = 0, 1. \tag{9}$$

This equation recognizes the fact that alarms are considered as disjoint, i.e. an A-event following n consecutive A-events results in an alarm only if the $n - 1$ previous A-events were not part of a previous alarm.

Equating expressions (8) and (9) gives

$$D_i = \frac{1 - P_i^n(A)}{P_i^n(A)\{1 - P_i(A)\}} \qquad i = 0, 1, \tag{10}$$

which can be rearranged to give

$$P_i(A) = \{1 + D_i - D_i P_i(A)\}^{-1/n} \qquad i = 0, 1. \tag{11}$$

Equations (10) and (11) are used to find values for n and T such that D_1 is minimal or, equivalently, so that the out-of-control ARL D_1/π_1 is minimal. According to Gallus *et al.* (1986) simulation results suggest that D_1 does have a unique minimum with respect to n and T. The values for n and T are found by an iterative procedure that can be terminated as soon as the value of D_1 is found to be higher than at the previous iteration.

The iterative procedure is as follows, starting with $n = 2$.

(a) Calculate the value of $P_0(A)$ by applying Newton–Raphson iteration to equation (11), using as an initial value the solution to equation (11) obtained for $n - 1$.
(b) Interpolate the value of T from the simulated empirical distribution of X under H_0.
(c) Interpolate the value of $P_1(A)$ from the simulated empirical distribution of X under H_1.
(d) Calculate D_1 from equation (10).
(e) If $n + 1 > D_0$, stop.
(f) Increase n by 1.

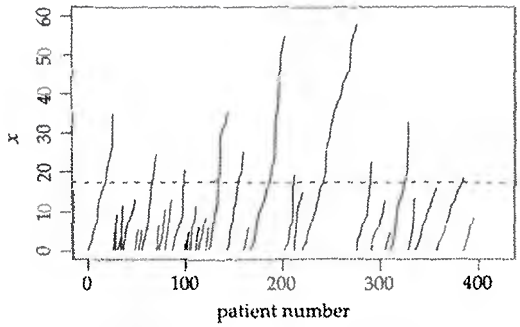

Fig. 5. Grass plot retrospectively monitoring a cardiac surgeon (example 1; $n = 10$; $T = 17.31$)

5.1. Example

Suppose that we want to test (for the example 1 data) H_0: $p_{r0} = p_r$ *versus* H_1: $p_{r1} = Rp_r/\{1 + (R-1)p_r\}$, $r = 1, 2, \ldots, m$. Assuming that the failure rate averaged over the Parsonnet score is 0.066, for a patient of type r we would add the weight $p_r/0.066$ to X.

By simulating the in- and out-of-control distributions of X under hypotheses H_0 and H_1 respectively, and following the algorithm above with an in-control ARL fixed at 6700 patients, the optimal values for n and T were found to be 10 and 17.31. The corresponding out-of-control ARL was 324.6. Since the optimal value for n is not equal to 1, the Shewhart time between events chart is not optimal for this particular data set. Fig. 5 illustrates a sets chart (grass plot), as proposed by Grigg and Farewell (2004), with values of n and T that are appropriate for the example 1 data. The chart simply plots the observation number against the cumulative size of the current set or blade. The chart is reset to 0 (a new set is begun) after every failure.

6. Comparison of charts for binary data

Chen (1987) suggested that the original sets method performs better than the CUSUM when the rate of adverse outcomes is low. Gallus *et al.* (1986) and Barbujani and Calzolari (1984) questioned the results of Chen, but Gallus *et al.* (1986) argued that their modified sets method can be more efficient than the CUSUM, but under different circumstances. The examples that they gave demonstrate that the refined sets method performs better when the change in rates that it is designed to detect is large, and not necessarily when the initial rate is low.

Here we have compared the sets method with the CUSUM and also the Shewhart p-chart, using the case mix from example data set 1 as a basis for the comparison. The focus of the comparison is on two factors: the size of the change in parameter being tested for and the case mix probabilities. So, the relative efficiencies of the charts under testing for a doubling in odds of 30-day mortality compared with testing for a fivefold increase were calculated. This was done for each of three sets of case mix probabilities: the original probabilities ($\bar{p} = 0.066$); the original probabilities multiplied by $\lambda = 0.5$ ($\bar{p} = 0.033$); the original probabilities multiplied by $\lambda = 1.5$ ($\bar{p} = 0.099$).

Fig. 6 shows the ratio of the out-of-control ARL for the sets method to that for the CUSUM measured for various values of in-control ARL (on a log-scale).

For charts testing for a larger increase in parameter (Fig. 6(b)) it appears that the sets method is more efficient (for the smallest two of the three sets of case mix probabilities) than the CUSUM for a slightly larger range of in-control ARL values than when the increase in the parameter is smaller (Fig. 6(a)). By efficient, it is meant that the out-of-control ARL is smaller for a

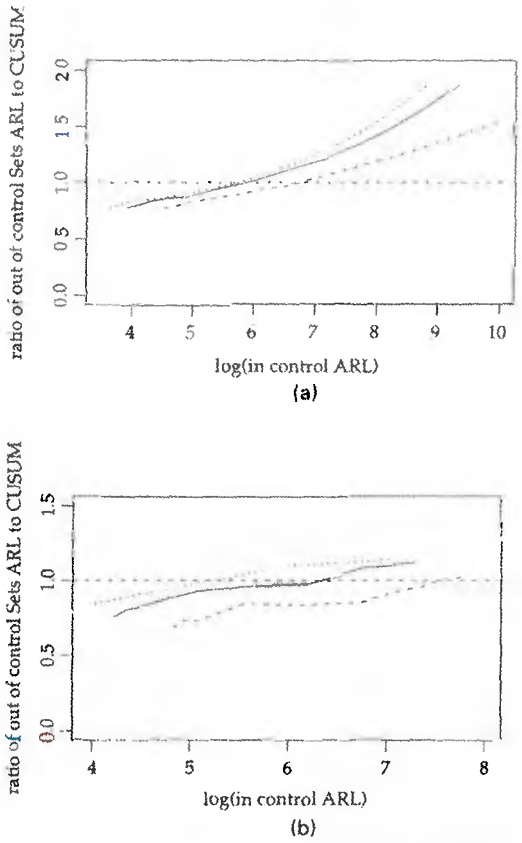

Fig. 6. Ratio of out-of-control ARL for the sets method to that of the CUSUM for fixed log(in-control ARL) (———, $\lambda = 1$; - - - - - - -, $\lambda = 0.5$; · · · · · · ·, $\lambda = 1.5$): (a) charts testing for a doubling in odds; (b) charts testing for a fivefold increase in odds

fixed in-control ARL. The size of case mix probabilities seems to have a noticeable effect. The larger the case mix probabilities, the less efficient the sets method is compared with the CUSUM. Although the effect can be seen, it does not appear to be large. However, this may be because the change in average case mix probabilities across the three sets (0.033,0.066,0.099) is small.

Tables 2 and 3 give the full results, including the Shewhart chart ARLs. Table 2 compares charts testing for a doubling of the odds of 30-day mortality following cardiac surgery and Table 3 compares charts testing for a fivefold increase.

From both Tables 2 and 3 we see that the CUSUM chart is uniformly better than the Shewhart p-chart. For charts testing for a smaller change in odds ratio (Table 2) this is not surprising. However, for charts testing for a larger change in odds ratio (Table 3), the Shewhart chart might be expected to be more efficient than the CUSUM. The result is thought to be because observations must be grouped for the Shewhart chart. In the case of the larger change in odds (Table 3), the sets method is uniformly better than the Shewhart p-chart. In the case of the smaller change in odds (Table 2), for larger in-control run lengths (log(in-control ARL) > 8) and larger case mix probabilities ($\lambda = 1$ and $\lambda = 1.5$), the Shewhart chart is more efficient than the sets method, especially for $\lambda = 1.5$.

Table 2. Out-of-control ARLs of the sets method, CUSUM and Shewhart (group size 79) charts for a fixed in-control ARL: charts testing for a doubling in odds of 30-day mortality following cardiac surgery

λ	*log(in-control ARL)*	*ARLs for the following methods:*			λ	*log(in-control ARL)*	*ARLs for the following methods:*		
		Sets	*CUSUM*	*Shewhart*			*Sets*	*CUSUM*	*Shewhart*
0.5	4.62	31.4	40.6	158	1.5	3.74	13.8	17.5	79
	4.74	34.7	43.9	158		3.88	15.7	19.3	79
	4.89	39.3	48.3	158		4.06	18.1	21.7	79
	5.38	56.6	66.1	158		4.58	25.8	30.1	158
	5.80	76.2	84.4	158		4.96	34.0	37.5	158
	6.54	121	124	237		5.69	54.4	54.6	158
	7.19	175	165	237		6.33	79.9	72.7	158
	7.79	240	208	395		6.92	112	91.4	158
	8.36	313	253	395		7.47	151	111	158
	8.91	395	297	632		8.01	200	130	158
	9.45	488	342	632		8.54	258	149	237
	9.97	591	388	1264		9.05	331	169	237
1	4.04	18.3	23.3	79					
	4.18	20.6	25.6	79					
	4.34	23.6	28.3	79					
	4.84	33.8	39.0	158					
	5.24	45.2	49.0	158					
	5.97	72.6	71.5	158					
	6.61	107	95.3	158					
	7.20	146	120	158					
	7.76	195	145	237					
	8.29	254	170	237					
	8.82	326	196	316					
	9.34	415	222	316					

7. Testing for improvements

When a process is to be monitored long term to detect a deterioration in the process, it is also important to take note of improvements in the process. If improvements in the process are ignored, a chart may be less sensitive to subsequent deteriorations in the process.

For the joint monitoring of improvement and deterioration, Page (1954) suggested the use of a two-sided CUSUM, i.e. the combined use of two one-sided tabular CUSUMs: one to detect improvement; one to detect deterioration. However, calculation of the ARL was not demonstrated.

More recently, Khan (1984) investigated the relationship between the run length of two one-sided CUSUMs, upper and lower, and a single two-sided CUSUM. The approximate formula derived was

$$\frac{1}{\mathrm{ARL}^{c}} = \frac{1}{\mathrm{ARL}^{+}} + \frac{1}{\mathrm{ARL}^{-}} \tag{12}$$

under certain regularity conditions, where ARL^{c} is the ARL for the two-sided CUSUM, ARL^{+} is the ARL for the upper one-sided CUSUM and ARL^{-} is the ARL for the lower one-sided CUSUM. Intuitively, the formula represents an assumption that the two sides of the chart are independent (the regularity conditions are, essentially, that the two halves cannot interact). The

Table 3. Out-of-control ARLs of the sets method, CUSUM and Shewhart (group size 40) charts for a fixed in-control ARL: charts testing for a fivefold increase in odds of 30-day mortality following cardiac surgery

λ	*log(in-control ARL)*	*ARLs for the following methods:*			λ	*log(in-control ARL)*	*ARLs for the following methods:*		
		Sets	*CUSUM*	*Shewhart*			*Sets*	*CUSUM*	*Shewhart*
0.5	4.84	11.3	16.5	80	1.5	3.96	6.47	7.95	40
	4.87	11.6	16.6	80		3.99	6.62	8.05	40
	4.89	11.8	16.8	80		4.03	6.93	8.13	40
	4.92	12.5	17.0	80		4.07	7.01	8.28	40
	5.08	13.2	18.1	80		4.29	7.66	9.08	40
	5.55	18.3	21.8	80		4.86	10.7	11.5	40
	6.22	23.2	27.8	80		5.48	14.6	14.2	40
	6.72	27.5	32.2	80		5.98	18.2	16.6	40
	7.24	35.2	37.2	80		6.53	21.2	19.2	40
	7.79	44.1	42.5	80		7.05	24.8	21.8	80
1	4.23	7.62	9.97	40					
	4.26	7.75	10.1	40					
	4.29	7.94	10.2	40					
	4.33	8.31	10.4	40					
	4.36	8.54	10.5	40					
	4.56	9.47	11.4	40					
	5.08	13.1	14.0	40					
	5.74	17.2	17.7	40					
	6.22	20.0	20.5	80					
	6.77	25.8	23.8	80					
	7.29	30.2	27.0	80					

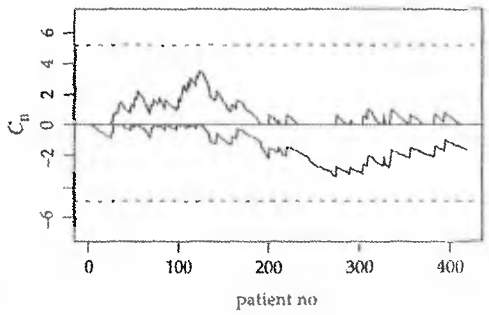

Fig. 7. Two-sided risk-adjusted CUSUM with $h_u = 5.18$, $h_l = -4.96$ and in-control ARL 6700 patients (example 1 data)

details are not shown here, but a simulation study demonstrated that this formula also applies to RSPRTs and that it works equally well for CUSUMs and RSPRTs with risk adjustment.

Fig. 7 demonstrates a two-sided risk-adjusted CUSUM for the example 1 data. The upper and lower boundaries have been chosen to be $h_u = 5.18$ and $h_l = -4.96$ respectively, so that the in-control ARLs for each half of the chart are both equal to 13400. This means that the overall ARL is approximately $13400/2 = 6700$. The in-control ARLs on each side have been made the same here to balance out the false alarm rate. However, we might decide to allow for more false positive than negative alarms, or vice versa, in which case an asymmetric chart should be employed.

8. Estimation

The primary purpose of a chart is not to estimate a process parameter. Even so, it is often natural to want to provide some estimate of a parameter after a warning signal.

Consider an unadjusted CUSUM chart for the data of example 2, where the rate of deaths per year, λ, is the parameter of interest. The difficulty, for a frequentist analysis at least, is that the maximum likelihood estimate (MLE) $\hat{\lambda}$ is biased. Although the likelihood is not affected by the stopping rule, the sampling distribution of $\hat{\lambda}$ is.

An approach to the problem, suggested by Grigg *et al.* (2003), is to obtain an MLE and then to implement Whitehead's (1997) method for adjusting the bias. This approach involves finding the bias function $b(\lambda)$ for a particular chart and solving

$$\tilde{\lambda} = \hat{\lambda} - b(\tilde{\lambda}) \tag{13}$$

where $\hat{\lambda} = Y_n/n$ is the MLE of λ at the point of stoppage, n. If the bias function is difficult to attain explicitly, a simulated approximation can work just as well.

For risk-adjusted charts, it is easier to deal with $\bar{\lambda}$ when constructing bias curves, where $\bar{\lambda}$ is the failure rate (per year) averaged over the type of patient, than to have multiple bias curves, one for each patient type's rate.

An estimate taken from a chart can be based on all the observations, since the start of monitoring. However, it is common, also, to base estimates on only the data that are observed after the estimated 'changepoint'. This is the point at which the process is deemed to have moved from a null state to an out-of-control state.

For RSPRTs, the time that the chart was last at a, the lower boundary, is the estimate of the changepoint (extended from the result stated for CUSUMs by Hawkins and Olwell (1997)). For the sets method it is estimated as being the observation before the start of the last n consecutive sets.

8.1. Example

Consider, for the example 2 data, a two-sided CUSUM testing the null hypothesis H_0: $\lambda_0 = 35$ *versus* the alternative H_u: $\lambda_u = 1.2\lambda_0$, H_l: $\lambda_l = 0.8\lambda_0$. Now, $\Pr\{\mathcal{P}(42) > 150\} \approx 0$. Therefore, constraining Y_t, the number of deaths per year, to be 150 or fewer should not result in much loss of information. From Section 3, the log-likelihood ratio weights are

$$\left.\begin{aligned} W_t(u) &= Y_t \log(1.2) - 7, \\ W_t(l) &= Y_t \log(0.8) + 7 \end{aligned}\right\} \qquad Y_t \in \{0, 1, 2, \ldots, 150\} \tag{14}$$

where u and l refer to the upper and lower charts respectively.

Fig. 8 shows a two-sided CUSUM consisting of these weights monitoring the observed death-rates per year over all types of patient under Harold Shipman, 1987–1998. Boundaries have been arbitrarily placed at $h = 1, 2, 3, 4, 5$ on both sides.

The chart would signal at the end of 1995 if h were chosen to be anywhere in the range [3,8] because of the extreme increase in rate after 1994. For boundaries at (−3,3), the in-control ARL is 52 years and the out-of-control ARL 5 years; at (−5,5), they are 403 and 7.5 years respectively.

Applying Whitehead's method of bias adjustment to the MLE of λ at the end of 1995, calculated from all the data, results in an adjusted value of $\lambda = 41$ from $\hat{\lambda} = 42.33$. An approximate 95% confidence interval for λ is [37,45].

The MLE since the chart was last at 0 (at the end of 1992) is $\hat{\lambda} = 53.33$. Applying Whitehead's method gives an adjusted value of $\lambda = 52$. An approximate 95% confidence interval for

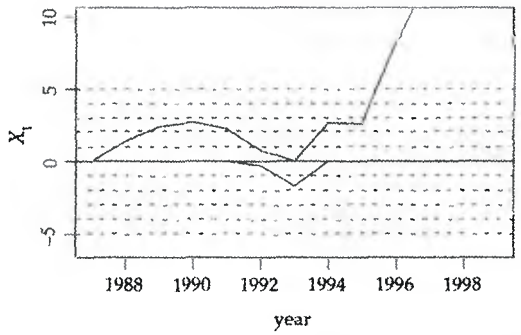

Fig. 8. CUSUM monitoring death-rates per year under Harold Shipman, 1987–1998

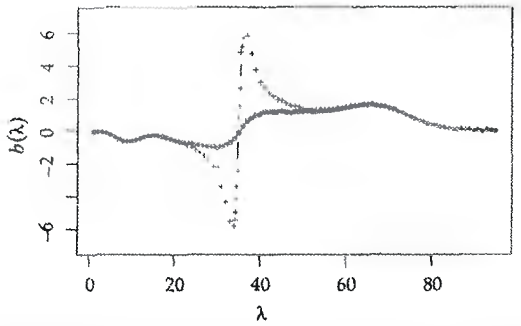

Fig. 9. Simulated bias curves for a two-sided CUSUM with $\lambda_0 = 35$, $\lambda_u = 1.2\lambda_0$, $\lambda_l = 0.8\lambda_0$ and $h_u = h_l = 5$ (example 2 data): ∘, all data; +, data since last at 0

this adjusted estimate is [43,60]. Note that the obtained confidence interval barely overlaps the interval that is obtained for the estimate using all the data (since 1987).

Fig. 9 illustrates the simulated bias curve for the MLE calculated by using all the data for a two-sided CUSUM chart with $\lambda_0 = 35$, $\lambda_u = 1.2\lambda_0$, $\lambda_l = 0.8\lambda_0$ and $h_u = h_l = 5$. The bias curve relating to estimates calculated by using only the data since the chart was last at 0 is also given.

The fact that the choice of estimator for λ results in such different values is evidently a problem. If a change in the process occurred in 1992, we would like to estimate the parameter by using data from that point onwards only. However, if a change had not occurred, or occurred earlier than 1992, not using the earlier data to form the estimate might result in an estimate with a large bias. Even if a bias adjustment were made, considerable bias could still remain.

There is an assumption here, also, that a change in process, if it occurs, will be immediate and sustained. Changes, in practice, however, might be gradual, or intermittent. In this case, other estimators than the two described might be more appropriate.

9. Conclusion

A variety of risk-adjusted charts have been presented here. Comparisons between the charts are based on the empirical case mix distribution from a single data set. However, it is thought that the results could, with due caution, be generalized to a broader spectrum of data. More work in this area, on other contrasting data sets, is certainly required for a greater understanding of how the methods presented compare.

For the RSPRT class of charts (which includes the CUSUM as a special case) it is shown that the optimal chart, under the 'minimum out-of-control ARL for a fixed in-control ARL' criterion is an RSPRT with low α^* and high β^*. It is argued, however, that this criterion is not sensible for optimizing over this class, because the optimal chart chosen is the chart that can build up the most credit and therefore is the least sensitive to changes in the process that occur at any time other than early on in monitoring.

A comparison is also made between the sets method, the CUSUM and the Shewhart p-chart. For the sets method and CUSUM, the aim was to broaden and clarify comparisons of the two charts that have been made previously. From the results gathered, it is recommended that, when wishing to detect small changes in a low event rate process, the sets method should be used only if the changes need to be detected extremely quickly regardless of a higher rate of false alarms. Otherwise, the CUSUM is perhaps the better tool. The size of the underlying case mix probabilities has a clear but relatively small effect on the comparative efficiency of the charts in the example that was studied. Because of the constraints of the data set, though, it is difficult to say whether this effect might be more significant for larger changes in the case mix probabilities.

The Shewhart chart is included in the comparison, because it is a standard and simple chart. The chart is found (for these data, at least) to be less efficient than the CUSUM. This is thought to be because, to monitor binary data, it must necessarily work on groupings of the data. For charts testing for larger changes in parameters, and for charts with smaller in-control ARLs otherwise, it is also found to be less efficient than the sets method.

The importance of implementing charts that can detect improvement as well as deterioration in a process is highlighted. Taking note of improvement may prompt a re-evaluation of the standard and, moreover, identify centres or individuals who perform well. If those centres or individuals have a transferable method of working, a positive feed-back system could be induced.

With regard to estimating the process parameter from a chart, rather than using the chart directly, the parameter could be estimated by an on-going smoothing process, such as a straightforward exponentially weighted moving average, a Bayesian exponentially weighted moving average or possibly by the use of full Bayesian updating. Indeed, if estimation is of central importance, rather than quality control, using such techniques might be an alternative strategy to the use of control charts.

Concerning the practical issue of which charts retrospectively would have been best implemented to monitor the surgical data (example 1), the results of the comparison of Section 6 suggest that either the sets method or CUSUM are most efficient for the particular case mix that was observed: the rate of deaths in the charted data (1994–1998) is 0.086, corresponding to $\lambda = 1.3$. If we had wanted to detect a change in rate quickly or to detect only large changes in rate, the sets method would probably have been the more suitable method. However, the CUSUM would perhaps have been easier to implement.

For the Shipman data, any chart monitoring the rate of deaths among elderly females would have been useful for an early detection of the problem (Fig. 2, for example, illustrates that there were over 20 excess deaths (going by the averages for England and Wales) of females over 75 years per year going back to the end of 1988—the results of the inquiry suggest that about half of these were probably caused intentionally by Shipman). However, the prospective identification by control chart of problems in such subgroups, and indeed problems that are specific to one general practitioner among many, would prove difficult for two reasons. Firstly, using charts to monitor several subgroups simultaneously would mean a loss of power for each individual chart concerned, owing to the multiplicity. Secondly, the run length properties of a large group of combined charts are as yet unknown.

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Palliative Care: Research and Treatment

Death in Long-term Care: A Brief Report Examining Factors Associated with Death within 31 Days of Assessment

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ABSTRACT

INTRODUCTION: The ability to estimate prognosis using administrative data has already been established. Research indicates that residents newly admitted to long-term care are at a higher risk of mortality. Studies have also examined mortality within 90 days or a year. Focusing on 31 days from assessment was important because it appears to be clinically useful for care planning in end-of-life; whereby, greater utility may come from identifying residents who are at risk of death within a shorter time frame so that advance care planning can occur.

PURPOSE: To examine risk of mortality within 31 days of assessment among long-term care residents using administrative health data.

METHODS: Administrative data were used to examine risk of mortality within 31 days of assessment among all long-term care residents in Ontario over a 12-month period. Data were provided by the Canadian Institute for Health Information using the Continuing Care Reporting System (CCRS), Discharge Abstract Database (DAD), and the National Ambulatory Care Reporting System (NACRS).

RESULTS: A number of diagnoses and health conditions predict death within 31 days. Diagnoses that hold an increased risk of mortality include pulmonary disease, diagnosis of cancer, and heart disease. Health conditions that lead to an increased likelihood of death include weight loss, dehydration, and shortness of breath. The presence of a fall within the last 30 days was also related to a higher risk of mortality.

DISCUSSION: Long-term care residents who lose weight, have persistent problems with hydration, and suffer from shortness of breath are at particular risk of death. The presence of advanced directives also predicts death within 31 days of assessment.

KEYWORDS: aging, long-term care, death, mortality risk, survival

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Introduction

A greater number of residents are dying in long-term care homes instead of hospitals' or emergency departments' care.[1] Approximately 24% of all deaths occur in long-term care, and the numbers of long-term care home deaths are expected to rise steadily by 2030.[1] This has led to a growing interest in the development of end-of-life care programs in long-term care homes.

The need for long-term care homes to adopt standardized principles and practices in death and dying has never been more apparent and is considered an essential component of health care in Canada.[2] Long-term care residents often have complex needs: many of them live with non-cancer comorbidities, heart disease, or dementia,[3,4] making care and end-of-life complicated.

Estimating prognosis is important for care planning. Porock et al[5] examined the ability to estimate mortality within six months using the Minimum Data Set (MDS) 2.0 assessment tool. They found that items strongly associated with death within six months include (1) admission to the care home within three

months, (2) unintentional weight loss over preceding three months, (3) renal failure, (4) chronic heart failure, (5) poor appetite, (6) being male, (7) dehydration, (8) shortness of breath, (9) active cancer diagnosis, (10) age, (11) deteriorated cognitive skills in the past three months, and (12) rate of physical decline.[5] Alternatively, Wallace and Prevost[6] found that 22 MDS items were strongly related to death within six months. These items indicated extremely low levels of functioning, limited activity and involvement, low fluid intake/dehydration, significant medical interventions intravenous (IV fluids and suctioning), and problematic skin ulcers, oral debris, and lung aspirations. Gambassia et al[7] examined determinants of death but focused only on residents suffering from dementia. Predictors of death included advanced age, being male, limited physical function, conditions of malnutrition, and a diagnosis of diabetes or cardiovascular disease. Unfortunately, much of this research has been conducted in the United States. Very little research has examined death in long-term care in Canada because high-quality administrative data have not been available in Canada until recently.

The purpose of this paper is to examine the profile of long-term care residents who died within 31 days of assessment. Many deaths occur in long-term care; however, a significant number of deaths also take place in acute care settings (hospitals and emergency departments). As such, it is also important to examine where long-term care residents die. This is a necessary step in ensuring that appropriate care planning is taking place and strategies to improve end-of-life care in long-term care are being developed and/or improved.

Methods

Sample. The study sample included information on health from all long-term care residents in Ontario from April 1, 2011 to March 31, 2012. Information was collected using three databases: the Continuing Care Reporting System (CCRS), the Discharge Abstract Database (DAD), and the National Ambulatory Care Reporting System (NACRS).

The CCRS holds all information on the health and well-being from all long-term care homes in Ontario. This database gathers information using the MDS, Canadian version, a comprehensive standardized assessment tool made up of more than 400 items essential to care planning. A full assessment is required within 14 days of admission to any long-term care facility, annually, and after significant change in resident status. A shortened version is completed during each of the remaining three quarters while the resident is in long-term care. There is growing evidence in the literature of the reliability and validity of many of the items.[8–14] The domains include psychological, cognitive, physical, social, and spiritual well-being.[9,15] The MDS 2.0 is designed to assess level of cognition (Cognitive Performance Scale; CPS),[11] activities of daily living (Activities of Daily Living (ADL) Hierarchy Scale),[16] depression (Minimum Data Set Depression Rating Scale),[12] and pain (Pain Scale).[13]

For the purposes of this study, four additional variables were created to examine the relationship of diagnosis with mortality within 31 days: heart disease, pulmonary disease, psychiatric illness, and other comorbidities. Higher scores represent higher levels of comorbidity. The heart disease variable represents the additive summation of arterial heart disease, congestive heart failure, hypertension, a cerebrovascular accident, or any other cardiovascular disease (ranges from 0 to 5). The pulmonary disease variable is the summation of asthma, emphysema, pneumonia, and respiratory infection (ranges from 0 to 4). The variable to measure psychiatric disease includes the diagnosis of anxiety disorder, depression, or manic depression (ranges from 0 to 3). Other comorbidities include allergies, anemia, arthritis, diabetes, hypothyroidism, and urinary tract infection (ranges from 0 to 6).

The NACRS database contains admission and discharge information of patients admitted to an emergency department in Ontario. This database includes the date of admission, where patients are admitted from (home, long-term care, hospital), and basic information on diagnoses and treatment. It also records dates of death of patients who died while receiving care in an emergency department.

The DAD holds information on hospital admissions and discharges; it includes administrative, clinical, and demographic data. It also includes information detailing where patients were admitted from and discharged to, including dates of death.

All information on health (CCRS, NACRS, and DADs) was provided by the Canadian Institute of Health Information. All assessments were de-identified and anonymized; a unique identifier was provided so that the CCRS database could be linked to the DAD and NACRS databases. Ethics approval was provided by the Lakehead University Research Ethics Board.

Analyses. Data analyses were performed using SPSS v.22. A series of independent correlations, chi-squares, and tests of differences between means were used to examine factors associated with death within 31 days and place of death (long-term care vs. hospital care). Relationships were tested with a number of variables representing health conditions commonly found in long-term care. Multivariate analysis examined the relationships between the independent variables and the dependent variables using survival analysis and logistic regression, respectively. Multivariate models were derived using all statistically significant variables associated with the dependent variables found in univariate analyses. All variables were entered into the model in a single step. A probability level of $P = 0.05$ was used to determine whether the independent variables were statistically significant in the hypothesized model. A variable that was not significantly associated with the dependent variable was removed at each step, until no more non-significant variables remained.

Results

The most recent assessments from 96,760 residents were provided in the time frame of interest (April 1, 2011 to March 31, 2012). Assessments from 85,842 residents were available for examination. The majority of long-term care residents

were female (69%) and married (56%). Analyses showed that 19.4% (n = 18,778) of residents died over the course of the year, 14,668 died in long-term care, and 4,110 died while in hospital or emergency care. Of those residents who died, 42.2% (n = 7,924) died within one month (31 days) of assessment, 81.8% (n = 6,484) died in long-term care, and 18.2% (n = 1,440) died in hospital care.

Univariate analyses examined factors associated with death within 31 days. All factors associated with death within 31 days were entered into a Cox regression survival analysis model. Table 1 summarizes the independent predictors of mortality from all causes. Residents who were older, male, and experienced greater functional impairment, pain, and cognitive impairment were more likely to die within 31 days of assessment. Residents who suffered from heart disease (arterial heart disease, congestive heart failure, hypertension, cerebrovascular accident, or any other cardiovascular disease) or pulmonary disease (asthma, emphysema, pneumonia, or respiratory infection) were also more likely to die within 31 days of assessment. Psychiatric illness (anxiety disorder, depression, or manic depression) resulted in a decreased likelihood of death.

Advanced directives that include do-not-resuscitate and do-not-hospitalize orders were associated with a higher likelihood of death, while the presence of a legal guardian had an opposite effect. Health conditions that increased the likelihood of death include weight loss and dehydration or insufficient fluids. Residents who were assessed by physicians as having end-stage disease with six months or fewer to live were over five times more likely to die within 31 days of assessment than those who were not.

Table 1. Results of Cox proportional hazards model of death within 31 days of assessment.

RISK FACTOR	RELATIVE RISK	(95 PERCENT CI)
Demographics		
New admission	1.491	(1.371–1.623)
Sex	1.357	(1.290–1.427)
Age at assessment	1.029	(1.027–1.032)
Scales		
Activities of daily living[1]	1.523	(1.488–1.558)
Pain[2]	1.254	(1.222–1.286)
Cognition[3]	1.049	(1.033–1.066)
Aggressive behaviour[4]	0.971	(0.961–0.981)
Diagnoses		
Pulmonary disease	1.127	(1.082–1.173)
Diagnosis of cancer	1.123	(1.050–1.201)
Heart disease	1.069	(1.045–1.093)
Psychiatric disease	0.892	(0.857–0.927)
Advanced directives		
Do not resuscitate	1.392	(1.289–1.502)
Do not hospitalize	1.316	(1.253–1.383)
Legal guardian	0.901	(0.818–0.991)
Health conditions		
End stage disease	5.029	(4.708–5.371)
Insufficient fluids	1.849	(1.746–1.958)
Weight loss	1.749	(1.657–1.846)
Shortness of breath	1.671	(1.573–1.776)
Fever	1.642	(1.515–1.779)
Dehydrated	1.434	(1.308–1.571)
Fell in past 30 days	1.358	(1.282–1.439)
Internal bleeding	1.344	(1.166–1.549)
Experiencing acute episode	1.327	(1.250–1.408)
Vomiting	1.210	(1.105–1.324)
Condition lead to instable	1.157	(1.102–1.215)
Delusions	0.762	(0.678–0.857)

Notes: [1]ADL Hierarchy Scale; [2]Pain Scale; [3]CPS; [4]Aggressive Behavioral Scale.

Discussion

There is little information on short-term survival of long-term care residents in Ontario prior to its mandated collection in April 1, 2010. Much of the existing published research focus on reports using data from outside Canada or are focused on subpopulations of long-term care (eg, focus on dementia only). As long-term care is increasingly becoming a place where residents choose to die, the need for best practices and guidelines will also increase. Studies like this one will help guide and inform these practices.

Demographic variables were first examined. Consistent with the existing research, increased age was associated with a greater likelihood of death, and being male led to a 35% increased risk of death. New admission also predicted death within 31 days of admission; this is consistent with Porock et al,[5] with the exception that Porock et al defined new admission as residents admitted within three months, whereas this study defined new admissions as residents admitted within 14 days. Nevertheless, the results are not surprising given that admission to long-term care may result from a health care emergency.

Activities of daily living were a strong predictor of death within 31 days. In fact, of the scales, reduced levels of activities of daily living were the strongest predictor, where each level of the ADL Hierarchy Scale leads to a 50% increased likelihood of death. Activities of daily living often follow a predictable decline; a closer examination of this decline may be warranted. Increased pain, as determined by the Pain Scale, and cognition, measured by the CPS, also predicted death, but aggressive behaviors appeared to have a small but significant protective effect. An examination of place of death showed that residents who were more functionally and cognitively impaired were also more likely to die in the long-term care facility. Aggressive behavior has a similar but smaller effect.

The fact that advanced directives predicted death was not surprising: residents who had a do-not-resuscitate order in place were 39% more likely to die and residents who had a do-not-hospitalize order in place were just over 30% more likely to die. When examining the place of death, residents who had completed a do-not-hospitalize order were far less likely to die in hospital (RR: 0.28, CI: 0.24–0.34). Residents who had completed a do-not-resuscitate order were also more likely to die in long-term care. Although death in long-term care is not always ideal, this suggests that long-term care staff are able to follow through with the wishes of residents.

Health conditions in relation to death within 31 days of assessment and how they relate to the place of death were also examined. Results show that residents who were assessed to be in the end-stage disease, or having six months or less to live, were five times as likely to die within 31 days of assessment. They were also far less likely to die in hospital care (RR: 0.22, CI: 0.17–0.28). This indicates not only that staff are able to identify residents who are nearing end-of-life but also that they are able to incorporate this into the care plan to prevent death in hospital.

Both insufficient fluids, which refer to an instance where the resident did not consume all or almost all liquids provided during the last three days, and weight loss, which refers to an instance where the resident lists 1.5 kg or more in the last seven days, increased the likelihood of death but had a protective effect against hospital admission (hospital or emergency department). Other health conditions that increased risk of death include shortness of breath, fever, dehydration, falling, internal bleeding, vomiting, and experiencing an acute episode or condition that is unstable.

To the author's knowledge, this is the first study to examine risk factors for death in 31 days among long-term care residents in Canada, although earlier studies have attempted to examine death in other health care settings (complex continuing care) and other locations (United States). One study by Hirdes et al[17] developed the MDS-CHESS (Changes in Health, End-Stage Disease, and Symptoms and Signs) Scale. This scale focused on complex continuing care patients but corroborated many of the findings reported by this study. One limitation outlined by Hirdes et al was that death was not recorded for patients discharged from complex continuing care; only patients who died while in care were included. This study included all long-term care residents; dates of death were recorded for not only residents who died in long-term care but also residents who were discharged to hospital care or emergency department care. Had hospital discharge data not been included, nearly 20% of long-term care home deaths would not be accounted for.

A total of 31 days from the assessment time frame was chosen because it appears to be clinically useful for care planning in end-of-life. Residents who are identified as being at risk of death within the next month can then ensure that their goals of care and final wishes are heard. This includes advance directives, where measures can be taken to prevent hospitalization or resuscitation among residents who do not wish to receive these interventions.

The main limitation of this study was its inability to examine hospital use or emergency department use as a measure to predict mortality in long-term care. Further research to examine this relationship is likely warranted. Accuracy of data may also be a limitation. Earlier research suggests that functional status of residents may be overestimated and systematic inaccuracies may exist.[18]

A strength of this study is its use of the population-based administrative information on health from Ontario long-term care facilities, which included mortality data from residents who died in long-term care and were transferred to emergency care or admitted to hospital. Given that long-term care is most often the final place of residence, it is unlikely that many were transferred back home or to an alternate location.

Conclusion

The purpose of this paper was to examine the profile of long-term care residents in Ontario who died within 31 days of assessment. As stated previously, many deaths occur in long-term care; however, a significant number of deaths also occur in hospitals (including emergency departments). This study suggests that it is possible to predict short-term mortality among long-term care residents, and preparations and advance care planning for residents who are at risk are able to be finalized.

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Author Contributions

PB and MLK drafted the manuscript and participated in the design. PB performed the statistical analysis. PB and MLK conceived the study, and participated in its design and coordination. All authors read and approved the final manuscript.

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FEED FORWARD NEURAL NETWORKS FOR THE ANALYSIS OF CENSORED SURVIVAL DATA: A PARTIAL LOGISTIC REGRESSION APPROACH

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SUMMARY

Flexible modelling in survival analysis can be useful both for exploratory and predictive purposes. Feed forward neural networks were recently considered for flexible non-linear modelling of censored survival data through the generalization of both discrete and continuous time models. We show that by treating the time interval as an input variable in a standard feed forward network with logistic activation and entropy error function, it is possible to estimate smoothed discrete hazards as conditional probabilities of failure. We considered an easily implementable approach with a fast selection criteria of the best configurations. Examples on data sets from two clinical trials are provided. The proposed artificial neural network (ANN) approach can be applied for the estimation of the functional relationships between covariates and time in survival data to improve model predictivity in the presence of complex prognostic relationships. © 1998 John Wiley & Sons, Ltd.

1. INTRODUCTION

One of the promising areas of modern statistics is the application of the research on learning processes for the analysis of complex problems.[1] Starting from the *perceptron*,[2] the first mathematical model of the parallel distributed learning process of neurons, multi-layer perceptron models, better known as *artificial neural networks* (ANNs) have been the subject of great interest since the second half of the 1980s, due to the development of the *back-propagation* algorithm.[3] In the statistical framework, modelling the underlying relationships of multivariate data implies previous definition of the correct functional relationship between the variables considered, which must be expressed by a finite number of parameters. In many applied problems this could be a hard task due to the lack of prior information on the studied phenomena. In these situations it

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could be appropriate to consider flexible modelling approaches for both exploratory and predictive purposes. Since ANNs can be regarded as flexible models suitable for non-linear multivariate problems,[4] they have been applied to several classification and prediction tasks in the biomedical field, with the purpose of improving the discriminant power of diagnostic tools, or the prediction of outcome.[5,6] Recent papers have pointed out the extension of standard regression models for survival data as neural networks suitable for processing censored outcome time data. Approaches for grouped time data were proposed by Liestol *et al.*[7] For continuous time data Liestol *et al.*[7] proposed a piecewise constant hazard approach, while Faraggi and Simon[8] extended the linear proportional hazard Cox model with an ANN predictor. Other approaches have been published in the clinical literature, based on the use of standard ANN techniques with a particular organization of the data to deal with the censoring problem.[9] One important issue is the estimation of the conditional probability for the occurrence of a specific event as a function of time,[10,11] and of putative prognostic factors. Flexible modelling of covariate effects on the shape of this function, and its direct graphical exploration, may suggest new clinical and physiological hypotheses. Otherwise, the results may provide evidence that simpler modelling approaches, such as those based on proportional hazards and linear covariate effects, can be adopted without distortion of the true functional relationship.[12]

The aim of the present paper is the proposal of a flexible ANN approach, in a discrete survival time context, which provides smoothed hazard function estimation and allows for non-linear covariate effects. Our work starts from the definition of a general approach that can be implemented with standard ANN modelling tools. Criteria suitable for model selection are proposed, and, finally, direct graphical interpretation of model results is provided. In practice we propose an ANN model as a non-linear generalization of logistic regression, suitable for grouped failure time data. Since the approach is connected with the theory of partial likelihood we will call it PLANN from the acronym. The network model is represented in Figure 1; the input layer is composed of J units (nodes) plus one bias unit, one input node is for time while the others are for the covariates. The input nodes are fully connected with the H nodes of the hidden layer. A single output node estimates conditional failure probability values from the connections with the hidden and the bias units.

Section 2 gives the statistical framework for the application of ANN models for handling general regression problems. In Section 3 we examine the discrete model setting of survival analysis. Section 4 shows how non-linear generalization of logistic regression such as ANNs can be applied for modelling conditional probability of failure. In Section 5 we compare our ANN approach with the previous proposals appearing in the statistical literature. Two examples, with single and multiple covariate analyses, are reported in Section 6. In the first example, we applied the PLANN approach to data sets from a two-arm clinical trial conducted by the California Oncology Group on patients with head and neck cancer. In this study, radiation therapy alone (arm A) was compared with radiation plus chemotherapy (arm B). The endpoint of interest was disease recurrence. Arm A included 51 patients of whom 42 suffered recurrence, while arm B included 45 patients with 31 events. Efron[13] obtained smoothed hazard estimates from these data, separately for the two treatment arms, using a logistic regression approach for grouped survival times.

In the second example we considered the data set from the Veteran's Administration (VA) lung cancer study.[14] In this trial, male patients with advanced inoperable tumours were randomized to either standard (69 subjects) or test chemotherapy (68 subjects). The primary endpoint for efficacy assessment was survival time; only 9 of the 137 were censored. Information on performance status

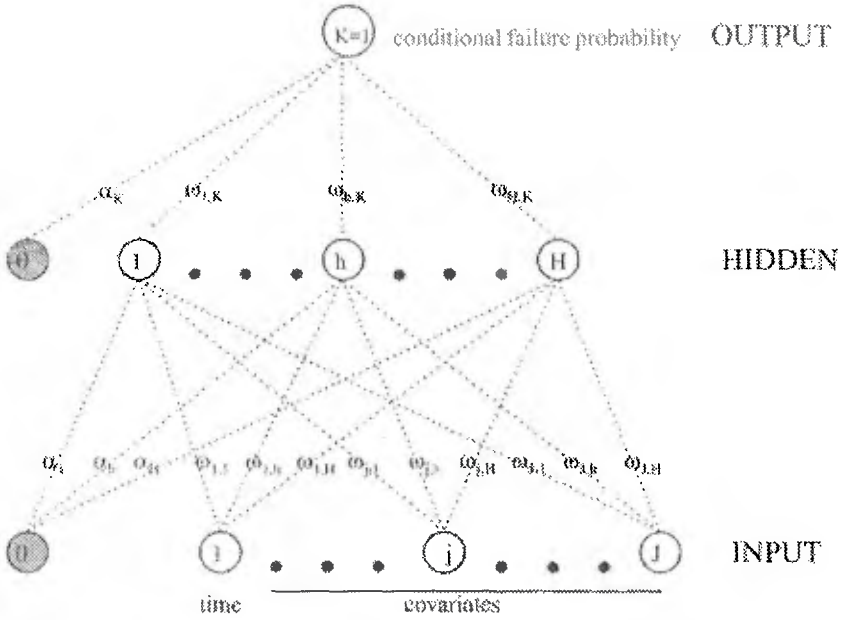

Figure 1. Feed forward neural network model for partial logistic regression (PLANN). The units (nodes) are represented by circles and the connections between units are represented by dashed lines. The input layer has J units, for time and the covariates, plus one bias unit (0). The hidden layer has H units plus the bias unit (0). A single output unit ($K = 1$) computes conditional failure probability. α_h and α_K are the weights for the connections of the bias unit with the hidden and output units. w_{jh} and w_{hK} are the weights for the connections between input and hidden units and hidden and output units, respectively

at baseline (Karnofsky rating – KPS), disease duration in months, age in years at randomization, prior therapy (yes, no), and cell type (large, squamous, small, adeno), was available.

2. ARTIFICIAL NEURAL NETWORKS AND GENERALIZED REGRESSION MODELS

The ANN term was introduced in the second half of the 1980s with the discovery of *back-propagation* as a method for jointly estimating the parameters of a multi-layer perceptron model.[3] *Feed forward* ANNs, are strictly equivalent to non-linear multivariate regression methods. Their topological interconnected structure is represented as a *directed graph of nodes without cycles.*[15] They are built (*trained*) with an initial set of observations (*patterns*) with the aim of generalizing the results to patterns not used for the generation of the model. The nodes (*neurons*) are the basic units of the model, organized hierarchically as layers, and linked by input–output relationships. A general ANN model has an input layer, one or more intermediate *hidden* layers, and the output layer. We will concentrate our attention on three layer networks with only one hidden layer with $h = 1, 2, \ldots, H$ nodes. Let $j = 1, 2, \ldots, J$ and $k = 1, 2, \ldots, K$ be the input and output nodes, respectively, x_{ij} will be the input values and y_{ik}^o the observed responses (*targets*) for each subject $i = 1, 2, \ldots, n$. The model will compute the outputs $\hat{y}_{ik}$ to approximate the y_{ik}^o. The input layer has only the role of distributing the inputs to the hidden layer. Each node in the hidden layer computes a weighted sum of the inputs x_{ij} with weights w_{jh}, adds a constant α_h (*bias*), and applies

a function (*activation*) ϕ_h to obtain its output. The outputs of the hidden layer become the inputs of the output layer nodes; their outputs are computed in the same way as the hidden layer with weights w_{hk} and activation ϕ_o. The presence of the hidden nodes provides a non-linear dependence of the outputs on the input variables. The mathematical representation of an ANN with a single hidden layer is given below:

$$\hat{y}_k(\mathbf{x}_i, w) = \phi_o\left(\alpha_k + \sum_{h=1}^{H} w_{hk}\phi_h\left(\alpha_h + \sum_{j=1}^{J} w_{jh}x_{ij}\right)\right). \tag{1}$$

The graphical representation of (1) for PLANN is in Figure 1.

The activation function ϕ_h used for the hidden nodes is generally the logistic one

$$\phi_h(u) = \frac{\exp(u)}{1 + \exp(u)}$$

while ϕ_o depends on the specific regression problem. The estimates of the weights w, parameters of the model, are obtained by minimizing an appropriate error function. Several error functions can be used based on the specific problem; the most frequent is the quadratic error

$$E = \sum_{k=1}^{K}\sum_{i=1}^{n}(\hat{y}_k(\mathbf{x}_i, w) - y_{ki}^o)^2 \tag{2}$$

while for binary classification problems the appropriate function is the cross-entropy error[4] given by

$$E = -\sum_{k=1}^{K}\sum_{i=1}^{n}\{y_{ik}^o \log \hat{y}_k(\mathbf{x}_i, w) + (1 - y_{ik}^o)\log[1 - \hat{y}_k(\mathbf{x}_i, w)]\}. \tag{3}$$

The absolute minimum of the error function (3) occurs when $y_{ik}^o = \hat{y}_{ik}$ for all the n subjects for the K outputs, and is expressed by

$$E_{\min} = -\sum_{k=1}^{K}\sum_{i=1}^{n}\{y_{ik}^o \log y_{ik}^o + (1 - y_{ik}^o)\log[1 - y_{ik}^o]\}. \tag{4}$$

Therefore, the use of binary target variables y_{ik}^o, necessarily implies that expression (4) vanishes at its minimum. Particular cases of feed forward ANNs with only input and output layers are therefore equivalent to generalized linear regression models (GLMs) with ϕ as link function, and the appropriate error term defined implicitly from the error function E. Several iterative algorithms can be used to search for the error function minimum, the most widely used is the back-propagation method (gradient descent). Other techniques are based on quasi-Newton methods.[16] Feed forward ANNs with logistic outputs can be regarded as flexible non-linear regression models for conditional probability estimation.[4] Their flexibility must be optimally tuned to achieve the best trade-off between fitting the training data and approximation of the underlying true functional dependence with the smallest bias.[17] Several techniques can be applied to modulate the degree of fitting of a neural network such as the choice of the number H of hidden nodes, the use of regularization techniques, such as the addition of a penalty term to the error function, or early stopping in the number of iterations of the optimization algorithm. All these techniques are directed to the control of the effective complexity of the model which is related to the number of parameters estimated. The choice of the best network configuration is finally based on the maximization of its predictive capability. Therefore, model selection is mainly done with validation techniques.[15]

3. DISCRETE TIME MODELS FOR SURVIVAL DATA

Different strategies can be applied to model censored survival data. For continuous-time survival data, the *hazard function* $h(t)$ is defined as:

$$h(t) = \lim_{\Delta t \to 0} \frac{P(T < t + \Delta t | T \geqslant t)}{\Delta t}. \tag{5}$$

In the discrete context a set of L times $0 < t_1 < t_2 < \cdots < t_L$ is obtained which arises from the finite precision of time determinations. Analogously we can consider the grouping of continuous survival times into $l = 1, 2, \ldots, L$ disjoint intervals $A_l = (t_{l-1}, t_l]$ with $t_0 = 0$ and l_i the last observation interval for the ith subject, and apply the relationships derived for the discrete setting.[18] The pertinent functions are the survival function

$$S(t_l) = P(T > t_l) \tag{6}$$

the discrete probability function

$$f_l = P(T \in A_l) = S(t_{l-1}) - S(t_l) \tag{7}$$

and the discrete hazard rate h_l, defined as the conditional failure probability:

$$h_l = P(T \in A_l | T > t_{l-1}) = \frac{f_l}{S(t_{l-1})}. \tag{8}$$

The conditional failure probabilities h_l approximate the continuous hazard function $h(t)$ as the intervals A_l become infinitesimal. From (7) and (8) it is easy to verify that, having defined $S(t_0) = 1$

$$S(t) = \prod_{l: t_l \leqslant t} (1 - h_l). \tag{9}$$

The contribution to the likelihood function of the ith subject will be given by the product of conditional survival probabilities for the time intervals in which he/she is observed and the conditional failure probability in the interval A_{l_i} in which the event of interest occurs. Only the case of right censoring will be considered, so for the set U of uncensored subjects the contribution is

$$P(T_i \in A_{l_i}) = f_{l_i} = h_{l_i} \prod_{l=1}^{l_i - 1} (1 - h_{il}) \tag{10}$$

while for the set C of censored subjects it is

$$P(T_i > t_{l_i}) = S(t_{l_i}) = \prod_{l=1}^{l_i} (1 - h_{il}). \tag{11}$$

If one introduces the censoring indicator d_{il}, equal to 1 in the interval A_l containing the event of interest for the uncensored subjects, and equal to 0, otherwise, the total likelihood is

$$L = \prod_{i=1}^{n} \prod_{l=1}^{l_i} h_{il}^{d_{il}} (1 - h_{il})^{1 - d_{il}} = \prod_{l=1}^{L} \prod_{i \in R_l} h_{il}^{d_{il}} (1 - h_{il})^{1 - d_{il}} \tag{12}$$

where R_l is the set of individuals at risk in the lth interval of time. In this way a product of Bernoulli likelihoods is obtained, one for each individual i in the interval l in which he/she is

observed. If we consider a homogeneous population, (12) can be rewritten in the binomial form

$$L = \prod_{l=1}^{L} \binom{n_l}{s_l} h_l^{s_l}(1 - h_l)^{n_l - s_l} \tag{13}$$

where n_l and s_l are the number of subjects at risk and the number of failures in the time interval l, respectively. The discrete time model can be fitted by considering the observations in each time interval as independent across intervals, with the event indicator d_{li} as response variable with a Bernoulli distribution (12). Alternatively, the number of events s_l in each interval is modelled with a GLM model with binomial error, and n_l as binomial weights (13). Though approximate, the assumption of independence of the contribution to the likelihood for each individual across time intervals leads to reasonable results.[13] For covariates, Cox[19] proposed the proportional odds model for grouped survival times as follows:

$$\frac{h_l(\mathbf{x}_i)}{1 - h_l(\mathbf{x}_i)} = \frac{h_l(\mathbf{0})}{1 - h_l(\mathbf{0})} \exp(\boldsymbol{\beta}^{\mathrm{T}}\mathbf{x}_i) \tag{14}$$

where $\mathbf{x}_i$ is the covariate vector for subject i, $\boldsymbol{\beta}$ is the vector of regression coefficients and $h_l(\mathbf{0})$ is the baseline hazard rate for individuals with $\mathbf{x} = \mathbf{0}$. Defining $\theta_l = \log[\frac{h_l(\mathbf{0})}{1 - h_l(\mathbf{0})}]$, expression (14) is written as

$$h_l(\mathbf{x}_i) = \frac{\exp(\theta_l + \boldsymbol{\beta}^{\mathrm{T}}\mathbf{x}_i)}{1 + \exp(\theta_l + \boldsymbol{\beta}^{\mathrm{T}}\mathbf{x}_i)}. \tag{15}$$

Thus the discrete hazard rates are modelled by a logistic regression model having a predictor which is a linear combination of covariate values $\mathbf{x}_i$, with coefficients $\boldsymbol{\beta}$, and the values θ_l. This approach allows for the joint modelling of covariates and time interval effects by considering the interval l as a block factor in a GLM model, to obtain $\boldsymbol{\beta}$ estimates adjusted for the baseline log-odds.[18] In this case attention is focused on $\boldsymbol{\beta}$ rather than θ_l estimates, since this approach does not necessarily provide an interpretable shape for the discrete hazard function. A smoothed estimated of the discrete hazard function can be obtained by applying a vector of transforms $\mathbf{a}_l$ for each mid-point a_l of the time interval A_l as covariates vector. Several kinds of transformation can be considered, for example polynomials, or more flexible approaches. Efron[13] has specifically considered smoothing cubic splines in a *partial* logistic regression model as defined in connection with the theory of partial likelihood.[20] A crucial point for this approach is the choice of the number and location of the *spline* knots. Although the location of the knots could be estimated as adjunctive parameters, this approach could be very cumbersome and is rarely applied. A derivation based on logistic regression with polynomial smoothing of the hazards was introduced by Maul[21] for the joint modelling of covariate values and time interval effects. An approach based on dynamic modelling and penalized likelihood estimation was adopted in the same framework by Fahrmeir.[22]

4. PARTIAL LOGISTIC REGRESSION MODELS WITH ANN (PLANN)

In this section we propose the application of an ANN as an alternative approach to those described in the previous paragraph, for smoothed hazard rate estimates. This is achieved by flexible modelling of the joint dependence of hazards from time a_l and the covariate vector $\mathbf{x}_i$. Our work began with the GLM approach for modelling censored survival data for the discrete or

grouped situation.[13,18] We can take the negative logarithm of the likelihood (12) obtaining

$$E = -\sum_{i=1}^{n}\sum_{l=1}^{l_i}\{d_{il}\log h_l(\mathbf{x}_i, a_l) + (1-d_{il})\log[1-h_l(\mathbf{x}_i, a_l)]\} \tag{16}$$

that is equivalent to the cross-entropy error function (3). Total error (16) is summed both over the n subjects and over time intervals $l = 1, 2, \ldots, l_i$ in which the subject i is observed. It is easily shown that this can be calculated on a derived data set in which the vectors $\mathbf{x}_i$ for each subject are replicated for all the intervals in which the subject is observed, and coupled with the event indicator d_{il} defined above. By using the error function (16) in a neural network model with no hidden nodes and logistic activation function ϕ_o, a linear logistic regression model equivalent to (15) is obtained. Here the target variable is represented by the event indicator d_{il}. We propose the generalization of the *partial logistic regression* model to a feed forward ANN (PLANN) by the addition of a hidden layer of neurons. The PLANN model has one input node j assigned to each explanatory variable x_j and an additional input for the time interval a_l (Figure 1); the logistic function is used as activation for both the hidden nodes and the single output node. The output values $\hat{y}_1(\mathbf{x}_i, a_l, w)$ will provide smoothed estimates of the discrete hazard rates $h_l(\mathbf{x}_i, a_l)$. The PLANN model is not constrained to proportional odds assumptions since interaction of time and covariate effects will be modelled implicitly. The plot of the output of the PLANN model can be used to explore the shape of the hazard function depending on time and covariates. The PLANN model can be implemented by using data sets with subject vectors replicated for the time intervals as described above, and by using (16) as error function. An advantage of this kind of data structure is the possibility of straightforward use of time-dependent covariates since each subject is represented, for each observation interval, by one input vector which can change across intervals. If all the explanatory variables are categorical, the subjects can be grouped in the design cells $m = 1, 2, \ldots, M$ on the basis of covariate values, each with n_m subjects and s_m events; thus it is possible to model the empirical estimates $\hat{h}_m$ of discrete hazard rates obtained by

$$\hat{h}_m = \frac{s_m}{n_m} \tag{17}$$

which become the target values of the network. In this case the minimum of the error, which is expressed by (4) need not vanish, and its value depends on the particular data set; for this reason a suitable error function is obtained by subtracting expression (4) from (16) to obtain

$$E = -\sum_{m=1}^{M}\left[\hat{h}_m\log\frac{h_l(\mathbf{x}_i, a_l)}{\hat{h}_m} + (1-\hat{h}_m)\log\frac{1-h_l(\mathbf{x}_i, a_l)}{1-\hat{h}_m}\right]n_m \tag{18}$$

that is the Kullback–Leibler distance which always has its minimum at 0 irrespective of the type of data used.[4] This distance function has general application in the classification framework; it provides values which are equivalent to half the deviance of the logistic regression model for grouped and non-grouped cell data. In our applications we used (18) with $\hat{h}_m$ as target for grouped cell data and d_{il} for non-grouped cell data. Survival function estimates for the time intervals are calculated according to equation (9). The model can be easily implemented using software packages for ANNs based on back-propagation, or by using high-level programming languages containing specific routines for function optimization. We performed model optimization with variable-metric quasi-Newton algorithms, since this approach is generally more efficient than gradient descent techniques like back-propagation.[16] In particular, we applied the nnet S-plus

function provided by Venable and Ripley.[23] As explained in Section 2, network architectures with different degrees of complexity can be obtained by: (a) choice of the number of hidden nodes; (b) introduction of a penalty term in the loss function. For the latter, we adopted a commonly used approach in ANNs, called *weight decay*: it penalizes large weight values, by modifying the loss function as

$$E^* = E + \lambda \sum w^2.$$

Arguments based on Bayesian considerations[15] suggest $\lambda \approx 0{\cdot}01$–$0{\cdot}1$ depending on the degree of fit expected. The use of penalty has the advantage of both improving the convergence of optimization algorithms, and of avoiding overfitting. When weight decay is used, it is common practice to rescale covariates by multiplying them with appropriate factors so as to approximately span from 0 to 1, so as to be comparable with hidden unit outputs. Several criteria can be applied for the selection of the best model. In consideration of the computational drawbacks of cross-validation techniques, we adopted the NIC criterion suggested by Amari[24] and discussed in detail for its statistical applications by Ripley.[25] NIC is a generalization of Akaike's AIC criterion

$$\text{NIC} = \text{deviance} + 2p^*$$

where p^* is the effective number of parameters estimated. In our specific case this formula can be directly rewritten for the Kullback–Liebler distance E_{KL} as

$$\text{NIC} = 2E_{\text{KL}} + 2p^*.$$

When weight decay is used it has the effect of reducing p^* with respect to the number of connections of the chosen network model; so λ exerts an effective control on p^*. The formula for the calculation of p^*, reported by Amari,[24] is

$$p^* = \text{trace}(GQ^{-1}) \tag{19}$$

where Q is the expected Hessian matrix of the log-likelihood, and G is the expected value of the outer product of the score functions, evaluated at the fitted values of the model parameters w. Stone[26] proved that NIC is equivalent to leave one out cross-validation for large samples, it being computationally more advantageous. For the above reason, models with low NIC values have the best trade-off between the likelihood and the actual number of parameters estimated. A possible problem using this approach is that the NIC theory relies on a single minimum for the model loss function, and can be unreliable in the case of several local minima. Since the latter is common in non-linear models such as ANNs, we will consider NIC, in this context, as a criterion for exploring the performance of a large number of model configurations. On the other hand, general cross-validation techniques can also be cumbersome in the presence of multiple local minima of the loss-function.

5. PLANN AND PREVIOUSLY PROPOSED ANN APPROACHES FOR GROUPED SURVIVAL DATA

The PLANN approach is based on the discrete time context like the one proposed by Liestol *et al.*[7] Different from PLANN, the neural network model in their proposal has multiple outputs with one output node k for each interval of time l, for a total of L output nodes. The particular case of the proportional odds/hazards setting can be achieved by constraining all the weights of the connections out of each hidden node to have the same weights. A single layer network with

these constraints on the input nodes is equivalent to the linear model of (14). Data for the ith individual consists of a vector of $\mathbf{x}_i$ inputs and a target vector $\mathbf{d}_i = [d_{i1}, d_{i2}, \ldots, d_{il_i}]$. This situation implies that the network has a randomly varying number of target elements according to the time intervals l where an individual is at risk. Although this approach can be implemented by using a slight computational modification for the loss function (3), this cannot easily be done with standard ANN software. In the PLANN approach only one output node is used for the network; the loss function (18) which has general use is straightforwardly applied here, provided that vector $\mathbf{x}_i$ is replicated for all the intervals in which the ith subject is at risk, as previously described. Non-linear and non-proportional covariate effects are modelled with the approach by Liestol *et al.*, but smoothed estimates of the hazard function are not directly obtained from the network. Instead PLANN is proposed for the flexible modelling of the hazard function. In their paper Liestol *et al.* provided examples based on the subdivision of the time axis into four or five disjoint intervals; the effect of the covariates on the conditional event probability is, therefore, studied over large time intervals. Model validation is obtained by a *v-fold cross-validation*[27] procedure, with the subdivision of the original data set into five equally sized subsets used for testing five distinct models generated on the remaining part of the data; the *total error of prediction* is calculated as the sum of the log-likelihood of the test sets. The use of the NIC criterion in the PLANN approach allows for faster exploration of the results obtained from different network configurations. Ravdin and Clark[9] adopted an ANN with one output node, and the input covariate vector of each subject who presented the event is replicated for all the L time intervals, while censored subjects are replicated only for the observation intervals. The time interval index is included as an additional covariate. If a patient has been censored the target value is set to 0 for all the observation intervals. For a patient who developed the event, the target value is set to 0 for the interval before the occurrence of the event, and to 1 at the interval of the event occurrence and all subsequent intervals. Ravdin and Clark also proposed a correction for the bias introduced by the presence of data vectors of the uncensored subjects in the intervals after the occurrence of the event; randomly selected vectors of the uncensored subjects must be deleted so as to match the ratio between censored and uncensored patients estimated with the Kaplan–Meier method. It is not clear what type of error function was applied for the training of the network, but the authors stated that after training, the output of the network referred to as a prognostic index, is roughly proportional to the unconditional event probability estimated with the Kaplan–Meier method. PLANN is directed to model conditional event probabilities; when data are organized as we proposed in this paper, the subsequent estimation of survival probability is straightforward from relationship (9).

6. APPLICATION OF THE PLANN MODEL

6.1. Head and neck cancer trial

In the paper from Efron[13] the hazard estimates were based on the following cubic-linear spline $\mathbf{a}_l = (1, a_l, (a_l - 11)_+^2, (a_l - 11)_+^3)$ where $(t_l - 11)_+ = \min\{(t_l - 11), 0\}$. A dynamic logit model with linear predictor $\theta_l + \boldsymbol{\beta}^{\mathrm{T}}\mathbf{x}_i$ together with a random walk model for θ_l and $\boldsymbol{\beta}$ was adopted by Fahrmeir.[22] In our analysis, discretization of one-month intervals was applied for both arms of the study. Since only one explanatory binary variable for treatment was used, the data could be grouped into cells. We applied the PLANN model to obtain smoothed hazard estimates while jointly modelling the dependence of the discrete hazards from time and treatment. The

Table I. Search for the best model for the head and neck trial data: values of NIC

Number of hidden nodes (H)	Penalty factor (λ)			
	0·025	0·05	0·075	0·1
2	99·31	100·92	138·46	104·56
3	100·61	99·96	102·36	103·64
4	99·88	103·04	102·27	102·04
5	100·91	100·40	99·73	103·97
6	98·50	102·56	99·36	100·11
7	98·69	99·40	99·63	99·78
8	98·93	100·46	99·38	99·47
9	98·85	99·63	98·71	99·74
10	98·37	102·67	98·71	105·88
11	98·94	99·69	98·09	100·41
12	99·36	98·51	**97·81**	99·05
13	99·07	98·82	98·29	98·63
14	99·07	98·84	97·83	98·94
15	99·52	99·56	98·44	99·51

optimization process was repeated using multiple random starting points so as to verify the stability of model results in the presence of several local minima of the error surface. To select the network architecture we adopted a strategy suggested by Ripley,[28] namely, several neural network configurations were tested by modifying the number of hidden nodes and the value of the penalty factor, in a factorial array. We explored configurations of the number of hidden nodes ranging from 2 to 15, while for the penalty factor λ we tested four values: 0·025; 0·05; 0·075, and 0·1. Different seed values were used for the optimization of the same network configurations leading to substantially overlapping results. Model selection implies the choice of the appropriate complexity of the PLANN model to obtain the correct fit of the underlying true hazard function, thus preventing either underfitting or overfitting. Table I reports the results, in terms of NIC, of the search for the optimal PLANN model; although NIC values are rather irregular across the rows and columns of the table, it appears that an increasing number of hidden nodes will require increasing penalty factors to obtain lower NIC values. The configuration with the lowest NIC value has 12 hidden nodes and a penalty $\lambda = 0{\cdot}075$. One possible concern is the choice of a model with a high number of parameters to be estimated, but we found that the number of free parameters effectively estimated in the presence of the penalty term is around 6. In general the number of free parameters needed will depend upon the effective degree of complexity of the shape of the conditional hazard function. The spline approach considers the use of four linear coefficients for each arm of the study (excluding the position of the spline knot), therefore, in this case the ANN model does not seem to be overparameterized. It is noteworthy that the models with the lower NIC values provide almost equal graphical representations of the hazard function. This finding has already been discussed by Ripley for different data.[28] Figure 2(*a*) displays the results of this PLANN model: the continuous lines join the output values y_i of the neural network model. The estimates obtained with the cubic-linear spline proposed by Efron[13] are displayed in the same figure as dashed lines. The PLANN approach has generated smoothed hazard estimations by the joint modelling of the dependence of conditional failure probabilities from the time interval and the treatment covariate. The patterns for smoothed hazards obtained with the ANN model are quite similar to those obtained by Efron with the spline approach. Figure 2(*b*) shows

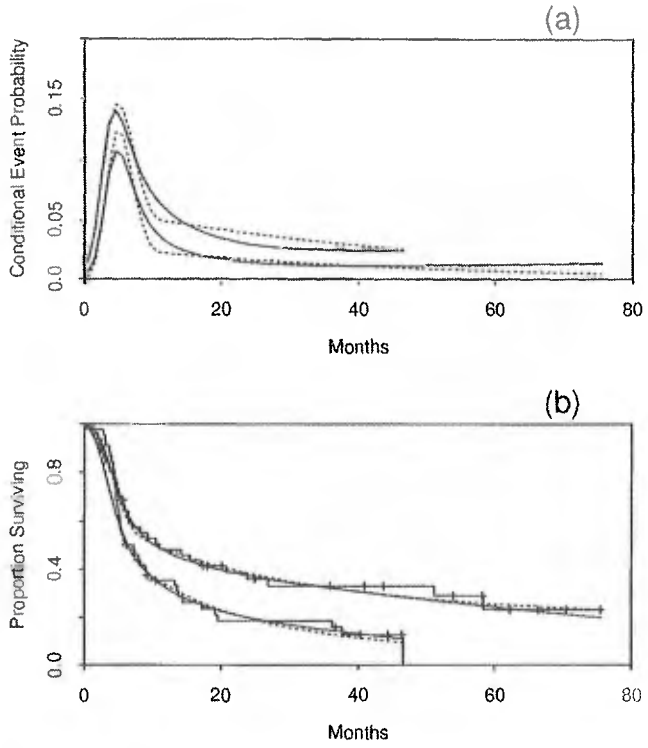

Figure 2. Head and neck cancer trial: (*a*) estimates of conditional failure probability obtained with the best PLANN configuration ($H = 12$, $\lambda = 0{\cdot}075$, solid line) and the cubic-linear spline proposed by Efron[13] (dashed line); (*b*) corresponding survival function and Kaplan–Meier estimates

the corresponding survival function calculated from equation (11), together with the Kaplan–Meier estimates. With the same number of nodes, but lowering the penalty from $\lambda = 0{\cdot}075$ to $\lambda = 0{\cdot}025$, we obtained a lower degree of smoothing and a tendency to overfit the empirical data as shown in Figures 3(*a*) and (*b*). The plot of the hazard function in Figure 3(*a*) shows a similar pattern of peaks as the corresponding one obtained by Fahrmeir[22] using dynamic discrete time models.

6.2. Veteran Administration lung cancer trial

To apply the PLANN approach, we discretized the survival times into weeks. The model was built on all the available explanatory covariates. Single indicator variables were used to distinguish treatment and prior therapy groups, three indicator variables were used for the cell type. An analysis of these data with parametric regression models and the Cox model by Kalbfliesch and Prentice,[14] showed a strong prognostic effect of KPS and of cell type, while there was no apparent dependence of survival time on age or disease duration, or the two treatments. A procedure for testing the adequacy of parametric models for these data provided evidence against both Weibull and log-normal models. Further, the shape of the failure time distribution was found to depend

Table II. Search for the best model for the VA lung cancer data: values of NIC

Number of hidden nodes (H)	Penalty factor (λ)			
	0·025	0·05	0·075	0·1
3	950·2	970·0	957·9	960·6
4	970·9	968·3	954·1	958·3
5	**935·1**	946·9	950·7	969·1
8	961·8	951·6	978·6	973·6

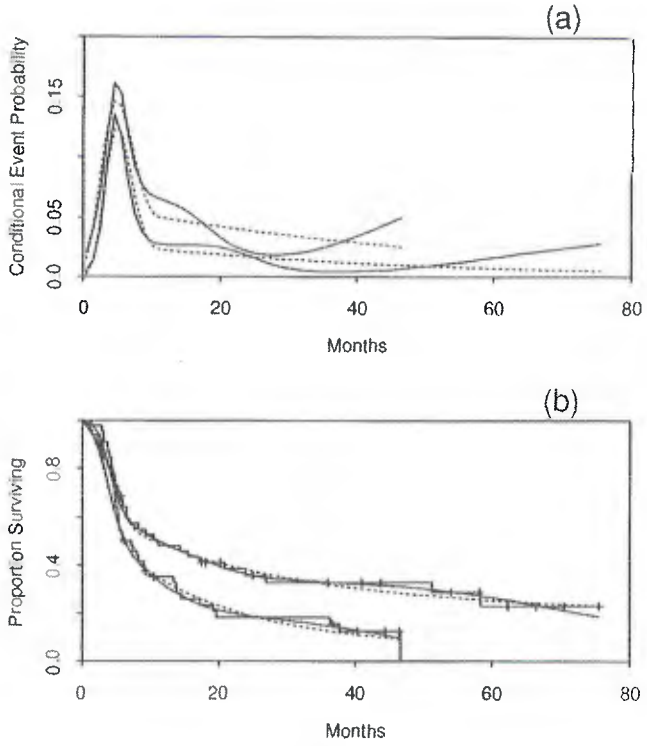

Figure 3. Head and neck cancer trial: (*a*) estimates of conditional failure probability obtained with a suboptimal PLANN model ($H = 12$, $\lambda = 0{\cdot}025$, solid line) and the cubic-linear spline proposed by Efron[13] (dashed lines); (*b*) corresponding survival function and Kaplan–Meier estimates.

on whether or not the patient had received prior therapy. For these reasons the task of modelling the underlying hazard function is certainly not easy. As in the first example we tested several network configurations with different numbers of hidden nodes and penalty coefficients in a factorial array; compared with the previous example, the analysis was conducted on a smaller number of combinations because of the higher computing times required. Table II shows the results from a series of distinct network configurations. The best performing PLANN model has five hidden nodes and $\lambda = 0{\cdot}025$ with an effective number of 42 free parameters estimated. For this model, we plotted the effects of performance status (Figure 4(*a*)) and age (Figure 4(*b*)) on the

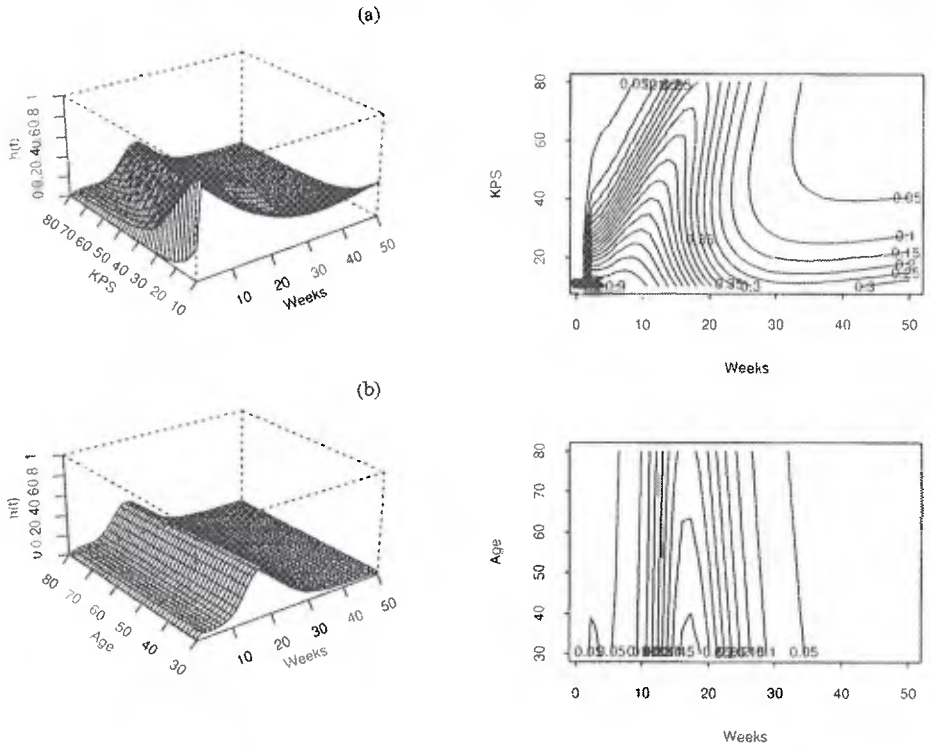

Figure 4. VA lung cancer trial: (*a*) PLANN estimates of conditional failure probability for the selected model, in dependence of time and KPS for the design cell without prior treatment, test therapy, small cell type — other continuous covariates are set to their median values; (*b*) effect of age in the same design cell

shape of the hazard function, fixing the values of the remaining variables at their medians for continuous covariates, and to no prior therapy, test treatment and small cell type for the categorical ones. The resulting three-dimensional plot shows that the effect of performance status on the shape of the conditional hazard estimates are both on the height of the peak value and its time location; this can be better examined with a contour plot. The effect of patient age seems small in this situation with the hazard peak values very slowly decreasing for older ages. The temporal shift observed for performance status is totally absent for age. The shift observed for performance status for this design cell seems concordant with the exploratory analysis carried out by Bennett.[29] In this paper smoothed empirical estimates of the hazard function were plotted for patients without prior treatment, classified by performance status as high (score over 50) or low (score 50 or below); a non-monotonic hazard shape was observed with a maximum occurring at nearly 20 days for the low KPS group while the high KPS group has a lower maximum shifted to 120 days. We did not observe the same shift in maximum hazard values for patients with prior therapy, in accordance with the findings of Kalbfleisch and Prentice,[14] of different failure time distributions depending on whether or not the patient had received prior therapy. Finally, Figure 5 shows how it is possible to explore graphically non-linear relationships and interaction

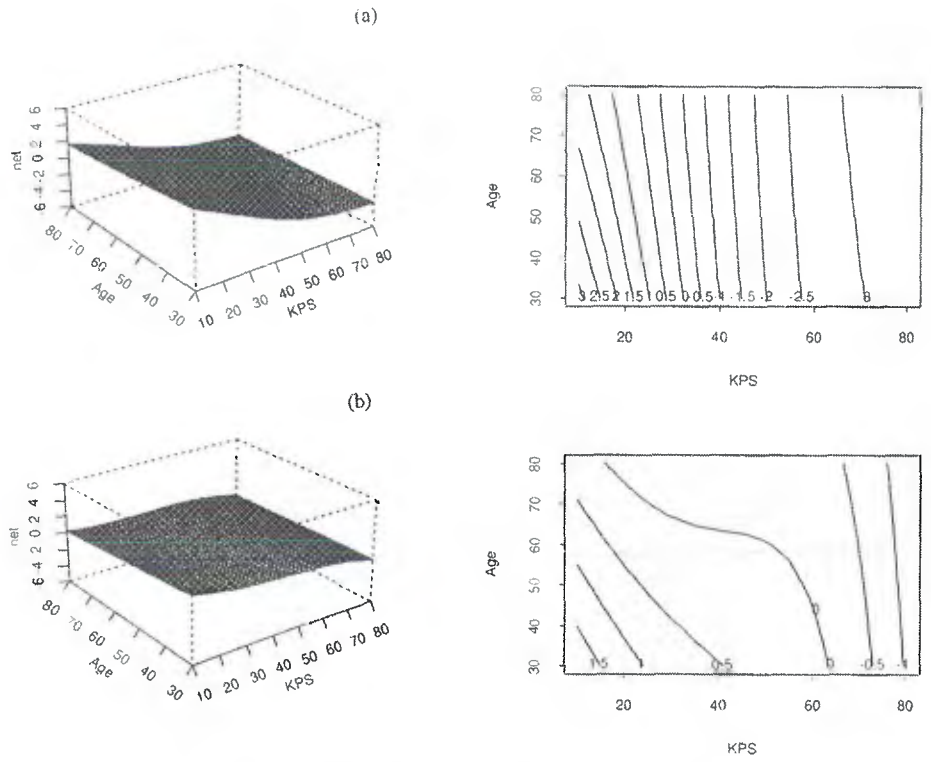

Figure 5. PLANN *net* values (before the application of the output activation function) as a function of KPS and age at fixed time intervals of (*a*) 5 weeks, and (*b*) 15 weeks

effects between explanatory variables with the PLANN approach. This figure reports *net* values, calculated by the output node before the application of the logistic activation, as a function of performance status and age. In the comparison with linear models they are the neural network equivalent of the linear predictor $\boldsymbol{\beta}^T\mathbf{x}_i$ of logistic regression before the application of the logistic transform, but for the PLANN model the predictor is given by the function

$$\alpha_1 + \sum_{h=1}^{H} w_{hk}\phi_h\left(\alpha_h + \sum_{j=1}^{J} w_{jh}x_{ij}\right).$$

In the absence of interaction between time and covariates it is possible to partition this function into the sum of two terms $g(a_l) + f(\mathbf{x}_i)$. Thus, in the proportional effects situation, and by fixing the time interval a_l, the predictor will be given by $f(\mathbf{x}_i) + I$ where I is a constant. For these reasons the plots of $f(\mathbf{x}_i)$ at different intervals must exhibit a parallel shift in a proportionality situation. To verify this last point, we calculated these plots for the chosen model predictor at 5 (Figure 5(*a*)) and 15 weeks (Figure 5(*b*)). Although the effect of performance status is maintained, there seems to be a change in its shape depending on time, thus suggesting the presence of non-proportional effects. With these plots the very low effect of age on

the hazards, and the slight non-linear effect of performance status, can be better appreciated for this cell design. Further, there seems to be no relevant interaction effect between the two variables considered.

7. DISCUSSION

Feed forward artificial neural networks represent a particular class of non-linear regression models so, in the statistical framework, they are mainly used for conditional probability estimation in pattern recognition.[30] These kinds of models can also be viewed as non-linear generalizations of GLMs because of the strict equivalence of the concept of link function for a GLM with the activation function in the output nodes for ANN, and the equivalence of the concept of loss function with the error terms of a GLM model. The modelling of censored survival times can be based on the estimation of the hazard, or the conditional probability of the event of interest. Previous proposals in the GLM framework jointly considered covariates and the time interval as block factors,[18] applied a flexible polynomial or spline smoothing,[13] or dynamic modelling and penalized likelihood estimation approaches.[22] The first approach allows for straightforwardly modelling linear interaction effects between covariates and/or between covariates and time, but it hardly provides interpretable shapes for the hazard function, and of the functional relationships between covariates and hazard. The second approach allows for smoothed modelling of both these functions but its correctness may be conditioned by the appropriate choice of the polynomial degree, locations of knots and constraints. This last point may be rather cumbersome in a multivariate context. The dynamic modelling approach is specifically directed towards the joint estimation of the shape of the hazard function and covariate effects, but it seems rather difficult to implement with standard algorithms. ANNs can be better suited for multivariate modelling of complex relationships between variables.[4] ANN approaches were proposed for modelling censored survival data as a generalization of the Cox model for both continuous and discrete (grouped) time data.[7,8] Our proposal starts from the linear approach for grouped survival times which introduces the time interval as a covariate in a GLM model. The PLANN approach allows for the joint modelling of time, and the continuous and categorical explanatory variables in a multi-layer perceptron model without proportionality constraints. As described above, the PLANN approach also allows for the straightforward modelling of time dependent explanatory variables. For each subject, output is the estimated conditional probability of the occurrence of an event as a function of the time interval and of covariate patterns. Flexible modelling can be applied both for predictive aims or as a powerful exploratory tool. Although common drawbacks in flexible modelling like ANNs are lacking in the direct interpretability of model coefficients and non-appropriateness of the standard statistical test, from an exploratory viewpoint ANN approaches can be very helpful for the improvement of modelling strategies. PLANN model outputs can be plotted to check whether model assumptions, such as proportional hazards and/or linear covariate effects, are tenable and to verify their impact on model predictive ability. On the contrary, potential disadvantages of PLANN are those of flexible modelling approaches: overfitting of the data used for the generation of the model itself; long computational times; presence of sub-optimal minima in the error function. A point that must be remarked upon regards optimal model selection when error penalty is applied during the optimization phase. NIC is specifically developed for this application but assumes the existence of a strong single local minimum. It is not easy to assess this condition when algorithms for local search are used. A possible approach is the repetition of the optimization process using multiple starting points to

track the minima of the error surface. By adopting this approach we verified that for the same number of hidden nodes and penalty terms, relatively stable values of p^* are obtained in the two examples. This could be an indirect indication of the usefulness of NIC, its values being mainly dependent on the model configuration, rather than on the specific local minimum. Nevertheless, we are aware that this approach can be used for initial exploratory purposes, while for predictive modelling a final validation procedure is needed.

In the first example the shape of the smoothed hazard function obtained by PLANN, jointly modelling time and treatment effects, largely overlapped the estimate provided by Efron.[13] It is also noteworthy to consider the model with higher complexity which, from NIC criterion, could be overfitted; it can provide information regarding the shape of a more complex underlying hazard function. In fact, the possibility of exploring more complex shapes with low bias could be very important from a biological point of view. By using the spline approach it is not so easy to obtain the same information without bias because of the need to specify a functional form which is less general than the ANN predictor. In Efron's example, the appropriate choice of degree of spline, of location, and number of knots is hardly feasible on the basis of the empirical hazards estimates only. In the second example the possibility of using PLANN in a multivariate context is shown, obtaining the estimates of the hazard function for different covariate combinations. The plots of network estimates showed different shapes of the hazard function for selected combinations of covariates, suggesting that a proportional hazards assumption was not tenable. This was also pointed out by other authors.[14,29] The functional relationships modelled by PLANN between logarithm of hazards and continuous covariates seem to agree with those adopted by Kalbfliesch and Prentice. Further work on simulated data sets will provide deeper knowledge of the statistical properties of the PLANN approach in comparison with traditional modelling strategies, so as to investigate the possible advantages in terms of predictive ability. Nevertheless, we think that our proposal shows how flexible modelling based on ANNs could be applied in survival analysis for exploratory purposes.

Recent papers pointed out a putative *competition*, existing between traditional linear models and their neural network extensions.[31,32] From our experience, and the above results, we think that a correct approach is the integration of traditional linear techniques with flexible ones, for optimal modelling of complex multivariate phenomena. If a statistician is faced with a problem that can be suitably modelled with linear approaches it would be disadvantageous to apply complex non-linear models. Nevertheless, in the presence of complex problems, flexible non-linear methods such as neural networks may provide additional advantages with respect to linear approaches.

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Original article

Functional decline and mortality in long-term care settings: Static and dynamic approach

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ABSTRACT

Background/Purpose: Functional impairment is known to be associated with higher mortality risk and adverse health outcomes. However, little is known about whether functional decline could predict mortality among the elderly in the long-term care setting.

Methods: This is a prospective cohort study in two veteran homes in northern Taiwan with active use of the minimum data set (MDS). Evaluation tools retrieved from the MDS, including MDS Resource Utilization Group-III for Activities of Daily Living (RUG-III ADL), MDS Cognitive Scale, MDS Social engagement, triggers for resident assessment protocol (RAP) and Pain scale, were utilized for the analysis.

Results: A total of 1125 male participants were included in this study. The mean age of the participants was 83.1 ± 5.1 years, and 65 (5.8%) developed physical functional decline within a 6-month period. Participants with functional decline [odds ratio (OR) 2.305, 95% confidence interval (CI) 1.002–5.303], poor baseline functional status (OR 1.116, 95% CI 1.002–1.242), positive RAP triggers for dehydration (OR 13.857, 95% CI 3.07–62.543), and underlying chronic lung diseases (OR 2.279, 95% CI 1.149–4.522), depression (OR 2.994, 95% CI 1.161–7.721), and cancer (OR 3.23, 95% CI 1.078–9.682) were more likely to have an additional 12-month mortality. By contrast, Parkinsonism (OR 3.875, 95% CI 1.169–12.841), increase in sum of RAP triggers (OR 6.096, 95% CI 2.741–13.562), and positive RAP triggers for cognitive loss (OR 3.164, 95% CI 1.612–6.212) and mood (OR 2.894, 95% CI 1.466–5.71) are strong predictors for functional decline within 6 months.

Conclusion: Physical function decline within 6 months predicted the subsequent 1-year mortality, whereas increased sum of RAP triggers and positive trigger for cognitive loss and mood were associated with functional decline.

1. Introduction

Functional deficit, or physical dependence, is a major determinant for short-term mortality and institutionalization among older people because of the increased care need and care complexity.[1–3] Moreover, it is also an important factor for poor quality of life, poor social engagement, and higher healthcare service utilization.[1–3] Longitudinal studies have shown that a rapid decline in physical function is positively correlated with higher risk of mortality,[4–7] whereas limitations in basic activities of daily living (ADLs) and instrumental ADLs were significantly associated with quality of life and clinical outcome among residents of long-term care facilities (LTCFs).[8,9] Several factors may result in functional limitation, such as aging, being male, malnutrition, comorbidities of cancer, diabetes mellitus, coronary artery disease, cerebrovascular disease, chronic lung disease, and low body mass index (BMI).[10–15] A number risk factors for a deterioration of ADL performance among nursing home residents were described using minimum data set (MDS), including poor balance, incontinence, cognitive impairment, depression, low BMI, loss of daily contact with proxies, and impaired vision and hearing.[8,9,16] Furthermore, a higher sum of MDS resident assessments protocol (RAP) triggers, a proxy indicator of care complexity, is associated with higher risk for physical functional decline and mortality.[7,17]

Most previous studies used the baseline characteristics of LTCF residents to predict their short-term health outcomes; however, it

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should be noted that those baseline conditions might be greatly influenced by recent acute illness or injuries, which may improve shortly after appropriate care. In contrast to the static point of view, the dynamic approach used for fall risk assessment had shown significant improvements in risk estimation. However, only a few studies took the same approach through evaluating changes of individual functional measurements in relation to adverse outcomes. In particular, changing individual RAP triggers to evaluate long-term care needs and functional outcomes has not been reported. The main aim of this study was to evaluate the impact of rapid functional decline and the increase in the sum of RAP triggers on 12-month mortality beyond the baseline functional status of LTCF residents.

2. Methods

2.1. Participants

Residents of Banciao and Taipei Veterans Homes in northern Taiwan were invited to participate in the study from January 2006 to December 2010. This study is a substudy of the Longitudinal Older Veterans study, which evaluated the benefits of implementing Minimum data set for Nursing Home, Chinese version 2.1, for health management and care planning in Taiwan.[17] The sociodemographic characteristics of the residents of the two veteran homes were similar because of the universal admission criteria. Only data from participants who were older than 65 years and under regular assessment for 18 consecutive months at the same facilities were included for further analysis. Residents were excluded if they were younger than 65 years, in a completely dependent state, or unable to complete the regular assessment in this period. Every participant was interviewed by the research staff in the beginning and then every 3 months in the following period. The study was approved by the Institutional Reviewing Board of National Yang-Ming University, Taipei, Taiwan.

2.2. Measures

2.2.1. Physical function

The Resource Utilization Group-III for Activities of Daily Living (RUG-III ADL) version 5.2 was used for physical function assessment.[18] The RUG-III ADL score were retrieved from MDS items for toilet use, transfer, bed mobility, and eating, in the range of 4–18. A higher score means more physical dependence and greater need for assistance, whereas a score of 4 means complete independence.

2.2.2. Cognitive function

Cognitive function in this study was evaluated using the MDS Cognitive Scale (MDS COGS). The MDS COGS were calculated from eight items for cognitive patterns, communication patterns, and physical functioning, and classified all residents into four categories of cognitive status—"intact–mild impairment," "mild–moderate impairment," "moderate–severe impairment," and "severe–very severe impairment"—as previously described.[19]

2.2.3. Social engagement

Social engagement indicates the ability to initiate social interaction and to be receptive to social overtures from others, including the formation of social ties, contact, and interactions. MDS social engagement (SocE) is calculated from the six categories of interaction, planned acts, self-initiated act, own-goal, involvement, and group acts. Each item was scored as present versus absent, and the sum ranged from 0 to 6.[20] A higher MDS SocE score indicated better social engagement and also represents better quality of life.

Table 1
Demographic data and clinical characteristics among veterans home residents.

Variables	Mean ± SD, or *n* (%)
Age (y)	83.1 ± 5.1
Body mass index (kg/m^2)	23.7 ± 3.5
Six-month ADL decline	65 (5.8)
Twelve-month mortality	113 (10)
Education (y)	
≤6	778 (71.4)
6–9	278 (25.5)
>9	33 (3)
MDS COGS	
Intact–mild	965 (86.5)
Mild–moderate	106 (9.5)
Moderate–severe	42 (3.8)
Severe–very severe	3 (0.3)
Pain scale	
No pain	689 (61.6)
Less than daily pain	285 (25.5)
Mild–moderate daily pain	135 (12.1)
Severe daily pain	9 (0.8)
Baseline RUG-III ADL	4.6 ± 1.9
Baseline SocE	1.7 ± 1.3
Comorbidities	
Amputation	12 (1.1)
Anxiety	8 (0.7)
Arthritis	171 (15.2)
Cancer	38 (3.4)
Congestive heart failure	15 (1.3)
Chronic lung disease	146 (13.0)
Cerebrovascular disease	86 (7.6)
Dementia	69 (6.1)
Depression	42 (3.7)
Diabetes	225 (20.0)
Deep venous thrombosis	3 (0.3)
End-stage renal disease	14 (1.2)
Hip fracture	12 (1.1)
Hypertension	596 (53)
Osteoporosis	12 (1.1)
Peripheral arterial occlusive disease	5 (0.4)
Parkinsonism	40 (3.6)
RAP triggers	
Delirium	25 (2.2)
Cognitive loss	379 (33.7)
Visual function	559 (49.7)
Communication	382 (34.0)
Rehabilitation needs	799 (71.0)
Urinary incontinence	186 (16.5)
Psychosocial well-being	611 (54.3)
Mood states	180 (16.0)
Behavior symptoms	18 (1.6)
Activities	842 (74.8)
Falls	355 (31.6)
Nutrition status	66 (5.9)
Dehydration	13 (1.2)
Dental care	807 (71.7)
Pressure sore	154 (13.7)
Psychotropic drugs	704 (62.6)
Physical restraint	42 (3.7)
Sum of RAP triggers at baseline	5.4 ± 2.5
Increase in sum of RAP triggers within 6 mo	520 (46.2)

ADL = activity of daily living; MDS COGS = Minimum Data Set Cognitive Scale; RAP = resident assessment protocol; RUG-III ADL = Resource Utilization Group-III for Activities of Daily Living.

2.2.4. Pain assessment

Pain scale is categorized for both frequency and intensity constructed from MDS items as four degrees of severity: "no pain," "less than daily pain," "mild/moderate daily pain," and "severe daily pain."[21]

2.2.5. RAP triggers

RAPs are the fundamental components established from different combinations of MDS items to evaluate the care problems of residents.[22] A total of 18 RAP triggers for different situations were

included in MDS, such as delirium, cognitive loss, visual function, communication, rehabilitation needs, urinary incontinence, psychosocial well-being, mood, behavior, activities, falls, nutrition, enteral feeding, dehydration, dental care, pressure ulcers, psychotropic drug use, and physical restraint. The sum of RAP triggers was considered an important indicator for care complexity and a predictor for mortality.[7,17]

2.2.6. Outcome measures

A concept of dynamic functional change within the past 6 months was used in this study to evaluate the 12-month mortality risk afterward. A recent decliner was defined as a participant with an increase in RUG-III ADL score of at least 1 point in the past 6 months, and a nondecliner was defined as having a stable or an improved RUG-III ADL score during the same period. All residents were followed for 12 months to evaluate their mortality status. Changes in the sum of RAP triggers within 6 months were included in the analysis.

2.2.7. Statistical analysis

Data in the text and tables are expressed as mean ± standard deviation or percentage when appropriate. All analyses were performed with the Statistical Package for the Social Sciences for Windows, version 18.0 (SPSS, Inc., Chicago, IL, USA). Comparisons between continuous variables were done using the Student *t*-test or Mann–Whiney *U*-test, whereas comparisons between categorical variables were done with the Chi-square test or Fisher exact test when appropriate. Variables with a p value <0.1 in univariate analyses were included in a logistic regression model using the forward stepwise method. As the sum of RAP triggers had a strong association with both functional decline and mortality, it was removed in the logistic regression model of 12-month mortality because of the potential confounding effect. For all tests, a p value <0.05 was considered statistically significant.

3. Results

Of the study participants ($n = 1380$), 31 were excluded for being less than 65 years old or having a completely dependent status (RUG-III ADL score of 18) in the beginning of the study. A total of 151 individuals were excluded during the first 6 months for lost follow-up. Another 73 were excluded for lost follow-up, for reasons such as moving out of the veteran home. A total of 1125 participants were recruited for analysis in this observational cohort study. All participants were males with a mean age of 83.1 ± 5.1 years, and their demographic profile and clinical characteristics are summarized in Table 1. Overall, 65 (5.8%) participants were categorized as functional decliners. A total of 113 (10%) residents died during the 12-month follow-up. Associative factors for 12-month mortality in the univariate analysis included BMI, baseline physical function, early functional decline, underlying disease of cancer, chronic lung disease, depression, and Parkinsonism, and positive RAP triggers of cognitive loss, urinary incontinence, nutrition status, dehydration, pressure sore, and use of psychotropic drugs (Table 2).

Participants with recent functional decline [odds ratio (OR) 2.305, confidence interval (CI) 1.002–5.303, $p = 0.049$], higher baseline RUG-III ADL score (OR1.116, CI 1.002–1.242, $p = 0.046$), positive RAP triggers for dehydration (OR 13.857, CI 3.07–62.543, $p = 0.001$), and underlying disease of depression (OR 2.994, CI 1.161–7.721, $p = 0.023$), chronic lung disease (OR 2.279, CI 1.149–4.522, $p = 0.018$), and cancer (OR 3.23, CI 1.078–9.682) were significantly more likely to die in the 12-month follow-up (Table 3).

Comparisons between recent functional decliners and nondecliners revealed that BMI, baseline MDS COGS status, baseline social engagement, underlying disease of dementia, depression, hypertension, and Parkinsonism, RAP triggers for cognitive loss, visual function, rehabilitation needs, urinary incontinence, mood states, behavior symptoms, falls, pressure ulcers, psychotropic drug use and physical restraint, baseline sum of RAP triggers, and increased sum of RAP triggers were significantly associated with recent functional decline (Table 4). Moreover, participants with an underlying disease of Parkinsonism (OR 3.886, CI 1.172–12.88, $p = 0.026$), baseline RAP triggers of cognitive loss (OR 3.178, CI 1.619–6.238, $p = 0.001$) and mood problems (OR 2.898, CI 1.468–5.719, $p = 0.002$), and increased sum of RAP triggers (OR 6.091, CI 2.738–13.549, $p \leq 0.001$) were significantly more likely to experience functional decline after enrolment (Table 5).

Table 2
Characteristics between surviving and deceased participants by univariate analysis.

Variables	Deceased $n = 113$	Surviving $n = 1012$	p
Age (y)	83.7 ± 5.4	83.0 ± 5.1	0.154
Body mass index (kg/m²)	22.6 ± 3.8	23.7 ± 3.4	0.01*
Baseline RUG-III ADL	5.1 ± 2.7	4.5 ± 1.8	0.017*
ADL decliner	15 (13.3)	50 (4.9)	<0.001*
Comorbidities			
Cancer	12 (10.6)	26 (2.6)	<0.001*
Chronic lung disease	22 (19.5)	124 (12.3)	0.03*
Depression	9 (8.0)	33 (3.3)	0.03*
Parkinsonism	10 (8.8)	30 (3)	0.004*
RAP triggers			
Cognitive loss	48 (42.5)	331 (32.7)	0.037*
Visual function	66 (58.4)	493 (48.7)	0.051
Urinary incontinence	30 (26.5)	156 (15.4)	0.003*
Nutrition status	15 (13.3)	51 (5)	<0.001*
Dehydration	5 (4.4)	8 (0.8)	0.006*
Pressure sore	24 (21.2)	130 (12.8)	0.014*
Psychotropic drugs	88 (77.9)	616 (60.9)	<0.001*
Baseline sum RAP	6.1 ± 2.4	5.4 ± 2.5	0.002*

*$p < 0.05$.
ADL = activity of daily living; RAP = resident assessment protocol; RUG-III ADL = Resource Utilization Group-III for Activities of Daily Living.

4. Discussion

Poorer current physical function and the presence of recent functional decline were both significant predictors for 12-month mortality among older men living in veteran retirement communities. Although comorbidity of cancer and chronic lung disease were also major factors for mortality, physical dependence, and recent functional decline remained independently associated with 12-month mortality after adjustment for comorbidities. Previous studies have shown that poor baseline ADL and presence of physical functional decline could predict long-term mortality in the elderly population.[23–25] In addition, functional decline was also strongly associated with short-term mortality of older patients discharged from hospitals.[26] Even a part of recent functional

Table 3
Predictors of 12-month mortality for residents after 6 months' admission.

Variables	Odds ratio	95% confidence interval	p
Age (y)	1.008	0.956–1.062	0.777
Body mass index (kg/m²)	0.929	0.855–1.008	0.077
Depression	2.994	1.161–7.721	0.023*
Chronic lung disease	2.279	1.149–4.522	0.018*
Cancer	3.23	1.078–9.682	0.036*
Baseline RUG-III ADL	1.116	1.002–1.242	0.046*
ADL decline	2.305	1.002–5.303	0.049*
RAP trigger for dehydration	13.857	3.07–62.543	0.001*

*$p < 0.05$.
ADL = activity of daily living; RAP = resident assessment protocol; RUG-III ADL = Resource Utilization Group-III for Activities of Daily Living.

Table 4
Associated factors between ADL decliner and ADL non-decliner by univariate analysis.

Variables	Decliner (n = 65)	Non-decliner (n = 1060)	p
Age (y)	84.2 ± 5.6	83 ± 5.1	0.084
Body mass index (kg/m^2)	22.6 ± 3.9	23.7 ± 3.4	0.026*
Baseline RUG-III ADL	5.1 ± 2.7	4.5 ± 1.9	0.127
Twelve-month mortality	15 (23.1)	98 (9.2)	<0.001*
MDS COGS			
Intact–mild	40 (61.5)	925 (88)	<0.001*
Mild–moderate	19 (29.2)	87 (8.3)	
Moderate–severe	5 (7.7)	37 (3.5)	
Severe–very severe	1 (1.5)	2 (0.2)	
Pain scale			
No pain	36 (55.4)	653 (62)	0.077
Less than daily pain	15 (23.1)	270 (25.6)	
Mild/moderate daily pain	13 (20.0)	122 (11.6)	
Severe daily pain	1 (1.5)	8 (0.8)	
Baseline SocE	1.2 ± 1.1	2 ± 1.3	<0.001*
Comorbidities			
Arthritis	5 (7.7)	166 (15.7)	0.082
Cerebrovascular disease	9 (13.8)	77 (7.3)	0.086
Dementia	12 (18.5)	57 (5.4)	<0.001*
Depression	8 (12.3)	34 (3.2)	0.002*
Hypertension	26 (40.0)	570 (53.8)	0.031*
Parkinsonism	7 (10.8)	33 (3.1)	0.006*
RAP triggers			
Delirium	4 (6.2)	21 (2.0)	0.051
Cognitive loss	44 (67.7)	335 (31.6)	<0.001*
Visual function	40 (61.5)	519 (49.0)	0.049*
Communication	29 (44.6)	353 (33.3)	0.062
Rehabilitation needs	55 (84.6)	744 (70.2)	0.013*
Urinary incontinence	22 (33.8)	164 (15.5)	<0.001*
Mood states	24 (36.9)	156 (14.7)	<0.001*
Behavior symptoms	4 (6.2)	14 (1.3)	0.017*
Falls	30 (46.2)	325 (30.7)	0.009*
Pressure sore	17 (26.2)	137 (12.9)	0.003*
Psychotropic drugs	55 (84.6)	649 (61.2)	<0.001*
Physical restraint	7 (10.8)	35 (3.3)	0.008*
Sum of RAP triggers at baseline	7.2 ± 2.7	5.3 ± 2.5	<0.001*
Increase in sum of RAP triggers within 6 mo	55 (84.6)	465 (43.9)	<0.001*

*$p < 0.05$.
ADL = activity of daily living; MDS COGS = Minimum Data Set Cognitive Scale; RAP = resident assessment protocol; RUG-III ADL = Resource Utilization Group-III for Activities of Daily Living.

decline among residents might be influenced by other acute illness or exacerbation of underlying chronic conditions; however, most attributable causes to recent functional decline should result from the geriatric syndrome. In this study, it is clearly shown that both physical dependence and recent functional decline were major factors for 12-month mortality, which was compatible with the terminal trajectory of physical function in the frail and diseased population.[1] Developing strategies to manage physical dependence and to prevent functional decline is important to prevent premature mortality in this setting.

Table 5
Risk factors associated with functional decline after adjustment by age and body mass index.

Variables	Odds ratio	95% confidence interval	p
Age (y)	1.043	0.979–1.111	0.194
Body mass index (kg/m^2)	0.929	0.845–1.021	0.127
Parkinsonism	3.875	1.169–12.841	0.027
RAP trigger for cognitive loss	3.164	1.612–6.212	0.001
RAP trigger for mood	2.894	1.466–5.71	0.002
Increase in sum of RAP within 6 mo	6.096	2.741–13.562	<0.001

*$p < 0.05$.
RAP = resident assessment protocol.

Increased sum of RAP triggers was positively correlated to recent functional decline, and may subsequently increase mortality risk. Furthermore, the dynamic increase in the sum of RAP triggers outweighed the importance of baseline sum of RAP triggers in this study related to functional decline. The sum of RAP triggers was believed to be a good indicator for the burden of care need and care complexity of individual residents, and it might be a better indicator for disease burden and severity than the other comorbidity indices based on MDS implementation. In the previous Longitudinal Older Veterans study results, the sum of RAP triggers showed a positive correlation with functional decline in an 18-month period and was associated with higher 12-month mortality risk.[7,17] Increase in the sum of RAP triggers suggested increased care burden and deterioration of physical independence, and was shown to have a good correlation with the trajectory of physical functional decline. Thus, a multidisciplinary approach should be used to appropriately manage and reverse each individual RAP trigger early and effectively to prevent increasing triggers of RAPs.

Positive RAP trigger for baseline dehydration was also found to be a strong predictor for additional 12-month mortality. Dehydration was not a rare problem to residents in LTCFs, and it affected the homeostatic status of individual organs and systems.[27] It was proven to be a major risk factor for morbidity and mortality because of related electrolytes and fluid imbalance among the elderly with impaired physiological reserve and reduced compensatory ability.[28] Many studies revealed that dehydration was a significant factor in predicting mortality among nursing home residents or in populations with dementia.[29–32] Unlike other factors such as underlying diseases or necessary medications, dehydration should be a reversible cause for mortality, and more attention should be paid to early identification and intervention.[33] The systemic approach and adequate assessment of fluid status would facilitate early and proper intervention of hydration among the elderly.[28,32–34]

Residents with depression were revealed to have a higher risk for mortality in our study, and positive RAP trigger for mood state was also found to be an associated factor for functional decline. Depression has been recognized as a major factor that worsened health outcomes of diseases and promoted disabilities, and was also revealed as a factor for functional decline by previous studies.[35–37] However, depression was influenced by various underlying diseases and socioeconomic statuses, and thus the association between depression and mortality was still controversial.[38] But it was generally believed that the diagnosis of depression was less appropriate, and the prevalence of depression was underestimated especially in the geriatric population.[35–38] As subsyndromal depression in the elder population is estimated to be 8–9% in Asia, early detection for depression by effective tools and adequate treatment for both depression and associated factors were of great importance.[39–41]

In addition to the neurological disease of Parkinsonism, positive RAP trigger for cognitive loss was identified to be a risk factor of functional decline. Cognitive impairment or dementia was proven to affect the deterioration of physical function in various durations, either due to behavior and psychological symptoms, or other acute illness associated with dementia.[7,16,42] Residents with cognitive impairment would have less ability to cope with environmental changes or cooperate with active intervention programs, and thus had higher risk of developing disabilities and physical dependence.[7,8,43,44] Multidimensional programs including reminiscence therapy and group exercise regimens might benefit cognitive impairment and further prevent advanced functional decline.[45–47]

Although this study showed that ADL decline was a risk factor of short-term mortality, there are still several limitations. First, the demographic characteristics of the study participants were

homogeneous, especially in terms of sex, which would limit the generalizability of these study results to the common population. However, these findings should still be applicable to residents hosted in long-term care settings. Second, this study is mainly an observational study and thus the effectiveness of intervention programs for each reversal of modifiable risk factors would prevent functional decline and reduce mortality. Further multidisciplinary intervention programs are needed to clarify whether change of modifiable risk factors would improve functional status and reduce mortality. Third, residents who died within the first 6 months were not included for analysis, and thus there might be bias related to a better health status among the remaining residents. However, an analysis of the baseline profile among deceased individuals within 6 months and those included in our study showed no significant difference in each category. Thus, we believed the factors distributed among different groups should not be disregarded after including those deceased individuals.

5. Conclusions

Functional decline independently predicts additional 12-month mortality among LTCF residents, whereas the increased sum of RAP triggers as well as a positive trigger for cognitive loss and mood were associated with functional decline. The implementation of an active screening strategy for RAP triggers and adequate interventional programs before the true development of functional decline was suggested.

Conflicts of interest

The authors have no conflicts of interest relevant to this article.

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