

National Pricing Model 2024-25

Risk adjustments for hospital acquired
complications

Technical Specifications

March 2024



IHACPA

National Pricing Model 2024-25 - Risk adjustments for hospital acquired complications - Technical Specifications - March 2024

© Independent Health and Aged Care Pricing Authority 2024

This publication is available for your use under a [Creative Commons BY Attribution 3.0 Australia](#) licence, with the exception of the Independent Health and Aged Care Pricing Authority logo, photographs, images, signatures and where otherwise stated. The full licence terms are available from [the Creative Commons website](#).



Use of Independent Health and Aged Care Pricing Authority material under a [Creative Commons BY Attribution 3.0 Australia](#) licence requires you to attribute the work (but not in any way that suggests that the Independent Health and Aged Care Pricing Authority endorses you or your use of the work).

Independent Health and Aged Care Pricing Authority material used 'as supplied'.

Provided you have not modified or transformed Independent Health and Aged Care Pricing Authority material in any way including, for example, by changing Independent Health and Aged Care Pricing Authority text – then the Independent Health and Aged Care Pricing Authority prefers the following attribution:

Source: The Independent Health and Aged Care Pricing Authority

1. Executive summary

1.1 Purpose

This document has been produced as an accompaniment to the National Efficient Price Determination 2024-25 (NEP24). It provides the technical specifications for how the Independent Health and Aged Care Pricing Authority (IHACPA) developed the hospital acquired complication (HAC) funding approach and risk adjustment methodology, which has been in effect since 1 July 2018. It also provides guidance to hospitals, local hospital networks (LHNs) and state and territory health authorities on how to apply these to hospital activity.

1.2 Risk adjustment

On the 29 August 2016, IHACPA received a ministerial direction which required IHACPA to develop a risk adjustment methodology 'to consider different patient complexity levels or specialisation across jurisdictions and hospitals.'

This approach is also relevant to risk adjustment for safety and quality where the objective is to provide funding signals so that hospitals can take action to reduce systemic risks related to the delivery of care. Some patients will be at higher risk of adverse events due to factors such as their age and the presence of other comorbidities. The design of risk adjustment for safety and quality has to balance two perspectives, namely that:

- Hospitals that treat more high-risk patients should not be disadvantaged compared to hospitals that treat fewer such patients.
- From the perspective of patients, high-risk patients want assurance that hospitals will take all necessary actions to manage their risks and mitigate the occurrence of any adverse events.

This means that risk adjustment should not discount away or fully adjust for the higher risks experienced by some patients.

The risk adjustment model is built on a logistic regression model for each HAC. To ensure each risk factor is assessed in an effective and timely manner, IHACPA established multiple stages for the development of the model and assessment of each of the risk factors. This assessment involved:

- Seeking clinical advice on the appropriateness of the proposed risk factors.
- Conducting preliminary assessment to determine whether there was adequate volume of information to allow for their use.
- Assessing the statistical performance of the risk factor in predicting the occurrence of a HAC.

Full details of the risk adjustment model are provided in Section 6.

Episodes are classified into complexity groups for the purposes of dampening and funding adjustments. Three complexity groupings of 'low', 'moderate' and 'high' have been adopted to provide an optimal balance between complexities, risk homogeneity and sample size within each group, except for HAC15 which has two complexity groupings, 'low' and 'high'. Further details are provided in Section 7.

1.2.1 Incremental cost of a HAC

The funding approach for HACs requires that the funding level for all HACs across every hospital be reduced to reflect the extra cost of a hospital admission with a complication.

This additional cost may be a result of a more complex episode of stay, or due to an increase in the length of stay than would have otherwise occurred. It is necessary then to determine the value of only the *incremental* cost relating to the HAC and use this as the basis of the funding adjustment.

The methodology used to determine the incremental cost of a HAC uses similar principles to that adopted for the national cost models, using a linear regression to predict the cost of an episode. The episode's Australian Refined Diagnosis Related Group (AR-DRG) and length of stay were adopted in the predictive model as these characteristics represent the most significant cost drivers.

Overall, HAC episodes had a 9.5 per cent higher cost compared to non-HAC episodes (or a cost ratio of 1.095). Table 1 shows the incremental costs for all HACs as well as by HAC group.

Table 1: Incremental cost adjustments by HAC group

Complication		Final incremental cost	Adopted adjustment
All HACs		9.5%	8.7%
1	Pressure injury	16.8%	14.4%
2	Falls resulting in fracture or intracranial injury	2.2%	2.2%
3	Healthcare-associated infection	9.4%	8.6%
4	Surgical complications requiring unplanned return to theatre	13.0%	11.5%
5	Unplanned intensive care unit admission	n/a	n/a
6	Respiratory complications	15.7%	13.5%
7	Venous thromboembolism	11.8%	10.5%
8	Renal failure	24.7%	19.8%
9	Gastrointestinal bleeding	10.0%	9.1%
10	Medication complications	12.9%	11.5%
11	Delirium	11.9%	10.6%
12	Incontinence	8.8%	8.1%
13	Endocrine complications	8.9%	8.1%
14	Cardiac complications	14.1%	12.4%
15.01	Third degree perineal laceration during delivery	n/a	n/a
15.02	Fourth degree perineal laceration during delivery	46.6%	31.8%
16	Neonatal birth trauma	n/a	n/a

Note: figures have been rounded to 1 decimal place

The final incremental costs for each HAC are then converted into adjustments which will be applied to the national weighted activity unit (NWAU) through the use of the formula:

$$\text{Adjustment} = 1 - \frac{1}{1 + \text{incremental cost}}$$

1.2.2 Dampening factors

The 29 August 2016 direction to IHACPA stated that pricing and funding approaches should balance the likelihood that some patients will be at higher risk of experiencing an adverse event. This has been addressed by the construction of dampening factors that vary depending on the episode's complexity, or risk, of a particular HAC occurring.

Section 9 provides further details on the quantile cut off points, dampening factors and adjustment factors for each of the HAC groups.

1.2.3 Funding adjustment

The following steps are used to determine the adjustment:

1. Calculate the overall complexity score for each HAC in an episode by summing the complexity scores derived from each risk factor variable relevant to each HAC.
2. Assign a complexity group for each HAC based on the complexity score using the quantile cut off points.
3. Apply the adjustment relevant to each HAC based on the assigned complexity group. If an episode contains more than one HAC, then the maximum adjustment is used for the funding adjustment (regardless of the complexity of the HAC).
4. Calculate the final safety and quality adjusted NWAU, calculated as:

$$\text{Adjusted NWAU} = \text{NWAU} - \text{base price weight} \times \text{adjustment factor}$$

The adjustments have been designed and calculated at an episode level allowing for aggregation to a jurisdiction, LHN or hospital level to determine the aggregate impact.

Contents

National Pricing Model 2024-25	1
1. Executive summary	3
1.1 Purpose	3
1.2 Risk adjustment.....	3
Contents	6
Acronyms and abbreviations	8
2. Introduction	9
2.1 Purpose	9
2.2 Background.....	9
2.3 Risk adjustment for hospital acquired complications	10
3. Data preparation	11
3.1 Overview	11
3.2 Identification of HACs.....	11
3.3 Hospital level trimming	12
3.4 Episode trimming	13
3.5 Distribution of HACs after trimming	15
4. Risk adjustment model	16
4.1 Overview	16
4.2 Identifying potential risk factors	16
4.3 Assessing risk factors to construct the risk adjustment model	16
4.4 Assessment of model fit	22
4.5 Third degree perineal laceration and neonatal birth trauma.....	23
5. Complexity scores	24
5.1 Overview	24
5.2 Complexity score conversion.....	24
5.3 Grouping of complexity scores	25
6. Incremental cost of a HAC	27
6.1 Overview	27
6.2 Methodology	27
6.3 Further adjustments	28
6.4 Results.....	29
7. Dampening factors	30
7.1 Overview	30
7.2 Methodology	31
7.3 Results.....	32

8. Funding adjustment	34
8.1 Overview	34
8.2 Methodology	34
8.3 Vignettes.....	35
9. Issues and other considerations	39
9.1 Treatment of episodes with multiple HACs.....	39
Appendix A: Risk factors considered in initial model development	40
Appendix B: ROC curves	41
Appendix C: PRC graphs	44
Appendix D: Complexity scores	47
Appendix E: Complexity bounds	53

Acronyms and abbreviations

APC NMDS	Admitted patient care national minimum data set
AR-DRG	Australian Refined Diagnosis Related Groups
ACHI	Australian Classification of Health Interventions
CAC	Clinical Advisory Committee
COAG	Council of Australian Governments
COF	Condition onset flag
Commission	Australian Commission on Safety and Quality in Health Care
GWAU	Gross weighted activity unit
HACs	Hospital acquired complications
ICD-10-AM	International Statistical Classification of Diseases and Related Health Problems, Tenth Revision, Australian Modification
ICU	Intensive care unit
IHACPA	Independent Health and Aged Care Pricing Authority
MDC	Major diagnostic category
NEP	National efficient price
NHCDC	National hospital cost data collection
NWAU	National weighted activity unit
ROC	Receiver operating characteristic
PRC	Precision recall curves
SEIFA	Socio-economic indexes for areas

2. Introduction

2.1 Purpose

This document has been produced as an accompaniment to the National Efficient Price 2024-25 (NEP24) Determination. It provides the technical specifications for how the Independent Health and Aged Care Pricing Authority (IHACPA) developed the hospital acquired complication (HAC) funding approach and risk adjustment methodology, which has been in effect since 1 July 2018. It also provides guidance to hospitals, local hospital networks (LHNs) and state and territory health authorities on how to apply these to hospital activity.

2.2 Background

In April 2016, all Australian governments signed a Heads of Agreement that committed to improve Australians' health outcomes and decrease avoidable demand for public hospital services through a series of reforms including the development and implementation of funding and pricing approaches for safety and quality.

The commitment by governments to pricing for safety and quality follows a four-year work program jointly undertaken by IHACPA and the Australian Commission on Safety and Quality in Health Care (the Commission) to undertake research and develop options for incorporating safety and quality into IHACPA's annual Pricing Framework for Australian Public Hospital Services (the Pricing Framework). One of the outcomes of this collaboration was the development, through a clinician-led process, of an agreed Australian list of HACs.

In August 2016, IHACPA was given a direction by the then Commonwealth Minister for Health and Aged Care, acting under subsection 226(1) of the *National Health Reform Act 2011* (the Act). IHACPA was directed to advise the Council of Australian Governments (COAG) Health Council on options for a comprehensive and risk adjusted model to determine how funding and pricing could be used to improve patient outcomes across three key areas: sentinel events, HACs and avoidable hospital readmissions.

Informed by feedback from the Consultation Paper on the Pricing Framework for Australian Public Hospital Services 2017–18, on 30 November 2016, IHACPA provided advice to the COAG Health Council on options for the integration of safety and quality into public hospital pricing and funding models.

In February 2017, the Commonwealth Minister for Health directed IHACPA to undertake implementation of three recommendations of the COAG Health Council relating to sentinel events, HACs and avoidable readmissions. IHACPA's decisions in relation to this were set out in the Pricing Framework for Australian Public Hospital Services 2017-18.

For HACs, this included that, consistent with the ministerial direction, IHACPA will reduce the funding level for all HACs across every hospital to reflect the extra cost of a hospital admission with a complication by 1 July 2018, subject to the results of a shadow year from 1 July 2017.

In implementing this approach, IHACPA was directed to:

- Further refine the risk adjustment methodology prior to 1 July 2018.
- Shadow the implementation of the HACs model to assess the impact on funding, data reporting, clinical information systems, and specific population and peer hospital groups.
- Conduct public consultation on the findings of the shadow implementation and report to the COAG Health Council by 30 November 2017.

2.3 Risk adjustment for hospital acquired complications

The August 2016 ministerial direction required IHACPA to develop a risk adjustment methodology 'to consider different patient complexity levels or specialisation across jurisdictions and hospitals.'

The Pricing Framework includes adjustments to the NEP that are intended 'to reflect legitimate and unavoidable variations in the costs of delivering health care services' (Clause A131(d) of the Act). This is intended to ensure that hospitals are not unfairly penalised if they experience higher costs due to factors that are largely outside their control. IHACPA's Pricing Guidelines stipulate that adjustments to the price should, as far as practicable, be based on patient-related rather than provider-related characteristics.

This approach is also relevant to risk adjustment for safety and quality where the objective is to provide funding signals so that hospitals can take action to reduce systemic risks related to the delivery of care. Some patients will be at higher risk of adverse events due to factors such as their age and the presence of other comorbidities. The design of risk adjustment for safety and quality has to balance two perspectives, namely that:

- Hospitals that treat more high-risk patients should not be disadvantaged compared to hospitals that treat fewer such patients.
- However, from the perspective of patients, high-risk patients want assurance that hospitals take all necessary action to manage their risks and mitigate the occurrence of any adverse events.

This means that risk adjustment should not discount away or fail to account for the higher risks experienced by some patients. Pricing and funding approaches should balance the likelihood that some patients will be at higher risk of experiencing an adverse event while ensuring that all hospitals have ongoing responsibility to mitigate risks, to reduce and manage any negative impacts for all patients, and to improve safety and quality systemically.

In November 2016, IHACPA's initial advice to COAG Health Council included a preliminary risk adjustment approach for HACs based on a patient's age, as this is the single biggest predictor of the likelihood of someone incurring a HAC.

Since February 2017, IHACPA has worked with a range of stakeholders including jurisdictions, clinicians and technical experts to refine the risk adjustment methodology. Refinements included consideration of a broad range of patient factors in the model, the technical approach to funding adjustments and the balancing of the two perspectives described above. Additionally, from NEP20, HAC15.02 Fourth degree perineal lacerations from delivery was included in the risk adjusted models with risk factors specific to this HAC category.

3. Data preparation

3.1 Overview

The development of the risk adjustment model and funding adjustments for HACs utilised hospital activity and cost data related to admitted acute separations.

Three years of hospital activity data were used to develop the risk adjustment model, using the admitted patient care (APC) datasets for the 2019-20, 2020-21 and 2021-22 years. These datasets contain episode-level information about the hospital, patient and importantly, diagnoses information which allowed for HAC identification.

Hospital cost data was used in the modelling to determine the incremental cost of a HAC. This data was sourced from the 2019-20, 2020-21 and 2021-22 National Hospital Cost Data Collection (NHCDC). These data sources are summarised in Table 2.

Table 2: Data used for the development of pricing for hospital acquired complications¹

Data source	Risk adjustment model	Incremental cost model
APC1920	Yes	Yes
APC2021	Yes	Yes
APC2122	Yes	Yes
NHCDC1920	No	Yes
NHCDC2021	No	Yes
NHCDC2122	No	Yes

3.2 Identification of HACs

Fundamental to the development of the risk adjustment model and funding adjustments was the list of the HACs which were considered in the modelling. In 2012, the Commission and IHACPA established a joint working group and over the years have refined and developed the current list of HACs (the HAC list).

All the work undertaken for the development of pricing for HACs in NEP24 has utilised the HAC list Version 3.1 as at March 2021. This list contains 16 HACs summarised in Table 3. A full list of all HACs and identifying diagnoses is available on the Commission's website². The only change in moving from Version 3.0 to Version 3.1 is the inclusion of mental health cohorts which do not impact HAC counts.

There are two key pieces of information required to determine the presence of a HAC in a hospital separation within the APC dataset; the diagnosis code and the condition onset flag (COF). The diagnosis code is recorded using the International Statistical Classification of Diseases and Related Health Problems, Tenth Revision, Australian Modification (ICD-10-AM) under the edition which is relevant to each year's data collection.

In the APC dataset, each diagnosis code in the diagnosis array will also have an associated COF, which identifies whether the condition was present on admission or not. This information is critical in

¹Details on these datasets can be found at: <https://www.ihacpa.gov.au/health-care/data/data-specifications/>

² <https://www.safetyandquality.gov.au/our-work/indicators/hospital-acquired-complications/>

determining whether the complication was acquired during the hospital stay for the purposes of correctly identifying a HAC.

Table 3: List of hospital acquired complications

Number	Complication
1	Pressure injury
2	Falls resulting in fracture or intracranial injury
3	Healthcare-associated infection
4	Surgical complications requiring unplanned return to theatre
5	Unplanned intensive care unit admission
6	Respiratory complications
7	Venous thromboembolism
8	Renal failure
9	Gastrointestinal bleeding
10	Medication complications
11	Delirium
12	Incontinence
13	Endocrine complications
14	Cardiac complications
15	Third and fourth degree perineal laceration during delivery
16	Neonatal birth trauma

Although the HAC list from the Commission includes HAC05: unplanned intensive care unit admission, this currently cannot be measured. This is because the information that is required to identify an unplanned intensive care (ICU) unit admission is not collected in the current dataset specification and thus cannot be identified.

3.3 Hospital level trimming

In order to develop a robust risk adjustment model, the APC data was trimmed such that only records which were of a certain quality and reflective of hospital experience would be included in the modelling dataset. It was particularly important to understand and only retain records from hospitals which had a high quality of COF reporting. This process was carried out at a hospital level.

Three rules were developed to identify whether a hospital would be trimmed:

- Hospitals with fewer than 100 episodes were trimmed. This removed low-volume hospitals where it is not possible to determine the quality of COF reporting.
- Hospitals where less than one per cent of episodes contained conditions arising in the hospital (that is, where less than one per cent of records had a COF = '1' for any diagnosis). This removed hospitals deemed to have unusually few episodes with any condition arising during episode.
- Hospitals where more than 10 per cent of episodes had no reported COF (that is, where more than 10 per cent of episodes only reported COF = '9' for all diagnoses). This removed hospitals deemed to have poor quality COF reporting due to the high proportion of unknown condition onset statuses.

This process resulted in:

- 262 hospitals out of 767 public hospitals being trimmed for 2019-20, accounting for 144,078 episodes (or 2.1 per cent).
- 284 hospitals out of 798 public hospitals being trimmed for 2020-21, accounting for 189,494 episodes (or 2.7 per cent).
- 221 hospitals out of 750 public hospitals being trimmed for 2021-22, accounting for 107,059 episodes (or 1.6 per cent).

3.4 Episode trimming

In addition to hospital level quality trimming, records were also trimmed based on characteristics of the episode of care. These records were trimmed to improve the robustness of the risk adjustment model as some types of admissions would not be expected to receive a HAC. These trimmed records generally fell into three categories.

The first category included trimming episodes considered to be outliers. This was after discussions with risk adjustment experts Professors Scott and Yong, who advised that their inclusion would disproportionately skew the risk adjustment model. These outlier episodes included:

- Long-stay patients (patients with a length of stay greater than 200 days).
- Patients over 95 years old.
- Episodes where the patient died.

The second category included trimming episodes where the admission characteristics could not lead to a HAC or that they were generally not representative for the purpose of determining the probability of a HAC occurring, as advised by the Commission. This category included:

- Episodes classified as same-day dialysis, chemotherapy or radiotherapy, on the basis that these are high-volume, same-day episodes with very low HAC counts and have the potential to 'wash' out the analysis.
- Episodes from rehabilitation, mothercraft, psychiatric, other non-acute and unpeered hospitals. These hospitals had a very low prevalence of HAC and were selected for trimming.

The final category included trimming episodes considered out-of-scope for the purpose of developing the risk adjustment model and calculating the funding adjustments. This included:

- Episodes not from activity based funding (ABF) public hospitals (that is, private or block-funded hospitals).
- Episodes with error or ungroupable diagnosis related groups (AR-DRGs).

Additionally, episodes with input errors were removed from the in-scope datasets. These include:

- Episodes where the separation date is before the admission date.
- Episodes where the admission date is before the birth date.
- Episodes where the separation date is before the birth date.
- Episodes with the default birth date of 1 January 1900.

The number of episodes trimmed for the 2019-20, 2020-21 and 2021-22 activity data at each step is summarised in Table 4.

Table 4: Summary of trimmed episodes for the 2019-20, 2020-21 and 2021-22 activity data

	Number of records 2019-20	Number of records 2020-21	Number of records 2021-22
Total episodes	6,734,253	7,054,704	6,787,446
Trimming due to:			
Non-public hospitals	219,175	261,386	269,128
Hospital quality trimming:			
<i>Stage 1: low volume</i>	5,572	4,735	4,532
<i>Stage 2: COF = 1 less than 1%</i>	138,506	184,759	99,359
<i>Stage 3: COF = 9 greater than 10%</i>	0	0	3,168
Error AR-DRGs	126	285	991
Peer group trimming	7,448	2,387	2,375
Non-ABF hospital trimming	184,793	170,612	213,402
Same-day dialysis trimming	1,241,409	1,298,639	1,223,465
Same-day chemotherapy trimming	283,119	293,827	305,469
Patient over 95 trimming	18,666	19,933	21,001
Death trimming	30,877	30,307	35,289
Long stay patient trimming	173	136	162
Same-day radiotherapy trimming	3,256	2,859	3,397
Input error trimming	1	0	0
Total episodes remaining (untrimmed)	4,601,132	4,784,839	4,605,708
% of episodes trimmed from public hospitals	29.38%	29.57%	29.34%

3.5 Distribution of HACs after trimming

The number of HACs identified after trimming is presented in Table 5.

The total number of episodes identified with a HAC was 91,956, 93,528 and 89,112 for 2019-20, 2020-21 and 2021-22 respectively. This equates to approximately 2.0 per cent, 2.0 per cent and 1.9 per cent for each year respectively of untrimmed episodes.

The number of episodes identified for each HAC group is also shown in Table 5. Episodes with multiple HACs have been counted more than once (in their respective HAC groups) and thus the total HAC episodes will be less than the sum of the individual HAC groups.

Table 5: Number of HACs for 2019-20, 2020-21 and 2021-22

No.	Complication	2019-20	2020-21	2021-22
	Total episodes with a HAC	91,956	93,528	89,112
	<i>Number of episodes with:</i>			
1	Pressure Injury	1,416	1,382	1,522
2	Falls resulting in fracture or intracranial injury	1,292	1,368	1,557
3	Healthcare-associated infection	35,087	34,706	35,113
4	Surgical complications requiring unplanned return to theatre	16,232	17,382	14,221
5	Unplanned intensive care unit admission	n/a	n/a	n/a
6	Respiratory complications	9,008	9,831	10,252
7	Venous thromboembolism	2,780	3,077	3,030
8	Renal failure	453	459	428
9	Gastrointestinal bleeding	3,074	3,126	3,015
10	Medication complications	2,892	2,909	2,221
11	Delirium	14,774	15,484	15,004
12	Incontinence	1,281	1,427	1,152
13	Endocrine complications	8,902	9,374	9,738
14	Cardiac complications	14,115	12,933	11,565
15	Third and fourth degree perineal laceration during delivery	4,922	4,723	4,655
16	Neonatal birth trauma	1,098	1,101	1,029

4. Risk adjustment model

4.1 Overview

This section outlines the methodology used to develop the risk adjustment model and the risk factors adopted. Overall, the risk adjustment model predicts the probability of a specific HAC occurring within an episode of care. A patient with a higher probability of receiving a HAC is expected to be at a 'higher risk'.

4.2 Identifying potential risk factors

IHACPA previously undertook an extensive consultation process with the Australian Commission on Safety and Quality in Health Care (the Commission), IHACPA's Clinical Advisory Committee (CAC) and jurisdictions to investigate potential risk factors for HACs.

Empirical evidence suggested that patient age was a strong predictor for the probability of a specific HAC occurring within an episode of care. Thus, the preliminary risk adjustment model developed in 2016 utilised patient age as the only risk factor (the age only model). This model was conceptually simple and easy to explain, however it did not appear to adequately adjust for specialist paediatric and tertiary hospitals.

Further, it was believed that there may be other risk factors which could significantly impact the probability of a particular patient acquiring a HAC which should be also considered in the model. IHACPA sought consultation from the Commission and the CAC regarding risk factors that should be considered in a refined risk adjustment model. The various risk factors investigated in the model presented for consultation in the HAC Technical Specifications in July 2017 are provided in **Appendix A**.

Based on advice from the Commission, a unique set of risk factors were investigated for fourth degree perineal laceration during delivery (HAC15.02) risk model, as shown in **Appendix A**. This includes the use of young and mature aged primigravida instead of primiparity due to the lack of consistent documentation in the latter category. The panel has recommended advocating for routine coding of parity. Another risk factor that was noted by the panel, but not included in the model due to lack of documentation, was mothers of Asian ethnicity.

4.3 Assessing risk factors to construct the risk adjustment model

The risk adjustment model is built on a logistic regression model for each HAC. To ensure each risk factor is assessed in an effective and timely manner, IHACPA has established multiple stages for the assessment of each risk factor and the development of the risk adjustment model. This assessment involves:

- Seeking clinical advice on the appropriateness of the proposed risk factors.
- A preliminary assessment to determine whether there was adequate volume of information to allow for their use.
- Assessing the statistical performance of the risk factor in predicting the occurrence of a HAC.

4.3.1 Clinical advice

IHACPA sought the advice of the CAC at various points during the development of the original risk adjustment model on the choice of risk factors, first for broad consideration and exploration, and then following statistical analysis, for finalisation of the model.

This included advice in relation to the potential use of length of stay and presence of another HAC within the same episode as risk factors within the model. Advice from the CAC was that the lines of causation and correlation between these risk factors and HACs were blurred, and that it was not appropriate to include them within the model. For example, an episode with a higher length of stay has a higher exposure to risk receiving a HAC (correlation). However, conversely, the episode may have a longer length of stay due to a HAC occurring (causation). Risk factors deemed nonviable due to clinical advice were removed before the subsequent stages.

4.3.2 Overall risk factor significance

A stepwise selection methodology was adopted in the final model proposed in July 2017 to test and select the risk factors included in the logistic regression model.

The stepwise selection methodology involves starting with a model with no variables and then iteratively adding each risk factor that provides the highest statistically significant improvement to the model's objective function. Variables are added to the model in an iterative approach involving two stages:

- Independent assessment: chi-squared statistics are calculated and used to test the null hypothesis that 'a specific risk factor that is not already in the model has no effect on the model performance' given the other variables already included in the model. For the first iteration there are no variables other than the intercept term. For subsequent iterations the variables included are those that were selected in previous steps.
- Stepwise selection: the risk factor that is statistically significant with the highest chi-squared statistic is added to the model. Variables cease being added once there are no other risk factors that meet the significance criteria for inclusion in the model.

As the risk factors for HAC15.02 are limited and based on clinical advice, a stepwise selection was not adopted the final model.

4.3.3 Individual parameter assessment HAC01 to HAC14

The individual parameter assessment investigates if there are any further potential refinements to each logistic regression model through examining the statistical performance of each class within the risk factors. The classes within each risk factor were assessed under several criteria including:

- The statistical significance of each parameter (0.05 threshold was adopted).
- The statistical estimates of a class compared with subsequent classes (that is, if there are overlaps between confidence intervals indicating potential groupings of parameters).
- Analysing trends in overall estimates within the risk factors and comparing them to clinical expectations.
- Impact on model performance.

This was an iterative assessment where various scenarios of different groupings of parameters were investigated.

The groupings adopted for the current risk adjustment model are consistent with those adopted for the final proposed model for consultation.

4.3.4 Risk factor assessment

The prior sections provide a methodology to assess the various risk factors for each HAC in an autonomous fashion. This section details a methodology for reassessment of the impacts for each risk factor with the objective to optimise the statistical performance and reduce the overall complexity of each logistic regression model. Risk factors are assessed against several criteria including:

- Complexity of identification (for example, if there are any interaction effects between patient age and ICU status).
- The consistency of the risk factor across each HAC model (that is, how prominent each risk factor is across the HAC logistic regression models).
- The odds ratio for each of the parameters.
- The impact on model performance if specific risk factors are removed.

4.3.5 Risk factors adopted for the HAC risk adjustment model

For NEP24, the model has not been completely re-fit using stepwise regression. However, there has been a change to replace the Charlson Score with its constituent individual comorbidity conditions, as risk factors in the HAC risk adjustment model.

All other risk factors remain the same as those used in the original model developed for consultation and presented in the Risk Adjustment Model for Hospital Acquired Complications – Technical Specifications (HAC Technical Specifications) in July 2017. Checks have been carried out to ensure the risk factors were still significant.

4.3.5.1 Replacing the Charlson Score with its constituent comorbidity conditions as risk factors

The Charlson Score is a commonly used comorbidity measure which seeks to predict patients' 10-year survival rate after leaving the hospital. The score ranges from 0 to 16 and is calculated as the sum of weighted scores for 17 different comorbidity conditions. The Charlson Score, adapted from Sundararajan et al (2004)³, has been used as a risk factor for all HAC categories except HAC15.2, since the introduction of a safety and quality adjustment for HACs.

For NEP24, the diagnosis codes used to identify each comorbidity condition underpinning the Charlson Score were updated to reflect contemporary editions of the ICD-10-AM. The updated list of diagnosis codes used to flag each comorbidity condition is provided in Table 6.

The update to the ICD-10-AM codes meant that the existing Charlson Score approach was no longer feasible and the weights reported by Sundararajan et al (2004) could no longer be applied. Instead, the Charlson Score has been replaced with its constituent comorbidity conditions as risk factors to the HAC risk adjustment model. This is similar to how the comorbidity conditions are used in the avoidable hospital readmissions risk adjustment model.

³ Sundararajan, V., Henderson, T., Perry, C., Muggivan, A., Quan, H. and Ghali, W.A., 2004. New ICD-10 version of the Charlson comorbidity index predicted in-hospital mortality. *Journal of Clinical Epidemiology*, 57(12), pp.1288-1294.

Table 6: Updated diagnosis codes used for flagging Charlson comorbidity conditions, which are risk factors in the HAC risk adjustment model (HAC01-HAC04, HAC06-14)

Charlson comorbidity condition	Diagnosis Codes
Acute myocardial infarction	I21-prefix I22-prefix
Congestive heart failure	I50-prefix I11.0-prefix I13.0-prefix I13.2-prefix U82.2
Peripheral vascular disease	I70-prefix I71-prefix I73-prefix
Cerebral vascular accident	I60-prefix to I66-prefix I67.0-prefix to I67.9-prefix I68.0-prefix to I68.2-prefix I68.8-prefix I69-prefix
Dementia	F00-prefix F01-prefix F03-prefix U79.1-prefix
Pulmonary disease	J40-prefix to J47-prefix J60-prefix to J67-prefix U83.1 U83.2 U83.3 U83.4
Connective tissue disorder	M30-prefix to M36-prefix M05-prefix M06-prefix U86.1 U86.3
Peptic ulcer	K25-prefix to K28-prefix
Liver disease	K70.0-prefix to K70.3-prefix K70.9-prefix K71.0-prefix K71.2-prefix to K71.9-prefix K72.0-prefix K73-prefix to K75-prefix K76.0-prefix to K76.4-prefix K76.8-prefix K76.9-prefix B18-prefix
Diabetes	E10.8 E10.9 E11.8 E11.9 E13.8 E13.9 E14.8 E14.9-prefix
Diabetes complications	E10.0-prefix to E10.7-prefix E11.0-prefix to E11.7-prefix E13.0-prefix to E13.7-prefix E14.0-prefix to E14.7-prefix
Paraplegia	G81-prefix G82.0-prefix to G82.2-prefix
Renal disease	N03-prefix N05.2-prefix to N05.6-prefix N07.2-prefix to N07.4-prefix N01-prefix N18.0-prefix N18.3-prefix to N18.9-prefix N19-prefix N25-prefix I12.0-prefix I13.1-prefix Z49.0-prefix to Z49.2-prefix U87.1
Cancer	C0-prefix to C3-prefix C40-prefix C41-prefix C43-prefix C45-prefix to C49-prefix C5-prefix C6-prefix C70-prefix to C76-prefix C80-prefix to C86-prefix C88.0-prefix C88.2-prefix to C88.4-prefix C88.7-prefix C88.9-prefix C90.0-prefix to C90.3-prefix C91.1-prefix C91.3-prefix to C91.9-prefix C92-prefix C93.0-prefix C93.1-prefix C93.3-prefix C93.7-prefix C93.9-prefix C94.0-prefix C94.2-prefix to C94.4-prefix C94.6-prefix C94.7-prefix C95.0-prefix C95.1-prefix C95.7-prefix C95.9-prefix
Metastatic cancer	C77-prefix to C79-prefix
Severe liver disease	K70.4-prefix K71.1-prefix K72.1-prefix K72.9-prefix K76.5-prefix to K76.7-prefix Z94.4-prefix U84.3
HIV	B20-prefix to B24-prefix R75-prefix Z21-prefix

Table 7 outlines the individual risk factors utilised for each HAC logistic regression risk adjustment model.

Table 7: Final risk factors adopted for each HAC group

Risk factors	1. Pressure injury	2. Falls resulting in fracture or intracranial injury	3. Healthcare-associated infection	4. Surgical complications requiring unplanned return to theatre	6. Respiratory complications	7. Venous thromboembolism	8. Renal failure	9. Gastrointestinal bleeding	10. Medication complications	11. Delirium	12. Incontinence	13. Endocrine complications	14. Cardiac complications	15.2 Fourth degree perineal laceration during delivery
Emergency admission status	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Patient age	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Major diagnosis category 11	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Intensive care unit status	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
AR-DRG11 type	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Acute myocardial function	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Congestive heart failure	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Peripheral vascular disease	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Cerebral vascular accident	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Dementia	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Pulmonary disease	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Connective tissue disorder	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Peptic ulcer	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	

Liver disease	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Diabetes	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Diabetes complications	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Paraplegia	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Renal disease	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Cancer	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Metastatic cancer	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Severe liver disease	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Human Immunodeficiency Virus (HIV)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Sex ⁴		✓	✓		✓	✓	✓	✓	✓	✓	✓		
Admission transfer status	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓
Foetal distress													✓
Instrument use													✓
Persistent posterior occiput presentation													✓
Young and mature aged primigravida													✓

⁴ In previous NEP technical specifications, this category was referred as 'gender.' It has been updated in this technical specification to distinguish it from the reporting of 'gender' in APC datasets from 2022-23 onwards. For the purposes of the HAC risk adjustment model, the 'male' sex category includes all patients who are not reported as 'female.' This treatment has not changed since the implementation of the HAC risk adjustment in NEP18.

4.4 Assessment of model fit

4.4.1 Receiver operating characteristic curve

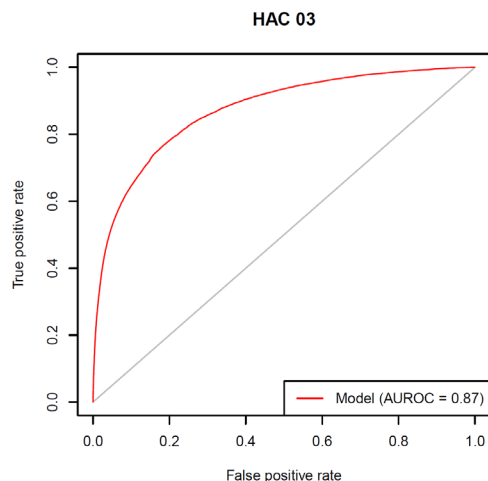
A receiver operating characteristic (ROC) curve is a statistical method that evaluates a model's ability to predict a binary outcome. In this context, it is the occurrence of a HAC during an episode of care. The ROC curve graphically compares the true positive rate to the false positive rate, where:

- A true positive rate is the rate at which the model *correctly* predicts a positive outcome.
- A false positive rate is the rate at which the model *incorrectly* predicts a positive outcome.

An optimal model would aspire to maximise its true positive rate and minimise its false positive rate (that is, maximising the area under the curve).

Figure 1 illustrates the ROC curve for HAC03 (healthcare-associated infections). **Appendix B** provides the ROC curve for each HAC complexity model.

Figure 1: HAC03 – Healthcare-associated infections – ROC curve



4.4.2 Precision recall curve

The precision recall curve (PRC) is a complement to the ROC curve. It may give additional insight compared to the ROC curve when evaluating model performance on imbalanced data.

Precision is the number of true positives out of all the predicted positives, meaning the number of episodes which actually had a HAC out of those predicted to have had a HAC.

Recall is another name of the true positive rate and represents how successful the model is in identifying an episode with a HAC. That is, out of all the HAC episodes in the data set, how many the model has identified.

This curve is also parametric, based on a threshold to declare each point as a readmission or not as a readmission. Similar to the ROC curve, PRC is a plot of precision versus recall as the threshold varies between 0 and 1.

PRC has been historically used in conjunction with ROC curves to evaluate the performance of the avoidable hospital readmissions model. To align to this reporting for NEP24, PRC results have also been computed for each HAC group and provided at **Appendix C**.

4.5 Third degree perineal laceration and neonatal birth trauma

In early 2019, the Commission convened condition-specific HAC curation clinical advisory panels for delirium, pressure injuries, renal failure, cardiac complications, respiratory complications, third and fourth degree perineal lacerations and neonatal birth trauma.

The panels considered the pricing of perineal lacerations and neonatal birth trauma, neither of which were included for a funding adjustment in NEP18 or NEP19. This was due to difficulty in identifying suitable risk factors to construct a robust risk adjustment model.

The clinical review supported further investigation into a risk adjustment model for fourth degree perineal lacerations. HAC funding adjustment for fourth degree perineal lacerations was implemented from NEP20. They did not support a HAC funding adjustment for third degree perineal laceration or neonatal birth trauma.

5. Complexity scores

5.1 Overview

This section outlines the methodology to transform the risk adjustment model into a set of complexity scores and assign a complexity group to each episode of care.

As separate risk adjustment models have been developed for each HAC, an episode is assigned different complexity scores for each HAC. That is, each episode can have a set of 14 complexity scores calculated using the various risk factor variables (corresponding to the 14 risk adjusted HAC groups).

5.2 Complexity score conversion

The logistic regression estimates for each risk factor variable are transformed into a score value. These score values are used in the calculation of an episode's overall complexity score for each HAC group. See **Appendix D** for the complete breakdown of complexity scores for each risk factor, for each HAC complexity model.

Table 8 provides an illustrative example for the derivation of the age group complexity score for HAC02 (falls resulting in fracture or intracranial injury). Table 8 shows that older patients are assigned a higher complexity score.

Table 8: HAC02 – Falls resulting in fracture or intracranial injury – Patient age complexity scores

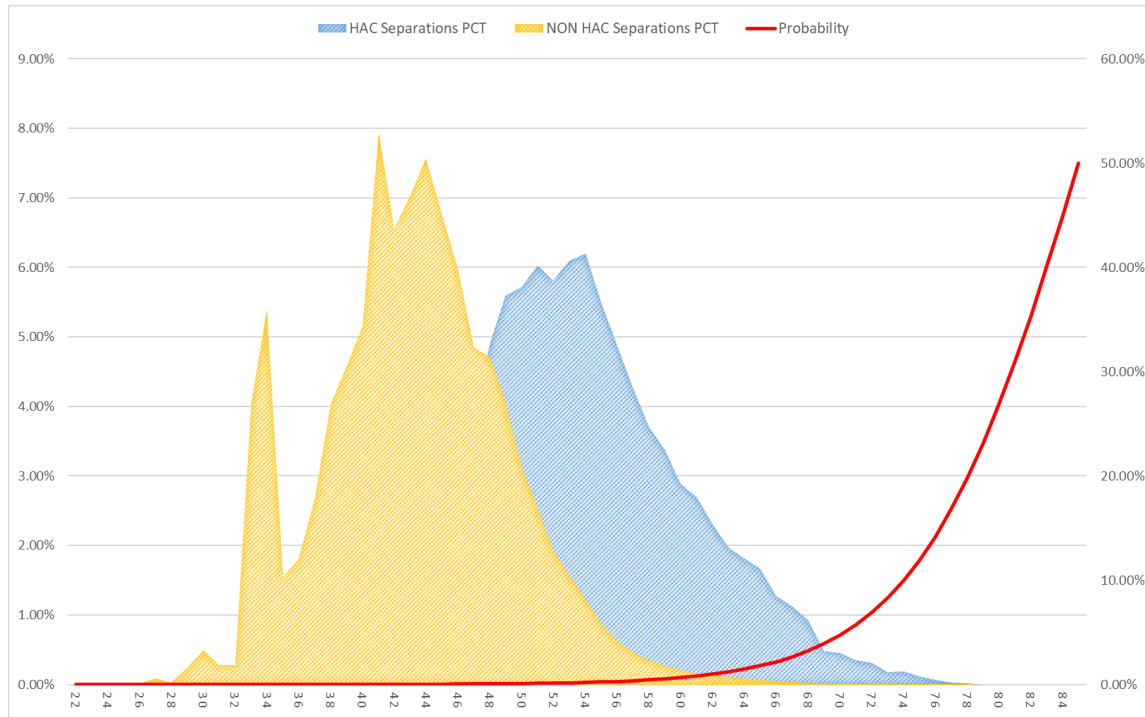
Parameters	Group	Estimate	Complexity Score
<i>Age group</i>	000 to 039	0	0
	040 to 049	0.6765	3.3824
	050 to 054	0.9978	4.989
	055 to 059	1.2645	6.3225
	060 to 064	1.5212	7.6058
	065 to 069	1.6525	8.2623
	070 to 074	1.7992	8.9961
	075 to 079	2.0502	10.2508
	080 to 084	2.4578	12.2889
	085 to 089	2.6939	13.4695
	090 to 099	2.8375	14.1874

The transformation of logistic regression estimates to score values are repeated for each risk factor. The complexity scores for each risk factor are additive, therefore, an episode complexity score for a specific HAC is the aggregation of scores across all risk factors based on the episode's characteristics.

To enable comparison across HACs, the episode complexity scores are derived such that they range from zero to 100, where zero represents the lowest chance of acquiring that HAC.

Zero is set with reference to an extremely low risk profile in the model, and 100 is set with reference to an extremely high risk profile in the model. Figure 2 illustrates the non-HAC and HAC complexity profiles for HAC10 (medication complications). Separations with a HAC are, in general, assigned a higher complexity score.

Figure 2: HAC10 – Medication complications – Complexity profile



5.3 Grouping of complexity scores

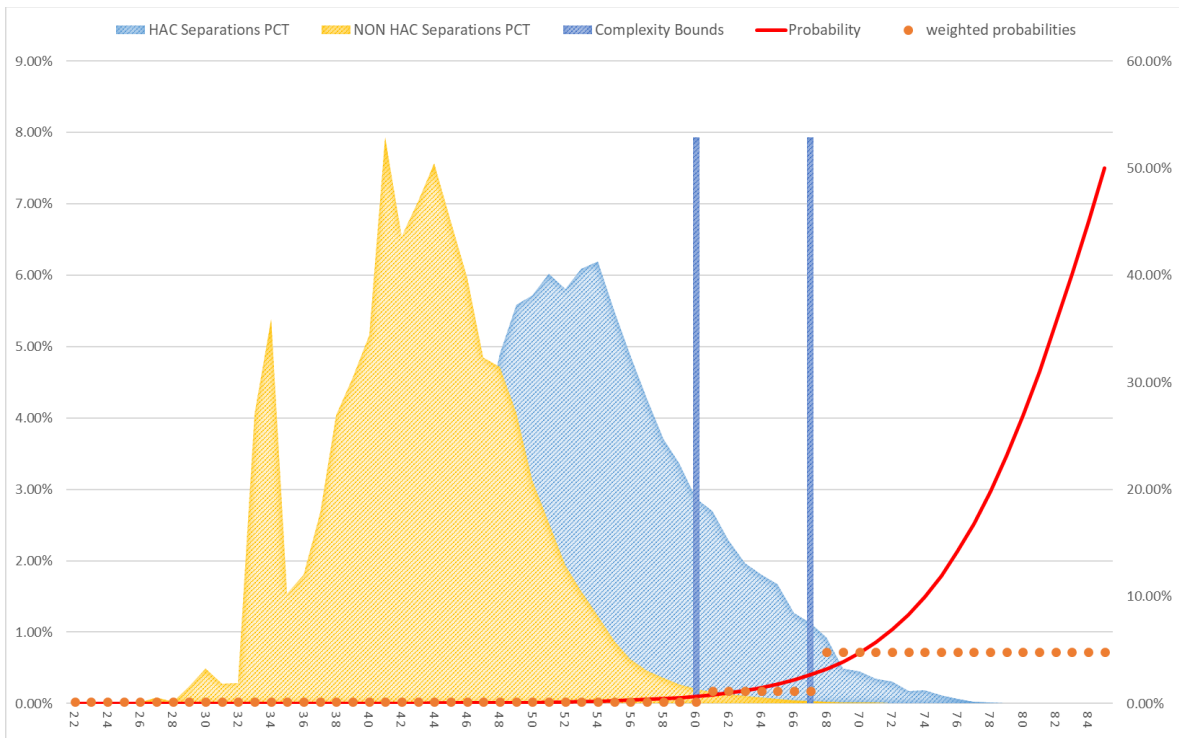
A range of complexity groups were investigated to provide balance between having enough volume of data for each grouping, to ensure reasonable separation between the cut-off points for each group and to distinguish the distribution of complexity scores for HAC and non-HAC separations. A range of options were tested, including two, three, five, eight and ten complexity groups. Three complexity groupings of 'low', 'moderate' and 'high' have been adopted to provide an optimal balance between complexities, risk homogeneity and sample size within each group. Due to the small cohort for HAC15.02, only two complexity groupings of 'low' and 'high' have been adopted.

The complexity bounds for each group were determined by first calculating the cumulative distribution of probability-weighted episodes for episodes with a HAC. The cut off points are calculated as the complexity score that divides the cumulative distribution into three quantiles with the following additional criteria:

- A minimum of 100 episodes must be contained within each complexity group.
- The ratio between probabilities between each group must be at least 1.2.

Figure 3 overlays the complexity bounds selected for HAC10 (medication complications) and the corresponding probabilities for each complexity group in the final selected groupings.

Figure 3: HAC10 – Medication complications – Complexity bounds



6. Incremental cost of a HAC

6.1 Overview

The funding approach for HACs requires that the funding level for all HACs across every hospital be reduced to reflect the extra cost of a hospital admission with a complication. This additional cost may be the result of a more complex episode of stay or due to an increase in the length of stay than would have otherwise occurred.

It is necessary then to determine the value of only the *incremental* cost relating to the HAC and use this as the basis of the funding adjustment. There are several challenges to this:

- In episodes that contain a HAC, it is impossible to identify what components of the cost directly result from the HAC in the NHDC data.
- The presence of a HAC may increase the length of stay, but it is impossible to determine the additional length of stay directly attributable to the HAC in the current data collections as there is no record of the date that the HAC occurred.
- The presence of a HAC may increase the complexity of an episode (resulting in a more complex AR-DRG) and this may confound analysis to determine the incremental cost and how an episode should be classified.

The following sections describe the methodology used to determine the incremental cost of a HAC and present the resulting factors used to calculate the funding adjustment.

6.2 Methodology

The methodology used to determine the incremental cost of a HAC uses similar principles to that adopted for the national cost models, in that it uses linear regression to predict the cost of an episode. The episode's AR-DRG and length of stay were adopted in the predictive model as these characteristics represented the most significant cost drivers. Other drivers of avoidable costs included in the national cost models, for example, remoteness and Indigenous status were not included to retain simplicity. These cost drivers may be considered in future refinements of the model.

Three years of activity and cost data were used for the incremental cost model and they were fit using untrimmed episodes only. The approach taken to determining the incremental cost can be summarised in the following steps:

1. A 'best fit' model was developed using a length of stay by AR-DRG linear regression to predict the cost of *non-HAC episodes* only. This model provides the best estimate for a cost of an episode with no HAC occurrence.
2. The modelled parameters were then applied to HAC episodes (by AR-DRG and length of stay) to calculate a predicted cost for HAC episodes based on the non-HAC information. This is the cost predicted for the HAC episode with the same AR-DRG and length of stay, but assuming the HAC was not present.
3. A cost ratio was then calculated to compare actual in-scope cost to the predicted cost for the HAC episodes.

$$\text{Cost ratio} = \frac{\text{Actual in-scope cost}}{\text{Predicted cost}}$$

Under the hypothesis that a HAC leads to greater cost, it would be expected that the actual in-scope cost of a HAC episode would be greater than what is predicted for a non-HAC episode with the same AR-DRG and length of stay. This would result in a cost ratio which is greater than 1.0 for HAC episodes.

This cost ratio formed the basis of the incremental cost calculation and was carried out for all HAC episodes in aggregate, as well as each HAC group separately to determine whether the incremental cost varied between HAC groups.

This approach was considered appropriate because of its relative simplicity, using a 'best fit' model that accounts for the main drivers of cost. Before finalising the incremental cost adjustments, some further adjustments were required to improve the overall results of the model as described below.

6.3 Further adjustments

In developing the cost ratios for each HAC group, several additional challenges were discovered, which required adjustments to the modelled incremental costs.

6.3.1 Low volume AR-DRGs and cost ratios less than 1

The overall HAC rates observed in the activity data were low, and therefore, using a model fit by AR-DRG meant that HAC rates were very volatile by AR-DRG. Furthermore, some AR-DRGs also had a low volume of non-HAC episodes, resulting in greater uncertainty in the modelled parameters.

For instance, the cost ratio of HAC episodes for some AR-DRGs were less than 1.0, despite HAC separations being more costly than non-HAC episodes at the aggregate and HAC group level. In addition to this, some AR-DRGs had many more HAC episodes compared to non-HAC episodes (for example some of the obstetrics AR-DRGs) which skewed the results for the HAC group related to perineal laceration during delivery.

As a result, the decision was made to trim AR-DRGs where the cost ratio was below 1.0 and calculate the cost ratio for the HAC group on the remaining AR-DRGs.

6.3.2 Treatment of HAC02: Falls resulting in fracture or intracranial injury and HAC12: Incontinence

These HACs had a very low number of HAC episodes and the resulting incremental cost calculations were therefore less robust than the other HAC groups. In particular, the incremental cost for HAC episodes was very close to 1.0. The decision was made to consider an alternative approach for these HAC groups which involved regrouping the affected episode's AR-DRG as if the HAC had not occurred. As described above, the presence of a HAC has the potential to increase the complexity of the episode, increasing the complexity of the episode's AR-DRG. This could result in that episode being compared to significantly more costly episodes which were in that AR-DRG for reasons other than the HAC.

Therefore, rather than applying the parameters from the 'best fit' model according to the recorded AR-DRG, the parameters for the regrouped (and potentially less complex) AR-DRG model were applied. This resulted in a lower predicted cost, and all else being equal, a potentially higher cost ratio.

The argument could be made that the 'best fit' model should be parameterised using regrouped AR-DRGs for all HAC groups. However, current price weights for the AR-DRGs are developed using a mix of HAC and non-HAC episodes for that AR-DRG and accordingly, the funding adjustment should be calibrated using the same AR-DRG assignments.

6.3.3 Treatment of HAC15.02: Fourth degree perineal lacerations during delivery

When a HAC15.02 occurs, the AR-DRG is usually changed to account for the new diagnosis. As a result, the cost of an episode with and without a HAC15.02 cannot be easily compared, as such the incremental cost of the HAC cannot be measured without regrouping the AR-DRG as if the HAC had not occurred.

Therefore, rather than applying the parameters from the ‘best fit’ model according to the recorded AR-DRG, the parameters for the regrouped AR-DRG model were applied. This resulted in a more accurate predicted cost and a more fitting cost ratio.

6.4 Results

Table 9 shows the incremental costs for all HACs, as well as by HAC group, using the trimmed AR-DRG and other adjustments as described in Section 8.3.

Table 9: Incremental cost adjustments by HAC group

Complication		Final incremental cost	Adopted adjustment
	All HACs	9.5%	8.7%
1	Pressure injury	16.8%	14.4%
2	Falls resulting in fracture or intracranial injury	2.2%	2.2%
3	Healthcare-associated infection	9.4%	8.6%
4	Surgical complications requiring unplanned return to theatre	13.0%	11.5%
5	Unplanned intensive care unit admission	n/a	n/a
6	Respiratory complications	15.7%	13.5%
7	Venous thromboembolism	11.8%	10.5%
8	Renal failure	24.7%	19.8%
9	Gastrointestinal bleeding	10.0%	9.1%
10	Medication complications	12.9%	11.5%
11	Delirium	11.9%	10.6%
12	Incontinence	8.8%	8.1%
13	Endocrine complications	8.9%	8.1%
14	Cardiac complications	14.1%	12.4%
15.01	Third degree perineal laceration during delivery	n/a	n/a
15.02	Fourth degree perineal laceration during delivery	46.6%	31.8%
16	Neonatal birth trauma	n/a	n/a

Note: figures have been rounded to 1 decimal place

Due to difficulty in constructing robust risk adjustment models, HAC15.01 Third degree perineal laceration during delivery and HAC16 Neonatal birth trauma were not considered for the funding adjustments. There are no funding adjustments for HAC05: unplanned intensive care unit admission because current dataset specifications do not collect information which can identify an unplanned ICU admission.

The final incremental costs for each HAC are then converted into adjustments which will be applied to the NWAU using the formula:

$$\text{Adjustment} = 1 - \frac{1}{1 + \text{Incremental cost}}$$

The application of the funding calculation is explained in detail in Section 10.

7. Dampening factors

7.1 Overview

The 29 August 2016 Direction to IHACPA stated that pricing and funding approaches should balance the likelihood that some patients will be at higher risk of experiencing an adverse event. This has been addressed by the construction of dampening factors that vary depending on the episode’s complexity, or risk, of a particular HAC occurring.

The episode’s complexity group (low, moderate or high, as defined in Section 7.3) is used to risk adjust the reduction. For example, an older patient admitted through emergency, and hence a higher probability of having a HAC, would not have as great a price reduction as a younger patient with a planned admission, and hence a lower probability of having the same HAC.

This section outlines the methodology adopted by IHACPA that were used to derive the dampening factors for each HAC. Dampening factors adjust the funding reduction for an episode containing a HAC based on the risk of that patient acquiring a HAC. This is determined using the incremental cost adjustment for each HAC as discussed in Section 8.4. Without dampening, episodes with higher complexity scores would be penalised the same amount for the same HAC as those with a lower complexity score. This goes against the intent of the pricing for safety and quality. Dampening factors have been developed to adjust for these differences in risk among patient profiles for different hospitals.

In preliminary modelling, dampening factors were determined through age alone. As a more refined risk model was developed, this also necessitated the refinement of the methodology used to calculate the dampening factors.

Dampening factors are represented as a set of percentage scores for each complexity group which is applied multiplicatively to the percentage reduction in NWAU (i.e. the lower the dampening factor applied, the smaller the reduction in NWAU). Table 10 provides an illustrative example.

Table 10: Example – Dampening factor calculations

Complexity Group	Reduction in NWAU (a)	Dampening Factor (b)	Funding Impact (c) = (a) x (b)
Low	-10%	100%	-10%
Moderate	-10%	50%	-5%
High	-10%	20%	-2%

Table 10 shows that all episodes receive the same percentage reduction in NWAU, which would be the case if the episodes had the same HAC. However, by varying the dampening factor, episodes within each complexity group for the same HAC vary as follows:

- Low complexity group receives a 10 per cent reduction in NWAU.
- Moderate complexity group receives a 5 per cent reduction in NWAU.
- High complexity group receives a 2 per cent reduction in NWAU.

Several different dampening factor methodologies were tested, considering variations on the number of complexity groupings and methods to determine the relative probability of a HAC derived from the risk adjustment model.

7.2 Methodology

The dampening factors were derived by assessing the difference in the cost profiles between HAC and non-HAC cohorts in each complexity group within the same HAC. Figure 4 illustrates the cost profile for HAC10: Medical Complications.

Figure 4: HAC10 Medical Complications - Cost profile analysis

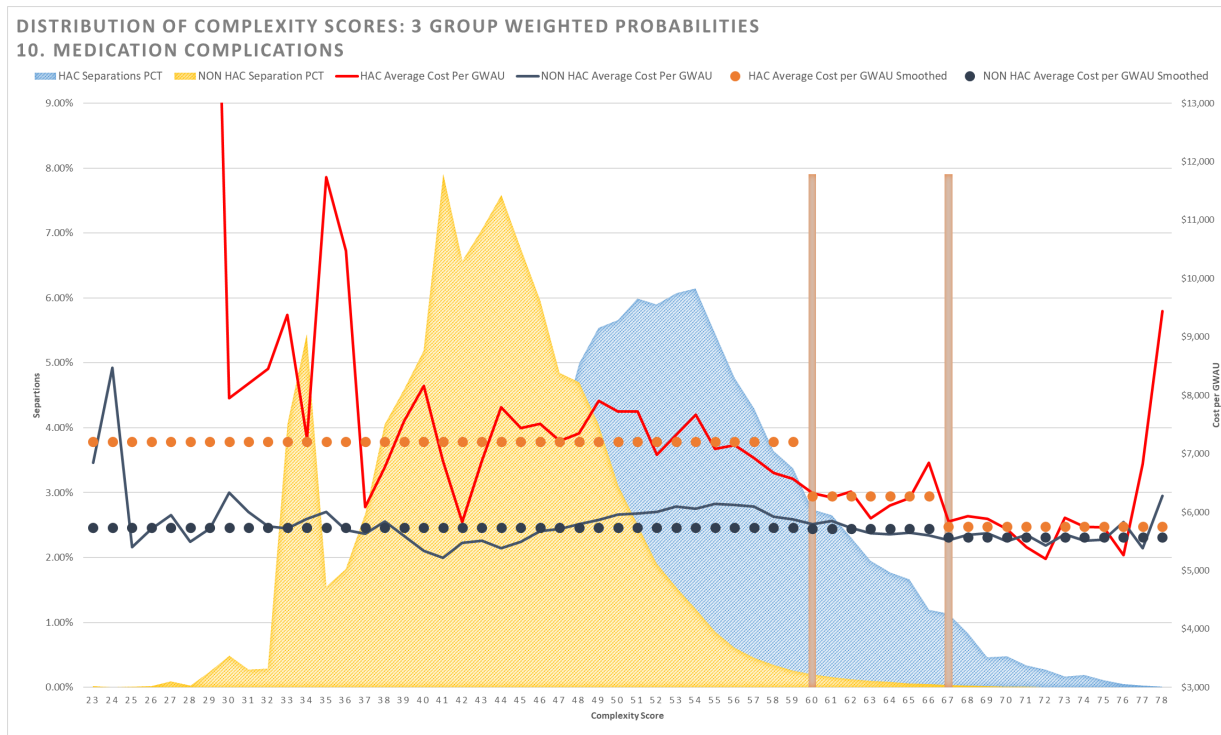


Figure 4 shows the cost differential between HAC and non-HAC cohorts. The red lines show the average cost per Gross Weighted Activity Unit (GWAU) for the HAC cohorts (the dotted line representing a smoothed average cost within the complexity group). The blue lines show the equivalent average cost per GWAU for the non-HAC cohorts. The NEP23 Determination was used to calculate the GWAU.

It was observed that the differential between the HAC and non-HAC cohorts differed depending on the complexity group, and that this differential reduced as the complexity increased (as demonstrated by the converging lines).

The differentials in the average cost per GWAU form the basis for determining the dampening factors in the following way:

- Episodes belonging to the lowest complexity group receive no dampening, that is, these episodes receive the full funding adjustment for that HAC.
- The dampening factors for episodes that are in moderate or high complexity group are calculated by dividing the cost differential in that group by the cost differential in the

lowest complexity group. That is, the cost differential in the lowest complexity group are used as a benchmark against which the moderate and high complexity groups are compared.

Table 11 shows an example calculation of the dampening factors and final adjustment to be applied for HAC10 Medical Complications. The dampening factor is calculated by using the cost differential for the lowest complexity group as a benchmark. These are then multiplied by the incremental cost adjustment for this HAC (11.5 per cent) to derive the final adjustment.

Table 11: Dampening factor calculation for HAC10 Medical Complications

Complexity Group	$\% \frac{\text{HAC cost profile}}{\text{non-HAC cost profile}} - 1$	Dampening factor	Adjustment after dampening
Low	$\frac{\$7,202}{\$5,739} - 1 = 25.5\%$	$\frac{25.5\%}{25.5\%} = 1.0000$	$1.0000 \times 0.115 = 0.115$
Moderate	$\frac{\$6,274}{\$5,716} - 1 = 9.8\%$	$\frac{9.8\%}{25.5\%} = 0.3826$	$0.3826 \times 0.115 = 0.044$
High	$\frac{\$5,755}{\$5,567} - 1 = 3.4\%$	$\frac{3.4\%}{25.5\%} = 0.1325$	$0.1325 \times 0.115 = 0.015$

7.3 Results

Table 12 summarises the quantile cut off points, dampening factors and adjustment factors for each of the HAC groups.

- The cut off points represent the lowest complexity score required to be assigned to a complexity group. For example, for medication complications, episodes with a complexity score:
 - Greater than or equal to 67 are assigned to the high complexity group.
 - Greater than or equal to 60, and less than 67, are assigned to the moderate complexity group.
 - Less than 60 are assigned to the low complexity group.
- The sizes of the dampening factors are derived from empirically observed cost differentials and as such, the dampening factors can vary between the different complexity and HAC groups.

Table 12: Final adopted quantile cut off points, dampening factors and adjustments after dampening

Complexity Groups	1. Pressure injury	2. Falls resulting in fracture or intracranial injury	3. Healthcare-associated infection	4. Surgical complications requiring unplanned return to theatre	6. Respiratory complications	7. Venous thromboembolism	8. Renal failure	9. Gastrointestinal bleeding	10. Medication complications	11. Delirium	12. Incontinence	13. Endocrine complications	14. Cardiac complications	15.02 Fourth degree perineal tears
Quantile cut off points														
Low	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Moderate	66	54	75	73	77	67	68	64	60	73	59	67	76	
High	72	59	81	77	82	71	72	72	67	79	61	74	83	55
Dampening Factors														
Low	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Moderate	0.6649	0.5309	0.3195	0.5027	0.4079	0.6011	0.4621	0.2321	0.3826	0.6857	0.8056	0.4324	0.8155	
High	0.5912	0.2394	0.2292	0.4257	0.1714	0.4440	0.4424	0.0839	0.1325	0.5067	0.3624	0.2845	0.7413	0.7924
Adjustments														
Low	14.4%	2.2%	8.6%	11.5%	13.5%	10.5%	19.8%	9.1%	11.5%	10.6%	8.1%	8.1%	12.4%	31.8%
Moderate	9.5%	1.2%	2.8%	5.8%	5.5%	6.3%	9.2%	2.1%	4.4%	7.3%	6.5%	3.5%	10.1%	
High	8.5%	0.5%	2.0%	4.9%	2.3%	4.7%	8.8%	0.8%	1.5%	5.4%	2.9%	2.3%	9.2%	25.2%

8. Funding adjustment

8.1 Overview

This section outlines the methodology that was adopted to combine the incremental cost of a HAC (Section 8) and dampening factors (Section 9) into a set of funding adjustments. The funding adjustments are ultimately applied as a percentage reduction to the NWAU for an episode where a HAC is present.

These adjustments also consider the complexity profile of each episode as they are modified for each complexity group (low, moderate or high) to ensure an equitable adjustment to public hospitals relative to their patient risk profile.

8.2 Methodology

The following steps are used to determine the adjustment:

- a) Calculate the overall complexity score for each HAC in an episode by summing the complexity scores for each risk factor variable relevant to each HAC.
- b) Assign a complexity group for each HAC based on the complexity score using the quantile cut off points.
- c) Apply the adjustment relevant to each HAC based on the assigned complexity group. If an episode contains more than one HAC, then the maximum adjustment is used for the funding adjustment (regardless of the complexity of the HAC).
- d) Calculate the final safety and quality adjusted NWAU as:

$$\text{Adjusted NWAU} = \text{NWAU} - \text{base price weight} \times \text{adjustment factor}$$

As discussed in Section 7, it is possible for an episode to have a different complexity score relating to each different HAC. Furthermore, since each HAC group has a different set of quantile cut off points it is possible for the same episode to be considered a low complexity group for one HAC and a moderate or high complexity for another HAC. Thus, in step c above, the final adjustment that is applied does not necessarily belong to the highest complexity, but rather the maximum adjustment.

Table 13 presents an example of how the adjustment factor is calculated for an episode with more than one HAC.

Table 13: Example calculation of adjustment factor for an episode with more than one HAC

HACs present	Complexity score	Complexity group	Adjustment after dampening
HAC06: Respiratory complications	75	Low	13.5%
HAC10: Medication complications	76	High	1.5%
Selected adjustment			13.5%

Even though the episode was considered as high complexity for HAC10, the adjustment for HAC06 was greater and therefore selected for the adjustment. This assessment is performed on an episode level for all HAC episodes.

The adjustments have been designed and calculated at an episode level allowing for aggregation to a jurisdiction, LHN or hospital level to determine the aggregate impact. The issues and other considerations of developing a funding adjustment for safety and quality are discussed further in Section 11.

8.3 Vignettes

The following clinical examples demonstrate the application of the risk adjustment model and funding adjustments to individual episodes.

8.3.1 Case one: falls resulting in fracture or intracranial injury – low risk

A 27 year old female patient was a booked admission to day-surgery for a cholecystectomy. She had no comorbid conditions. Following the surgery, she fell off the bed in the ward, hitting her head on the floor. A computed tomography (CT) scan showed a subdural haematoma. The patient remained in hospital for further treatment and surgery.

Table 14 breaks down the complexity and adjustment calculations for case one.

Table 14: Case one breakdown: HAC02 Falls resulting in fracture or intracranial injury

Complexity score calculations	
Risk factor breakdown	Complexity Score
<i>Baseline</i>	29.8771
<i>Age Group: 025 to 029</i>	0.0000
<i>Acute myocardial function: No</i>	0.0000
<i>Congestive heart failure: No</i>	0.0000
<i>Peripheral vascular disease: No</i>	0.0000
<i>Cerebral vascular accident: No</i>	0.0000
<i>Dementia: No</i>	0.0000
<i>Pulmonary disease: No</i>	0.0000
<i>Connective tissue disorder: No</i>	0.0000
<i>Peptic ulcer: No</i>	0.0000
<i>Liver disease: No</i>	0.0000
<i>Diabetes: No</i>	0.0000
<i>Diabetes complications: No</i>	0.0000
<i>Paraplegia: No</i>	0.0000
<i>Renal disease: No</i>	0.0000
<i>Cancer: No</i>	0.0000
<i>Metastatic cancer: No</i>	0.0000
<i>Severe liver disease: No</i>	0.0000
<i>HIV: No</i>	0.0000
<i>DRG Type: Intervention</i>	3.6049
<i>Sex: Female</i>	0.0943
<i>MDC: Diseases & Disorders of the Hepatobiliary System & Pancreas</i>	-2.7691
<i>Emergency admission: No</i>	0.0000
<i>ICU Hours: No</i>	0.0000
<i>Admission transfer status: No</i>	0.0000
Total	31
Adjustment calculations	
Complexity group	Low
Maximum adjustment	2.2%
Dampening	1.0000
Final adjustment	2.2%

As illustrated from the above table, an episode in the ‘low risk’ category for this HAC is subject to a negative funding adjustment equivalent to 2.2 per cent of the funding for this episode of care.

8.3.2 Case two: falls resulting in fracture or intracranial injury – moderate risk

The patient is a 73 year old male who was admitted through emergency for acute shortness of breath. The patient has a background of congestive heart failure, hypertension, peripheral vascular disease and type 2 diabetes managed with oral medication.

The patient was transferred to the ICU for non-invasive ventilation due to pneumonia before being transferred to the ward seven days later. While on the ward, the patient slipped and fell heavily while in the shower, resulting in a fracture of the lumbar vertebra L4-L5. The fracture was managed conservatively and the patient was discharged home 12 days following admission. Table 15 breaks down the complexity and adjustment calculations for case two.

Table 15: Case two breakdown: HAC02 Falls resulting in fracture or intracranial injury

Complexity score calculations	
Risk factor breakdown	Complexity Score
<i>Baseline</i>	29.8771
<i>Age Group: 070 to 074</i>	8.9961
<i>Acute myocardial function: No</i>	0.0000
<i>Congestive heart failure: Yes</i>	2.2402
<i>Peripheral vascular disease: Yes</i>	3.4181
<i>Cerebral vascular accident: No</i>	0.0000
<i>Dementia: No</i>	0.0000
<i>Pulmonary disease: No</i>	0.0000
<i>Connective tissue disorder: No</i>	0.0000
<i>Peptic ulcer: No</i>	0.0000
<i>Liver disease: No</i>	0.0000
<i>Diabetes: Yes</i>	-0.4674
<i>Diabetes complications: No</i>	0.0000
<i>Paraplegia: No</i>	0.0000
<i>Renal disease: No</i>	0.0000
<i>Cancer: No</i>	0.0000
<i>Metastatic cancer: No</i>	0.0000
<i>Severe liver disease: No</i>	0.0000
<i>HIV: No</i>	0.0000
<i>DRG Type: Intervention</i>	3.6049
<i>Sex: Male</i>	0.0000
<i>MDC: Diseases & Disorders of the Respiratory System</i>	-2.4862
<i>Emergency admission: Yes</i>	6.8613
<i>ICU Hours: Yes</i>	3.8148
<i>Admission transfer status: No</i>	0.0000
Total	56
Adjustment calculations	
Complexity group	Moderate
Maximum adjustment	2.2%
Dampening	0.5309
Final adjustment	1.2%

As illustrated from the above table, an episode in the 'moderate risk' category for this HAC is subject to a negative funding adjustment equivalent to 1.2 per cent of the funding for this episode of care.

8.3.3 Case three: falls resulting in fracture or intracranial injury – high risk

The patient is an 87 year old female who was admitted to hospital via the emergency department with a principal diagnosis of stroke. The patient has a background of dementia, severe liver disease, chronic renal failure, chronic obstructive pulmonary disease and type 2 diabetes managed with insulin.

The patient was treated conservatively. On the second day of her admission she fell while trying to take herself to the bathroom unsupervised, which resulted in a fractured neck of femur. A total hip replacement was performed. The patient was discharged to her residential aged care accommodation 25 days following admission.

Table 16 breaks down the complexity and adjustment calculations for case three.

Table 16: Case three breakdown: HAC02 Falls resulting in fracture or intracranial injury

Complexity score calculations	
Risk factor breakdown	Complexity Score
<i>Baseline</i>	29.8771
<i>Age Group: 085 to 089</i>	13.4695
<i>Acute myocardial function: No</i>	0.0000
<i>Congestive heart failure: No</i>	0.0000
<i>Peripheral vascular disease: No</i>	0.0000
<i>Cerebral vascular accident: No</i>	0.0000
<i>Dementia: Yes</i>	3.4088
<i>Pulmonary disease: Yes</i>	1.5816
<i>Connective tissue disorder: No</i>	0.0000
<i>Peptic ulcer: No</i>	0.0000
<i>Liver disease: No</i>	0.0000
<i>Diabetes: Yes</i>	-0.4674
<i>Diabetes complications: No</i>	0.0000
<i>Paraplegia: No</i>	0.0000
<i>Renal disease: Yes</i>	1.9591
<i>Cancer: No</i>	0.0000
<i>Metastatic cancer: No</i>	0.0000
<i>Severe liver disease: Yes</i>	4.5741
<i>HIV: No</i>	0.0000
<i>DRG Type: Medical</i>	0.0000
<i>Sex: Female</i>	0.0943
<i>MDC: Diseases & Disorders of the Nervous System</i>	0.5651
<i>Emergency admission: Yes</i>	6.8613
<i>ICU Hours: Yes</i>	3.8148
<i>Admission transfer status: No</i>	0.0000
Total	66

Adjustment calculations	
Complexity group	High
Maximum adjustment	2.2%
Dampening	0.2394
Final adjustment	0.5%

As illustrated from the above table, an episode in the 'high risk' category for this HAC is subject to a negative funding adjustment equivalent to 0.5 per cent of the funding for this episode of care.

9. Issues and other considerations

9.1 Treatment of episodes with multiple HACs

IHACPA initially undertook investigations to determine whether the presence of a second HAC could be used as a variable in the risk adjustment model. However, this approach could not be progressed given that it is not possible to determine which HAC occurred first from the episode data, as well as the issues addressed in Section 6.3.1.

IHACPA also considered whether the presence of multiple HACs could be addressed through a funding approach. An additive funding approach was evaluated, where the funding adjustment for each HAC that occurred is deducted from the NWAU of an episode. For example, if both a healthcare associated infection and a medication complication occurred within a moderate complexity episode of care, the NWAU would be reduced by $2.8 + 4.4 = 7.2$ per cent. This approach assumes that HACs occur independently, which is not the case and therefore found to overly penalise episodes with more than one HAC.

IHACPA then considered developing a model where the funding adjustment for episodes with multiple HACs would be scaled depending on the underlying correlation of one HAC to another. It was decided that the additional complexity of this approach was not warranted given the expected minimal funding impact.

Funding impacts have therefore been calculated using the HAC that results in the highest funding adjustment for an episode (see Section 10.2), with the additional costs of other HACs not considered in the funding adjustment.

Appendix A: Risk factors considered in initial model development

Table 17: List of potential risk factors investigated during initial model development

HAC01-HAC14 risk factors	HAC-specific factors
Patient age	Liver disease (HAC04)
Sex	Heart failure (HAC07)
MDC	Myocardial infarction (HAC07)
AR-DRG type (medical, intervention)	Stroke with immobility (HAC07)
Intensive care unit status	Cardiovascular disease (HAC08)
Presence of another HAC	Malignancy (HAC08)
Patient Indigenous status	Mechanical ventilation (HAC09)
Patient remoteness	Parkinson's disease (HAC13)
Patient SEIFA ⁵	Dementia (HAC13)
Admission transfer status	
Chronic disease count	
Highly specialised procedures	
Emergency admission status	
Length of stay	
Charlson score ⁶	

Table 18: Risk factors investigated for HAC15.02

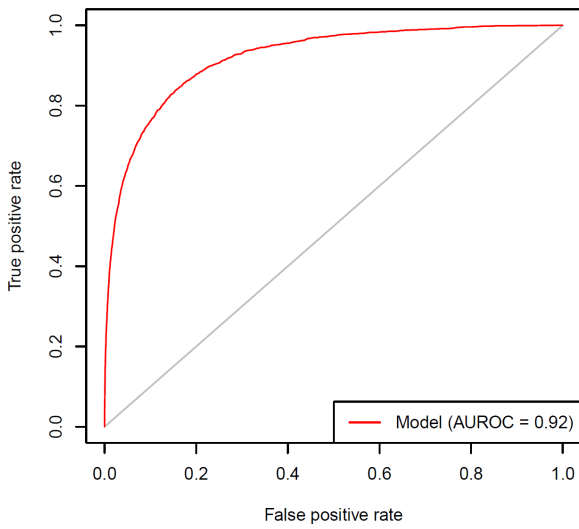
HAC15 specific risk factors	Diagnosis (surgical) codes
Foetal distress	O680, O682, O683, O688, O689
Use of instruments	(9047002), (9047004), (9046800), (9046801), (9046802), (9046803), (9046804), (9046805), (9046900), (9046901) and (9046806) for ICD10AM v.10 and above.
Young and mature aged primigravida	Z3551, Z356
Persistent posterior occiput presentation	O328, O640

⁵ Socio-Economic Indexes for Areas is a product developed by the Australian Bureau of Statistics that ranks areas in Australia according to relative socio-economic advantage and disadvantage.
<http://www.abs.gov.au/websitedbs/censushome.nsf/home/seifa>

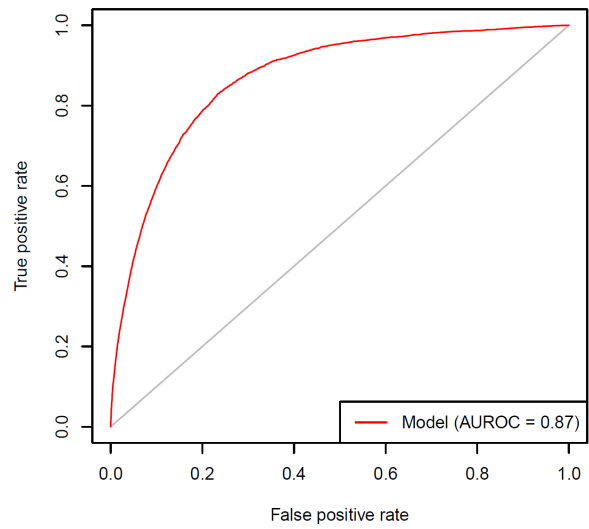
⁶ The Charlson index is a score that predicts the one-year mortality for a patient with a range of specific comorbidities.
National Pricing Model

Appendix B: ROC curves

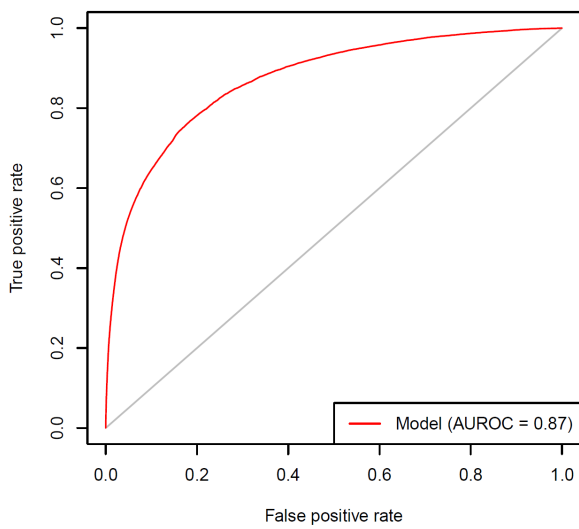
HAC 01



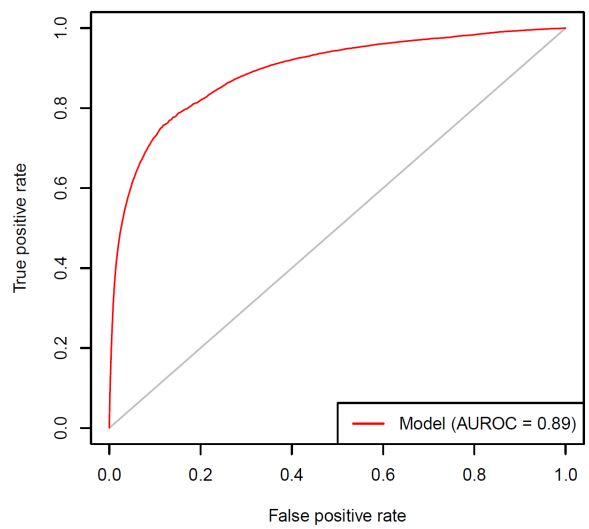
HAC 02



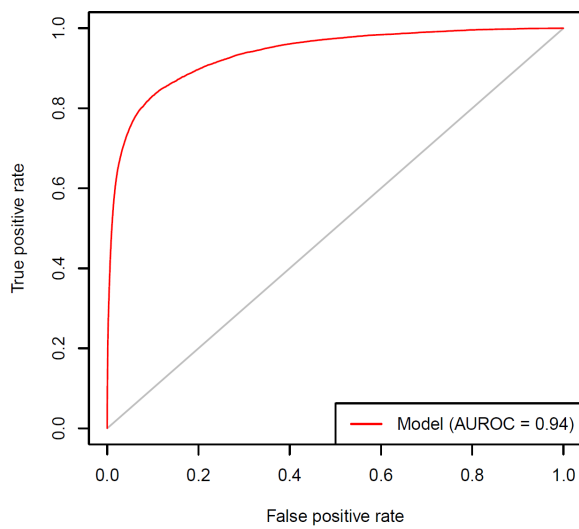
HAC 03



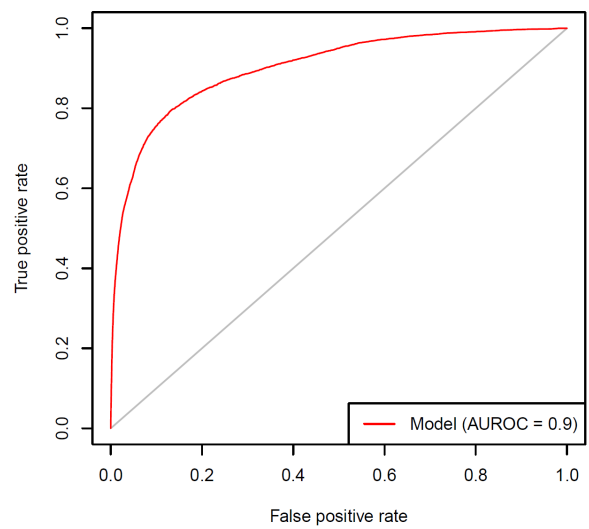
HAC 04



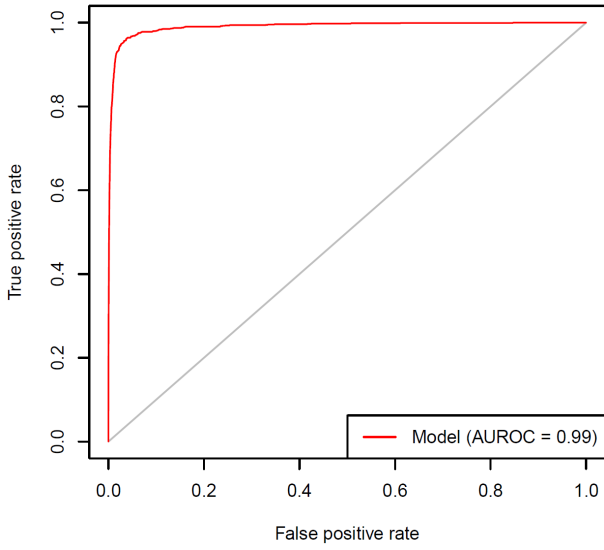
HAC 06



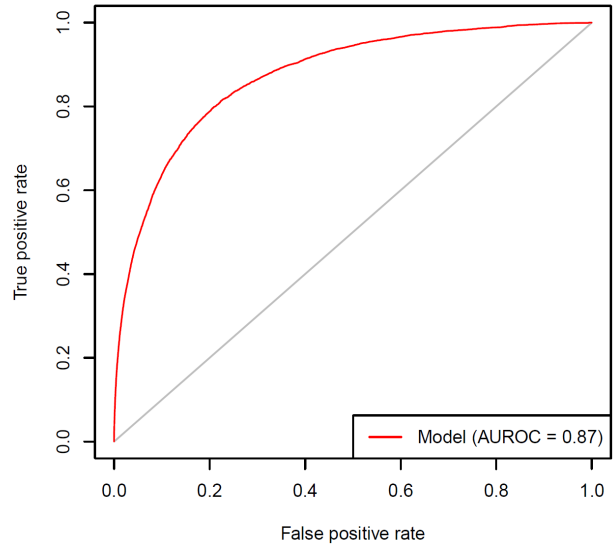
HAC 07



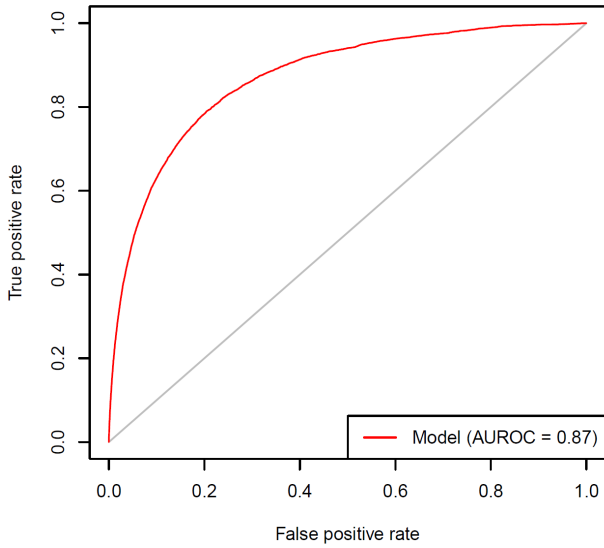
HAC 08



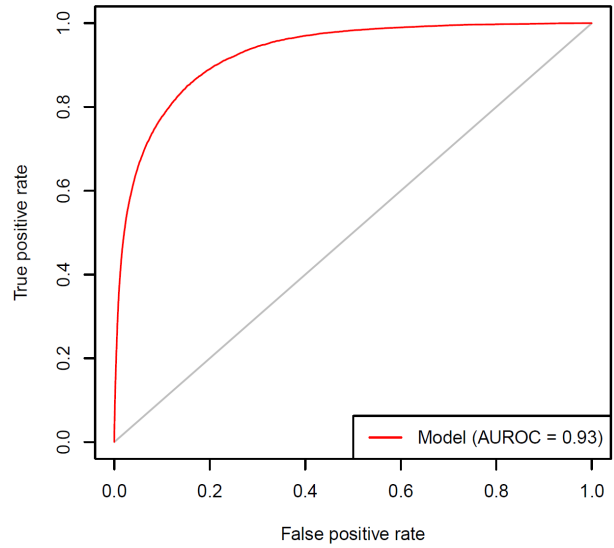
HAC 09



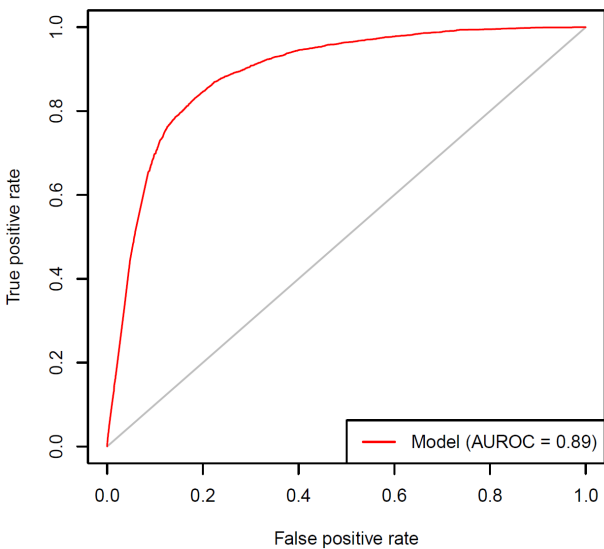
HAC 10



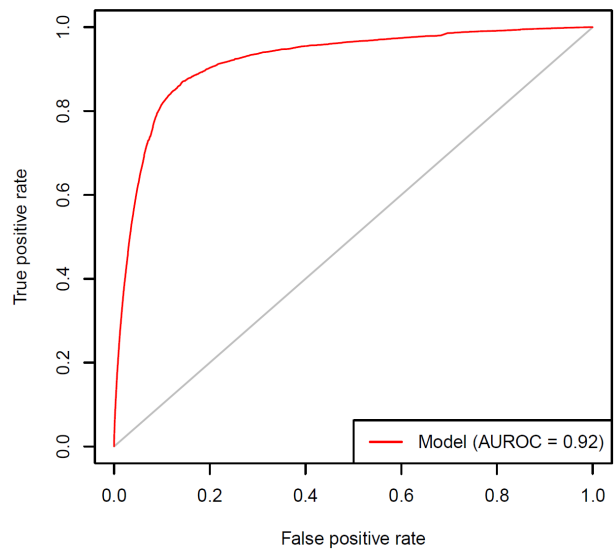
HAC 11



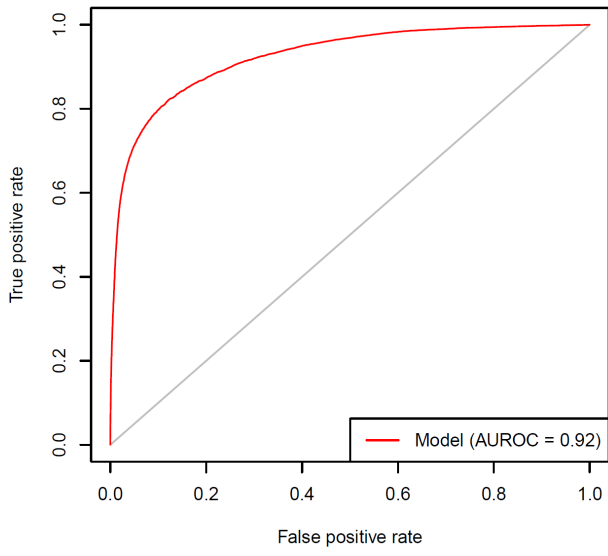
HAC 12



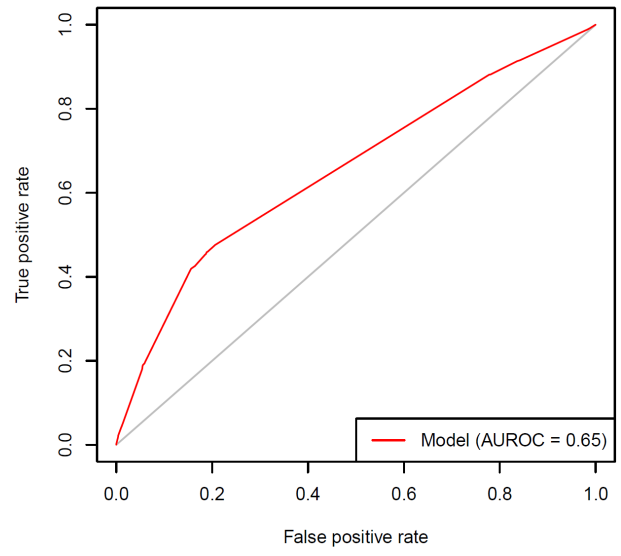
HAC 13



HAC 14

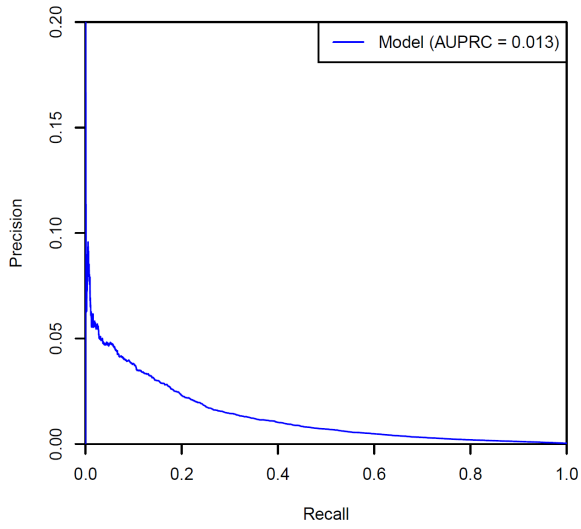


HAC 15

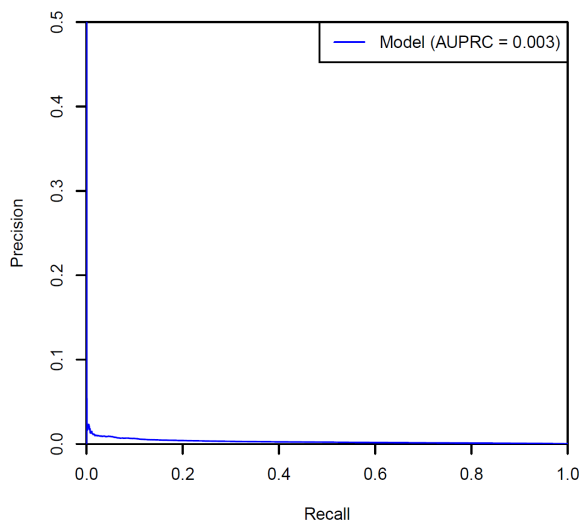


Appendix C: PRC graphs

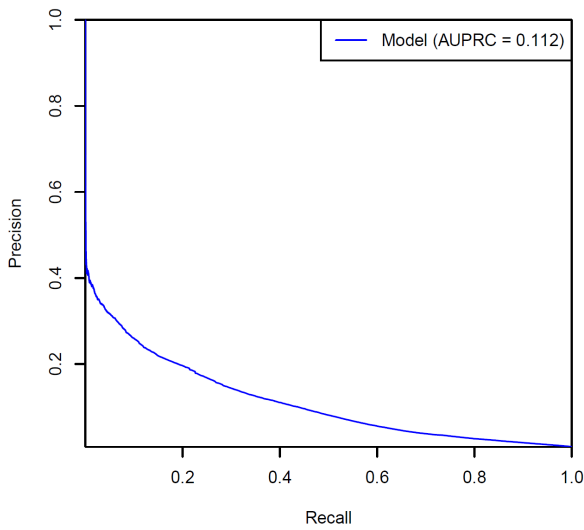
HAC 01



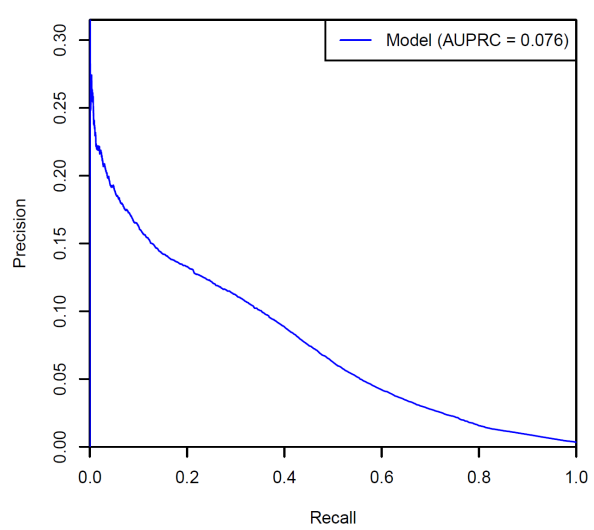
HAC 02



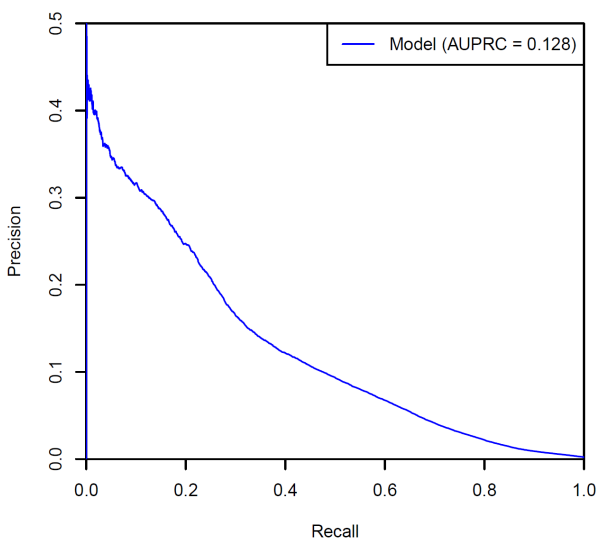
HAC 03



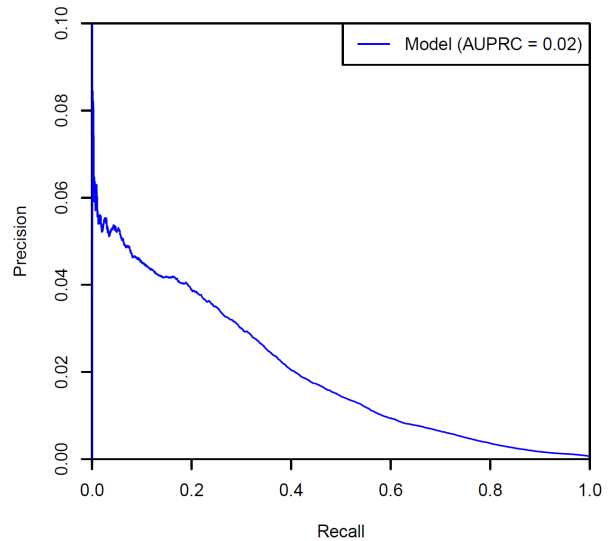
HAC 04



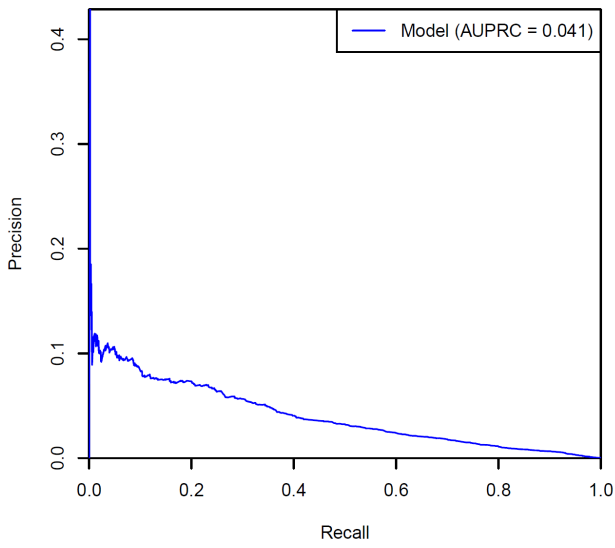
HAC 06



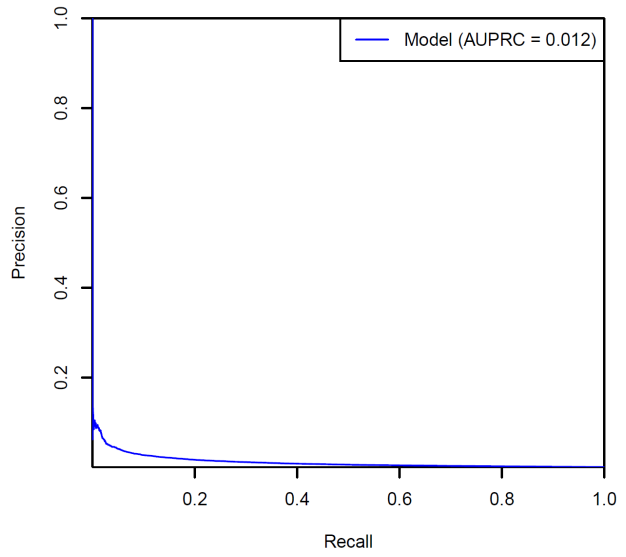
HAC 07



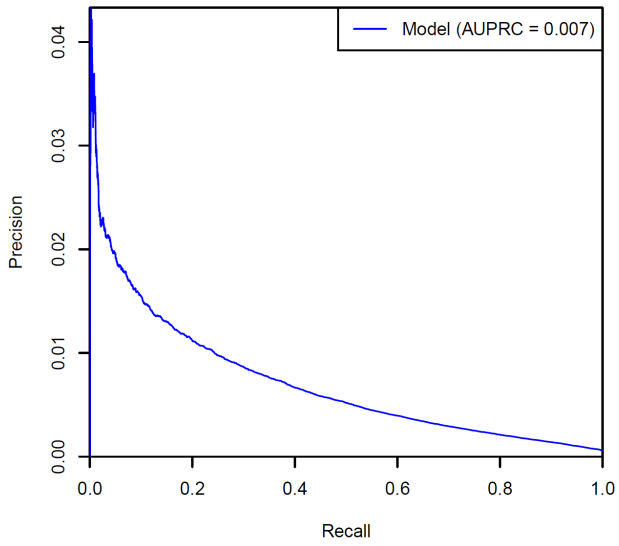
HAC 08



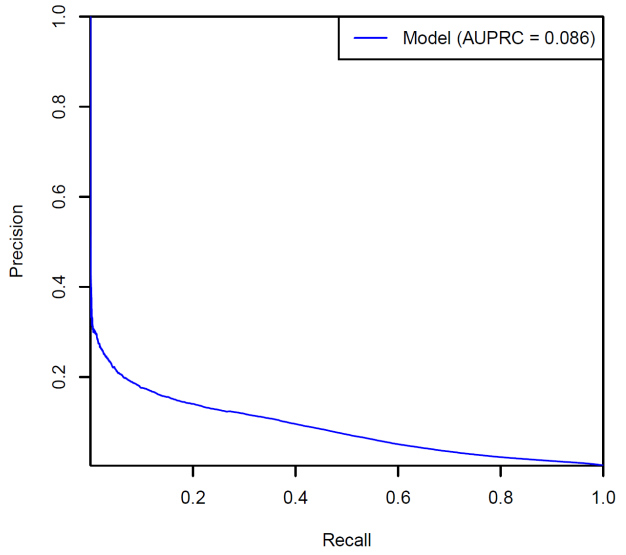
HAC 09



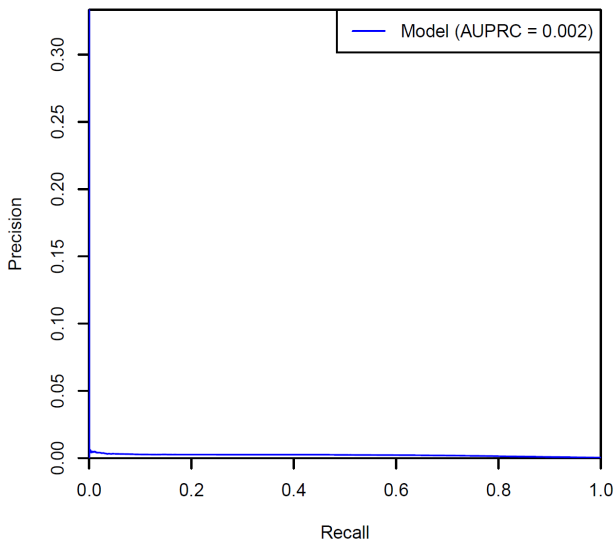
HAC 10



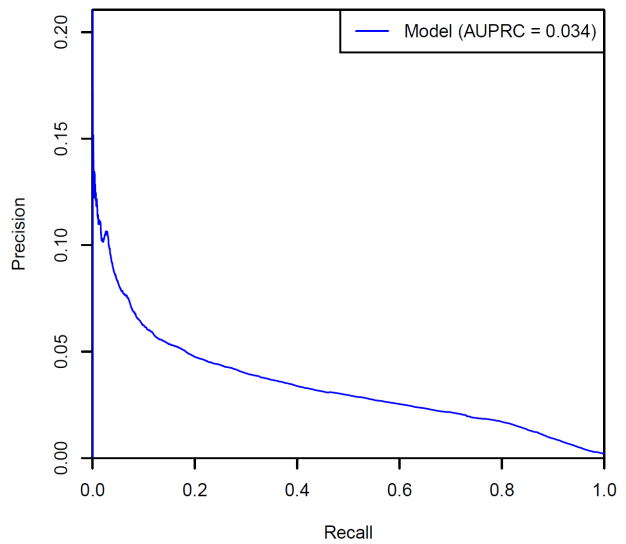
HAC 11



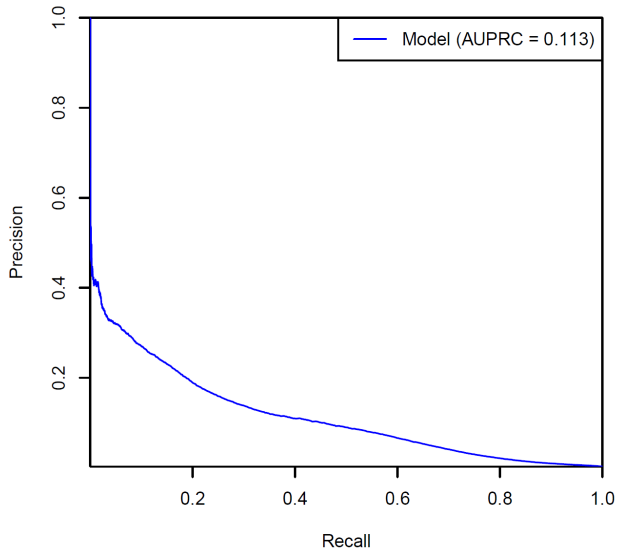
HAC 12



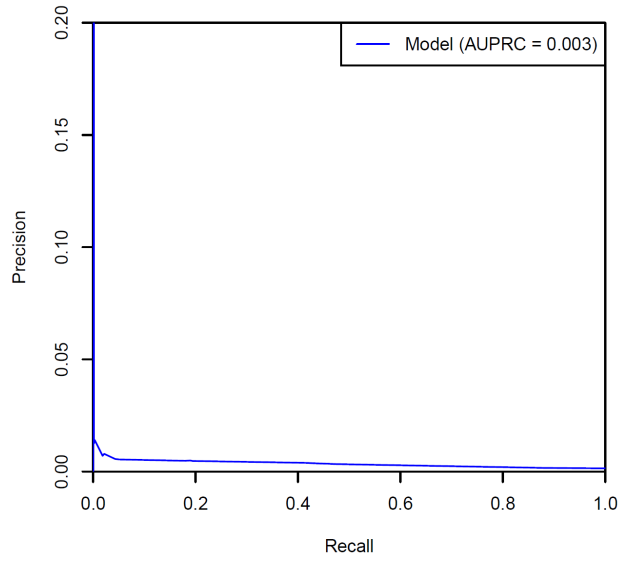
HAC 13



HAC 14



HAC 15



Appendix D: Complexity scores

Table 19: Complexity scores for HAC01 to HAC14 logistic regression model

Groups	1. Pressure injury	2. Falls resulting in fracture or intracranial injury	3. Healthcare-associated infection	4. Surgical complications requiring unplanned return to theatre	6. Respiratory complications	7. Venous thromboembolism	8. Renal failure	9. Gastrointestinal bleeding	10. Medication complications	11. Delirium	12. Incontinence	13. Endocrine complications	14. Cardiac complications
Baseline	41.0104	29.8771	55.1307	49.6400	51.6027	37.8514	33.8524	42.9396	39.1506	45.6576	37.9907	49.2135	48.1137
Emergency admission	5.4554	6.8613	3.9146	1.0214	3.2022	4.0497	-0.6235	3.0248	4.2037	3.7357	4.5988	4.2357	-0.2453
ICU Hours	9.1706	3.8148	10.4030	11.3383	14.8213	11.3590	23.5097	7.0900	8.9549	10.6006	9.1846	6.2372	12.3537
Admission Transfer Status	2.1656	1.9631	1.8967	1.1906	0.5999	2.2548	0.0000	2.0940	1.1047	1.5325	1.5633	2.2629	0.2355
AR-DRG 11 Type													
Medical	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Intervention	6.8352	3.6049	6.2600	11.5610	6.2339	8.1290	7.3330	4.2656	3.6653	7.6731	1.9317	3.7241	5.5851
Sex⁷													
Male	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Female	0.0000	0.0943	0.4117	0.0000	-1.5579	0.2070	-1.5371	-0.4713	0.0878	-0.8012	0.5628	0.0000	0.0000

⁷ In previous NEP technical specifications, this category was referred as 'gender.' It has been updated in this technical specification to distinguish it from the reporting of 'gender' in APC datasets from 2022-23 onwards. For the purposes of the HAC risk adjustment model, the 'male' sex category includes all patients who are not reported as 'female.' This treatment has not changed since the implementation of the HAC risk adjustment in NEP18.

MDC	1. Pressure injury	2. Falls resulting in fracture or intracranial injury	3. Healthcare-associated infection	4. Surgical complications requiring unplanned return to theatre	6. Respiratory complications	7. Venous thromboembolism	8. Renal failure	9. Gastrointestinal bleeding	10. Medication complications	11. Delirium	12. Incontinence	13. Endocrine complications	14. Cardiac complications
Pre MDC	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Diseases & Disorders of the Nervous System	-8.7892	0.5651	-6.2962	-6.8496	-8.8591	-6.3169	-13.5224	-5.3647	-0.5005	-7.7154	-4.7731	-5.2242	-5.3149
Diseases & Disorders of the Eye	-18.3628	-5.6512	-20.2014	-17.7407	-23.4467	-21.7787	-13.5224	-19.0242	-16.0178	-19.8810	-13.7667	-7.5695	-15.9668
Diseases & Disorders of the Ear, Nose, Mouth & Throat	-14.9215	-5.1393	-12.3788	-9.4111	-12.1154	-12.2771	-13.5224	-9.2049	-6.4976	-10.5492	-13.7667	-9.1372	-7.7912
Diseases & Disorders of the Respiratory System	-9.1384	-2.4862	-8.4466	-5.1189	-10.7945	-6.8493	-13.5224	-4.5788	-2.7528	-7.9550	-8.8560	-5.6994	-3.9215
Diseases & Disorders of the Circulatory System	-11.9403	-3.9791	-7.9755	-2.9953	-11.7067	-9.6492	-8.1704	-6.2063	-3.4391	-9.0992	-11.6736	-7.1033	-3.9599
Diseases & Disorders of the Digestive System	-12.0037	-4.9689	-6.3273	-5.0984	-9.1219	-7.5367	-13.7328	-4.2954	-5.8737	-9.1883	-6.1742	-4.9633	-4.5876
Diseases & Disorders of the Hepatobiliary System & Pancreas	-10.2909	-2.7691	-4.5917	-3.4830	-8.4117	-6.8463	-7.3634	-1.3043	-3.8468	-6.2945	-6.9111	-2.9973	-2.0313
Diseases & Disorders of the Musculoskeletal System & Connective Tissue	-5.8672	-1.5924	-4.4626	-0.8269	-8.8225	-1.4841	-10.3111	-4.2507	-1.6267	-2.7099	-2.0692	-5.5596	-2.3947
Diseases & Disorders of the Skin, Subcutaneous Tissue & Breast	-9.9724	-3.9450	-8.7365	-6.2519	-14.0320	-9.8257	-13.5224	-8.3295	-4.7816	-11.1085	-11.4871	-7.8388	-6.6393
Endocrine, Nutritional & Metabolic Diseases & Disorders	-8.0574	-0.6029	-7.0270	-4.9602	-10.6960	-7.6070	-13.5224	-4.4018	-4.9338	-8.2071	-8.1166	-3.7577	-4.4819
Diseases & Disorders of the Kidney & Urinary Tract	-10.7400	-2.9520	-7.2843	-5.1136	-11.9144	-8.3027	-10.3111	-5.8141	-4.8974	-9.7577	-6.4505	-6.1701	-4.5521
Diseases & Disorders of the Male Reproductive System	-18.3628	-5.6512	-10.1105	-5.7966	-14.3966	-10.1320	-13.5224	-8.3921	-7.3995	-9.7381	-2.1018	-10.0121	-5.8855

MDC	1. Pressure injury	2. Falls resulting in fracture or intracranial injury	3. Healthcare-associated infection	4. Surgical complications requiring unplanned return to theatre	6. Respiratory complications	7. Venous thromboembolism	8. Renal failure	9. Gastrointestinal bleeding	10. Medication complications	11. Delirium	12. Incontinence	13. Endocrine complications	14. Cardiac complications
Diseases & Disorders of the Female Reproductive System	-18.3628	-5.6512	-9.2392	-5.4073	-14.3966	-10.1320	-13.5224	-10.2644	-6.8167	-11.1721	-0.9814	-10.0121	-6.2522
Pregnancy, Childbirth & the Puerperium	-19.1568	-6.1127	-5.5023	-4.6092	-17.3089	-10.9776	-13.5224	-13.0703	-11.7008	-17.3515	14.3469	-7.5695	-4.2237
Newborns & Other Neonates	-1.8616	-6.1127	2.4332	-0.1649	-10.2333	-5.6656	-13.5224	-3.6190	-10.2954	-26.7920	-17.7541	-7.5695	-3.4860
Diseases & Disorders of Blood, Blood Forming Organs, Immunological Disorders	-11.9108	-5.6512	-7.6647	-4.5612	-11.4413	-7.4381	-13.5224	-5.0209	-7.7195	-10.5656	-13.1864	-7.2504	-5.2112
Neoplastic Disorders (Haematological & Solid Neoplasms)	-6.1543	-3.9791	-0.2735	-3.7197	-6.5244	-2.3107	-8.1704	-1.4074	-2.3958	-5.7763	-2.4073	-0.9548	-1.0061
Infectious & Parasitic Diseases	-5.8226	-0.4651	-5.9517	-2.6163	-9.2626	-3.2589	-8.7172	-1.4361	-1.9805	-6.0035	-4.0582	-3.9224	-1.1610
Mental Diseases & Disorders	-9.0411	3.4044	-6.2273	-10.9763	-9.1566	-8.5290	-10.8575	-7.3673	3.0577	-9.9654	-3.2914	-1.4843	-8.2118
Alcohol/Drug Use & Alcohol/Drug Induced Organic Mental Disorders	-14.7381	3.5013	-7.8355	-8.8079	-10.8844	-13.8856	-10.8522	-5.7098	0.2888	-8.4691	-6.4988	-8.8526	-7.8165
Injuries, Poisonings & Toxic Effects of Drugs	-6.4020	0.5651	-5.8506	-4.2359	-7.0770	-1.4841	-11.5506	-5.8098	-4.6518	-5.7519	-7.3254	-6.2185	-4.7843
Burns	-2.9462	4.0348	-0.3784	-2.2076	-4.1280	-1.3544	-8.7172	-3.3970	-0.9238	-0.6893	-6.1742	-5.6994	-1.9381
Factors Influencing Health Status & Other Contacts with Health Services	-11.1258	4.0348	-8.6113	-9.1138	-12.7903	-9.0775	-13.5224	-6.9665	-5.5978	-11.9106	-9.8678	-7.4578	-6.6573

Age Group	1. Pressure injury	2. Falls resulting in fracture or intracranial injury	3. Healthcare-associated infection	4. Surgical complications requiring unplanned return to theatre	6. Respiratory complications	7. Venous thromboembolism	8. Renal failure	9. Gastrointestinal bleeding	10. Medication complications	11. Delirium	12. Incontinence	13. Endocrine complications	14. Cardiac complications
000 to 004	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
005 to 009	0.0000	0.0000	-1.6931	-2.8254	-2.5369	-2.2163	0.0000	0.0000	0.0000	0.1214	0.0000	0.0000	-2.4709
010 to 014	-0.0974	0.0000	-1.4610	-2.8590	-1.3633	-2.2163	0.0000	0.0000	0.0000	-0.7048	0.0000	0.0000	-2.4284
015 to 019	0.4467	0.0000	-0.5750	-1.9648	0.7162	2.8735	0.0000	0.0000	2.2504	-0.2649	0.0214	0.3186	-2.7861
020 to 024	-1.3027	0.0000	-0.8278	-1.9292	1.1681	3.0014	0.0000	0.0000	2.4957	0.2697	0.0214	0.3186	-1.6703
025 to 029	-0.9156	0.0000	-0.6191	-1.8519	0.6187	3.9211	0.0000	-0.5775	1.5362	0.2802	0.0214	0.3186	-1.1657
030 to 034	-0.4018	0.0000	-0.2589	-1.6401	1.0198	4.9248	0.3095	-0.7139	2.2714	1.2867	2.6715	0.3186	-0.6812
035 to 039	-0.4018	0.0000	0.2618	-0.9284	1.0672	5.3804	0.3095	0.5531	2.4024	1.7472	2.6709	-0.3223	-0.0451
040 to 044	-0.3459	3.3824	0.7792	-0.4148	1.1952	5.8925	0.3095	1.5020	3.0708	3.2131	2.1362	-0.6741	0.8126
045 to 049	0.3084	3.3824	1.5711	0.4444	1.9275	6.1827	0.3095	2.3030	3.1157	4.2153	3.4775	-0.9296	2.4827
050 to 054	0.4484	4.9890	1.8692	0.6210	2.2321	6.3172	0.3095	2.4086	3.8779	5.0583	3.8473	-1.2725	2.8859
055 to 059	1.5646	6.3225	2.3566	0.6479	2.5393	6.5525	0.3095	3.0727	4.3780	5.7048	4.6467	-0.7964	4.2402
060 to 064	1.5646	7.6058	2.9409	1.1632	3.0064	6.8359	0.3095	3.8396	5.2541	7.4312	5.1560	-0.3104	5.0898
065 to 069	2.2077	8.2623	3.4483	1.4752	3.6682	7.4109	0.3095	4.3334	5.7368	9.2837	6.5707	-0.2971	6.1579
070 to 074	2.3155	8.9961	3.8242	1.8429	4.2277	8.0565	0.3095	5.2993	6.4023	11.0494	7.5659	-0.6167	6.7778
075 to 079	4.0028	10.2508	4.5672	2.0928	4.6461	8.0142	0.3095	6.1741	6.7756	12.8650	8.2942	-0.2276	7.3495
080 to 084	4.9814	12.2889	5.5584	2.4671	5.9485	8.7514	0.3095	6.9576	7.6336	14.8036	9.2561	0.0043	7.8239
085 to 089	6.0246	13.4695	6.5000	3.2541	7.3370	9.3530	0.3095	8.1610	8.1037	16.4194	9.1867	0.3855	8.6792
090 to 094	8.1497	14.1874	7.3374	4.0077	9.0102	8.8426	0.3095	9.0346	8.3621	17.7973	8.8977	0.5600	9.6243
095 to 099	8.1497	14.1874	7.3374	4.0077	9.0102	8.8426	0.3095	9.0346	8.3621	17.7973	8.8977	0.5600	9.6243

Charlson comorbidity condition	1. Pressure injury	2. Falls resulting in fracture or intracranial injury	3. Healthcare-associated infection	4. Surgical complications requiring unplanned return to theatre	6. Respiratory complications	7. Venous thromboembolism	8. Renal failure	9. Gastrointestinal bleeding	10. Medication complications	11. Delirium	12. Incontinence	13. Endocrine complications	14. Cardiac complications
Acute myocardial function	0.1557	0.3509	1.4813	0.6241	1.6546	-0.2772	-0.1760	3.9514	3.8092	1.2835	2.2220	0.1737	10.9633
Congestive heart failure	3.2128	2.2402	3.3307	0.8029	3.3133	1.6103	5.1944	2.4697	3.2528	1.9085	1.7935	1.8722	5.7130
Peripheral vascular disease	6.5779	3.4181	4.1885	5.2681	2.2518	2.4534	4.9773	4.2019	4.3607	4.5185	3.5770	3.3152	4.0102
Cerebral vascular accident	0.7084	2.4913	2.9000	1.4723	3.0888	2.5891	0.5950	3.9526	1.7867	3.5679	1.4895	2.6987	2.8198
Dementia	2.4121	3.4088	2.0713	1.4017	3.8202	0.1783	-6.3291	1.3609	2.6519	1.0657	-0.9432	2.0445	1.5186
Pulmonary disease	0.5000	1.5816	1.5398	0.5668	2.1028	0.5193	-0.5804	1.1172	1.4375	1.0233	1.4275	0.4491	0.2878
Connective tissue disorder	0.9883	1.3392	1.8096	1.6797	0.9957	1.1155	1.0512	2.0792	1.7322	1.0164	2.9106	2.7774	1.2232
Peptic ulcer	3.6968	2.6837	2.0204	0.6182	0.7703	3.8619	2.6188	8.9432	4.3505	0.8922	0.7698	2.6349	1.6958
Liver disease	3.0268	4.2906	2.8887	2.2579	1.2436	1.6636	3.8809	3.7705	3.0801	2.5075	3.6063	2.0759	1.4651
Diabetes	-1.6731	-0.4674	-0.9951	-0.9068	-1.5573	-1.6668	-19.2758	-1.4191	-1.6853	-0.7333	-1.2882	-5.4863	-0.9634
Diabetes complications	3.8239	2.4488	1.9940	1.2645	0.9780	1.4097	1.2320	1.2176	1.1826	1.8482	1.8038	13.8363	0.7087
Paraplegia	2.1635	1.7193	2.5098	0.6581	4.0461	1.5597	-0.0330	1.8697	1.5529	0.5673	4.9894	1.3723	1.2015
Renal disease	1.9186	1.9591	2.2128	2.4128	0.6770	0.4155	2.4116	3.0845	2.5699	1.5484	1.5915	2.0222	0.8429
Cancer	3.2369	4.2476	5.1167	4.9250	1.8670	4.6020	3.3375	4.6547	3.0022	2.9581	5.8997	3.4370	2.6650
Metastatic cancer	1.7919	1.0552	1.1239	0.4360	1.2231	2.2550	-4.3167	1.0659	1.2996	1.5826	1.4452	0.9886	1.0236
Severe liver disease	2.7659	4.5741	3.4363	2.5339	3.5717	-0.4083	4.0534	4.6158	3.5423	3.8045	2.0684	1.2268	2.2740
HIV	2.0455	1.0610	0.8935	-0.1394	0.5217	1.0906	0.2184	2.2144	-0.0535	0.8256	2.1805	1.8499	0.4316

Table 20: Complexity scores for HAC15.02 logistic regression model

Groups	15.02 Fourth degree perineal tears
Baseline	51.2371
Emergency admission	-0.4923
Foetal distress	-1.2979
Instrument use	6.9041
PPOP	2.9348
Primigravida	-0.4664
Age Group	
000 to 015	5.8934
016 to 034	0
035 to 099	-2.1272

Appendix E: Complexity bounds

Figure 5: HAC01 – Pressure Injury – Complexity bounds

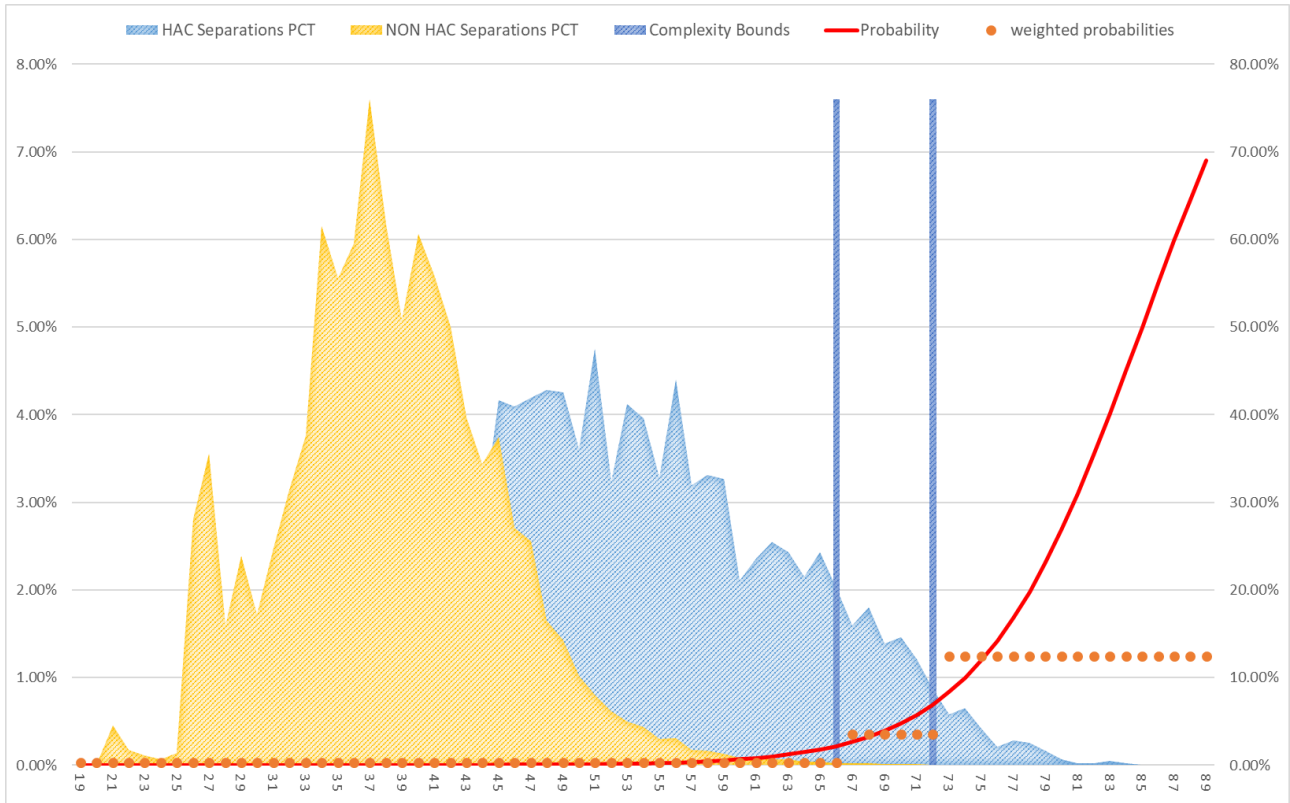


Figure 6: HAC02 – Falls resulting in fracture or intracranial injury – Complexity bounds

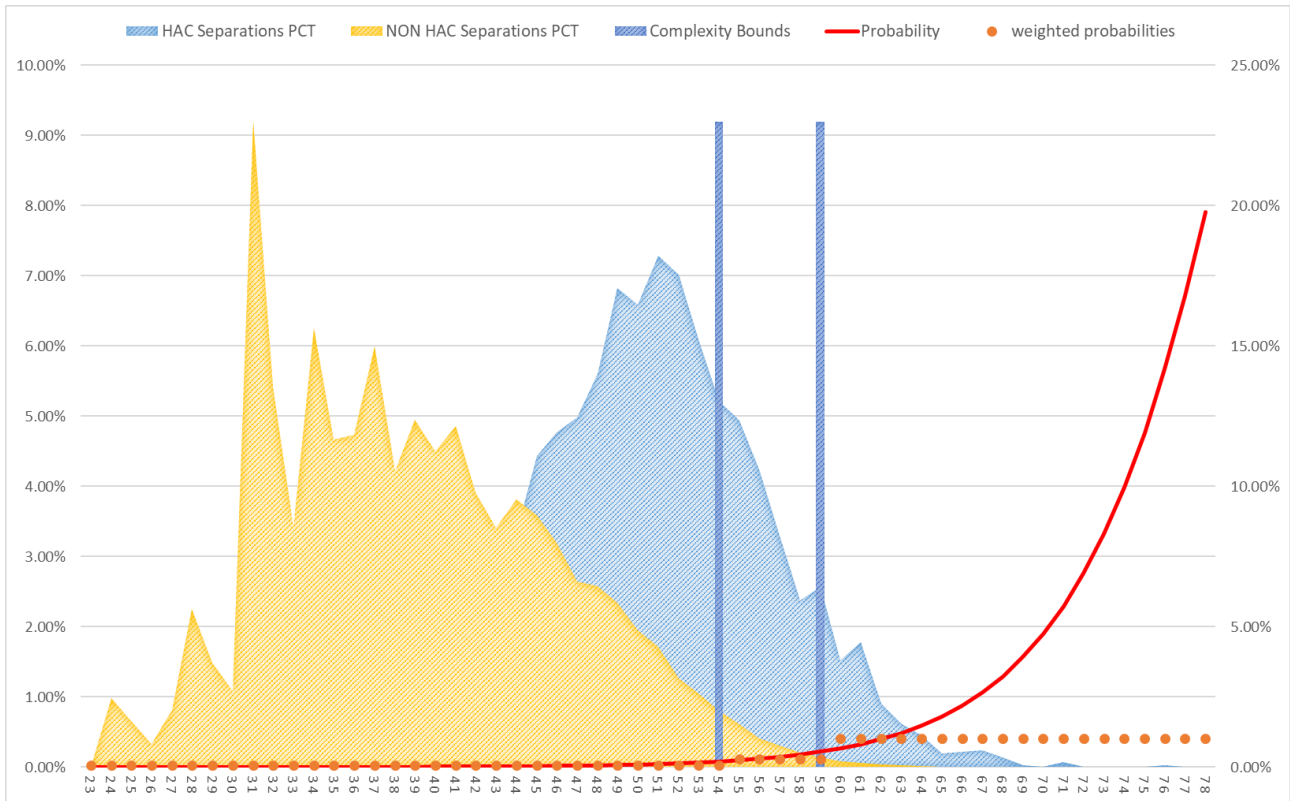


Figure 7: HAC03 – Healthcare-associated infections – Complexity bounds

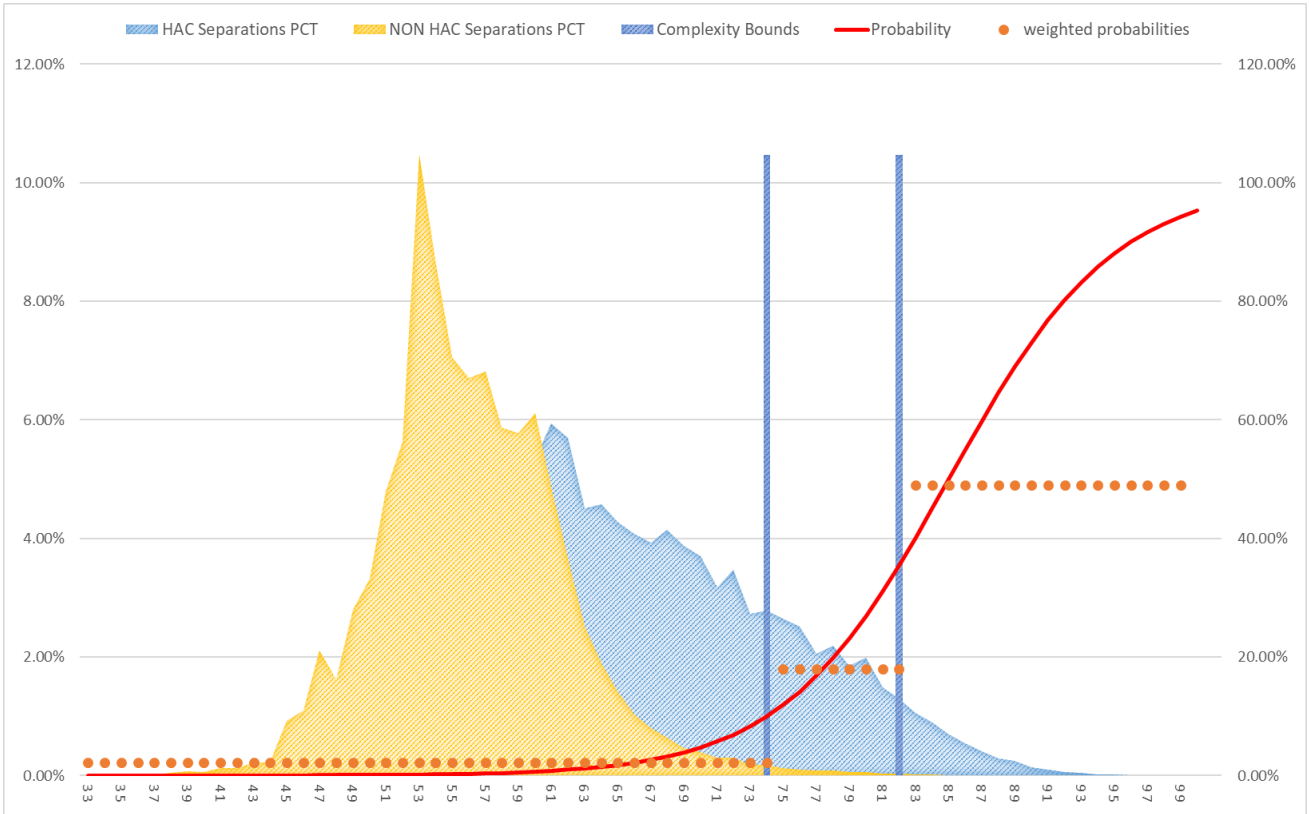


Figure 8: HAC04 – Surgical complications requiring unplanned return to theatre – Complexity bounds

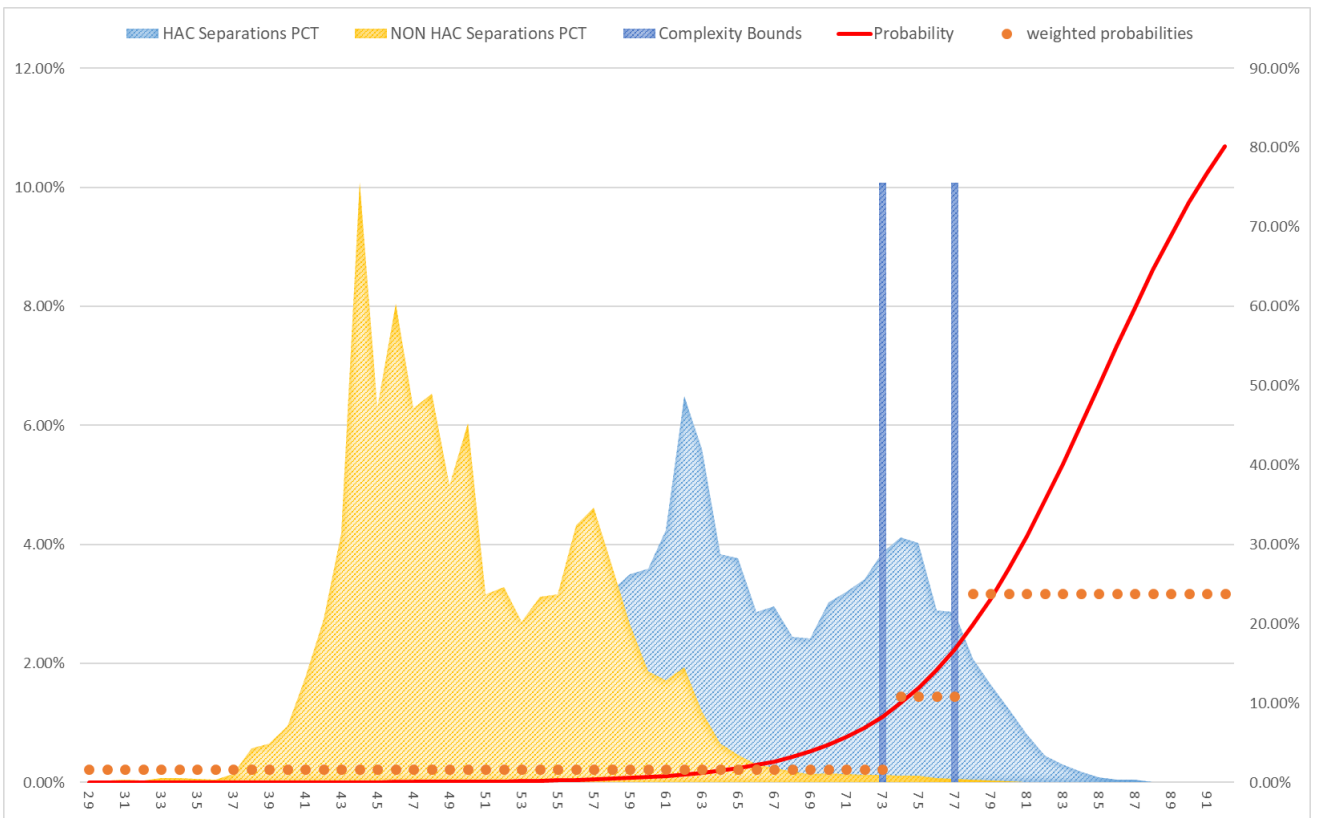


Figure 9: HAC06 – Respiratory complications – Complexity bounds

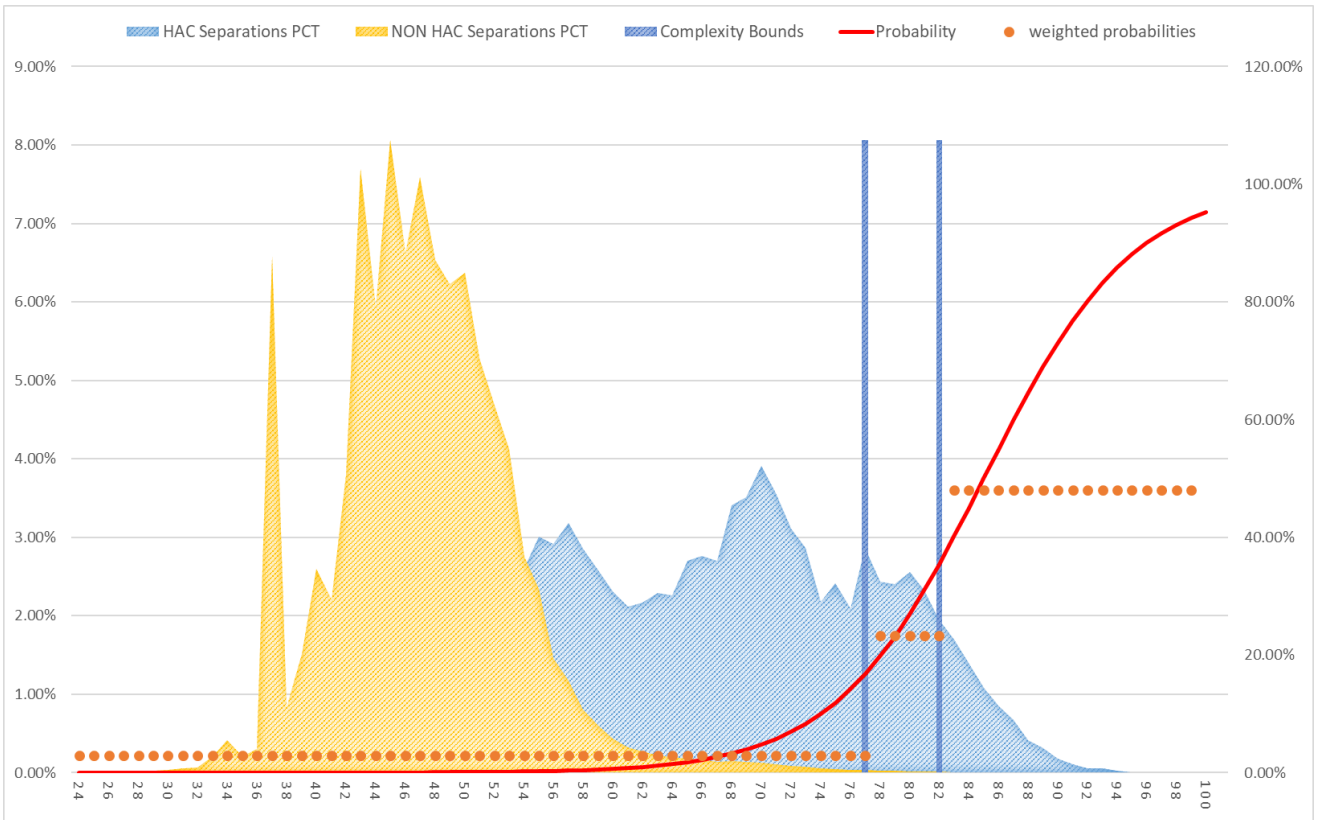


Figure 10: HAC07 – Venous thromboembolism – Complexity bounds

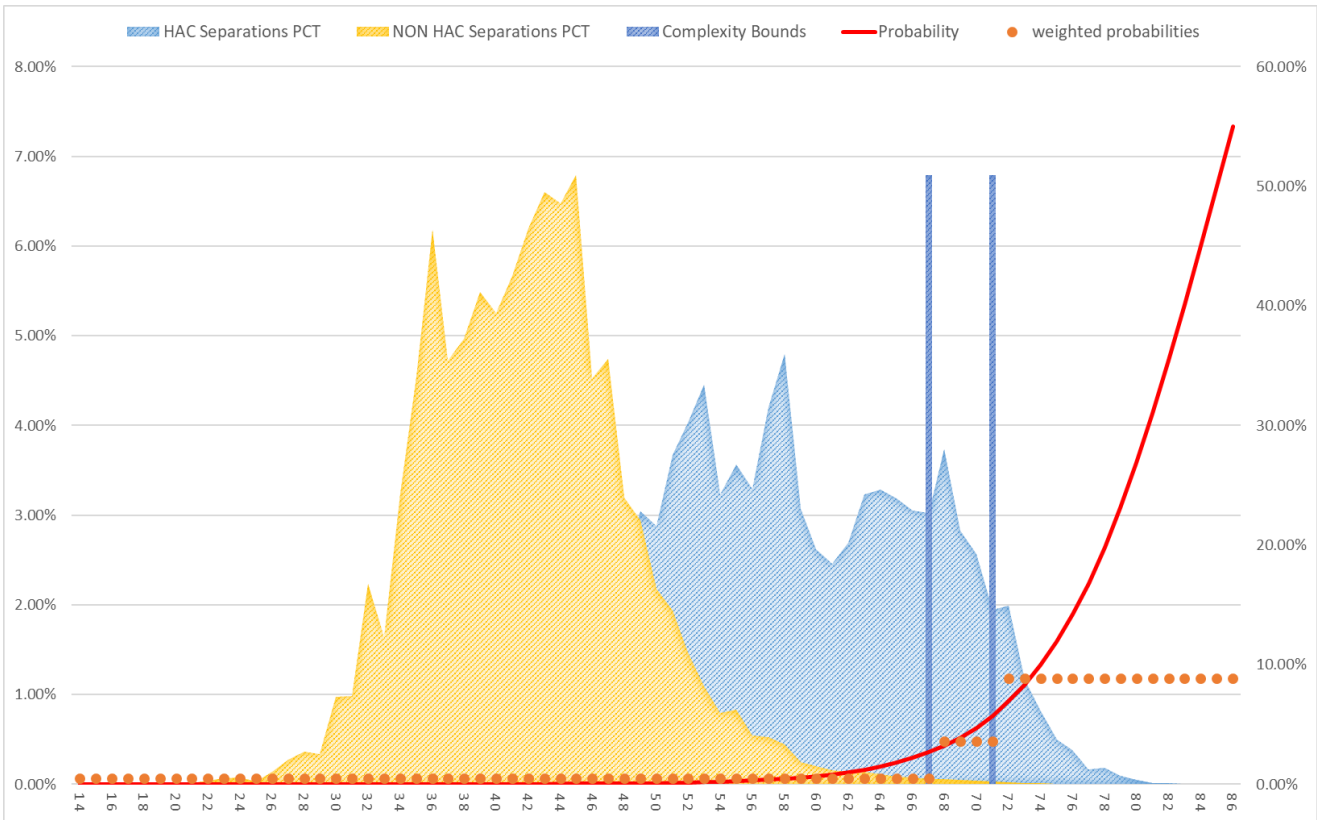


Figure 11: HAC08 – Renal failure – Complexity bounds

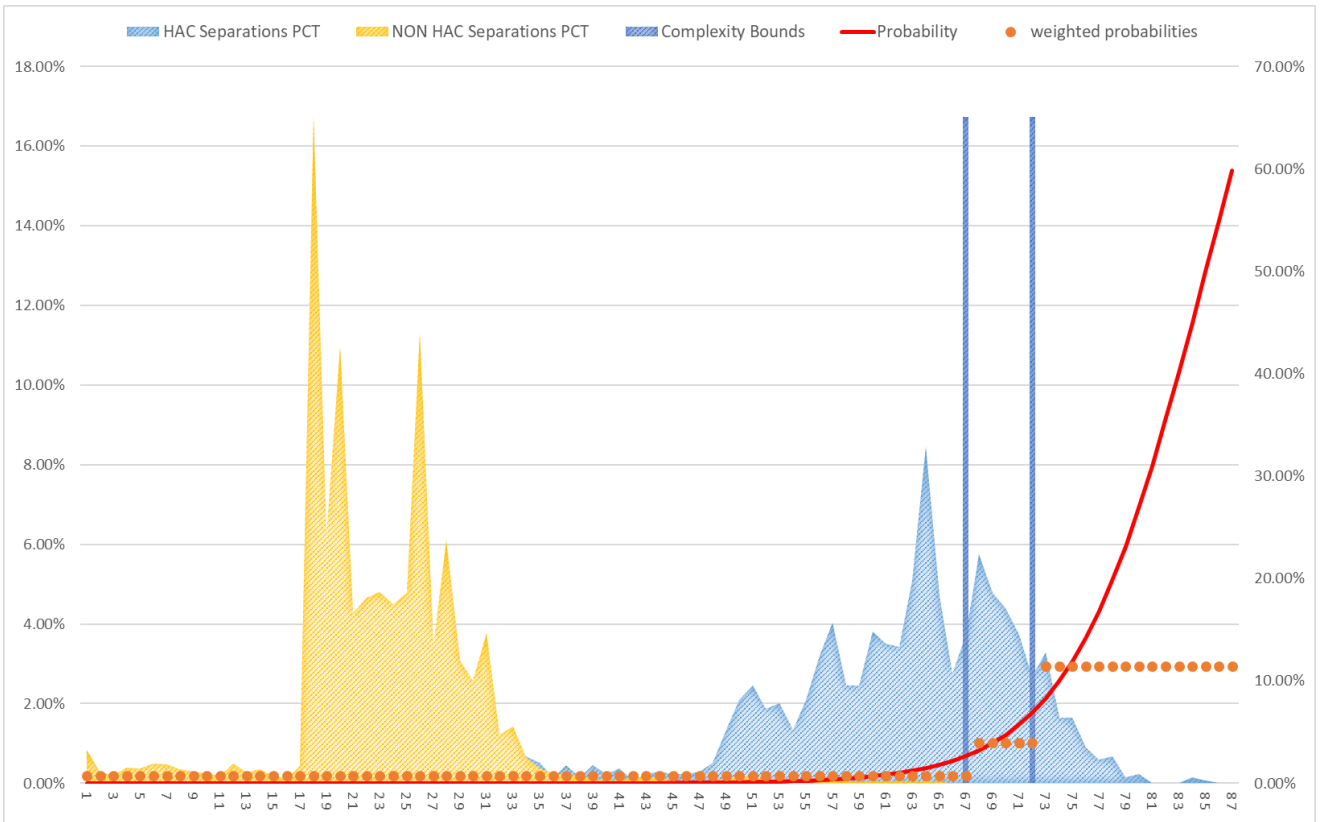


Figure 12: HAC09 – Gastrointestinal bleeding – Complexity bounds

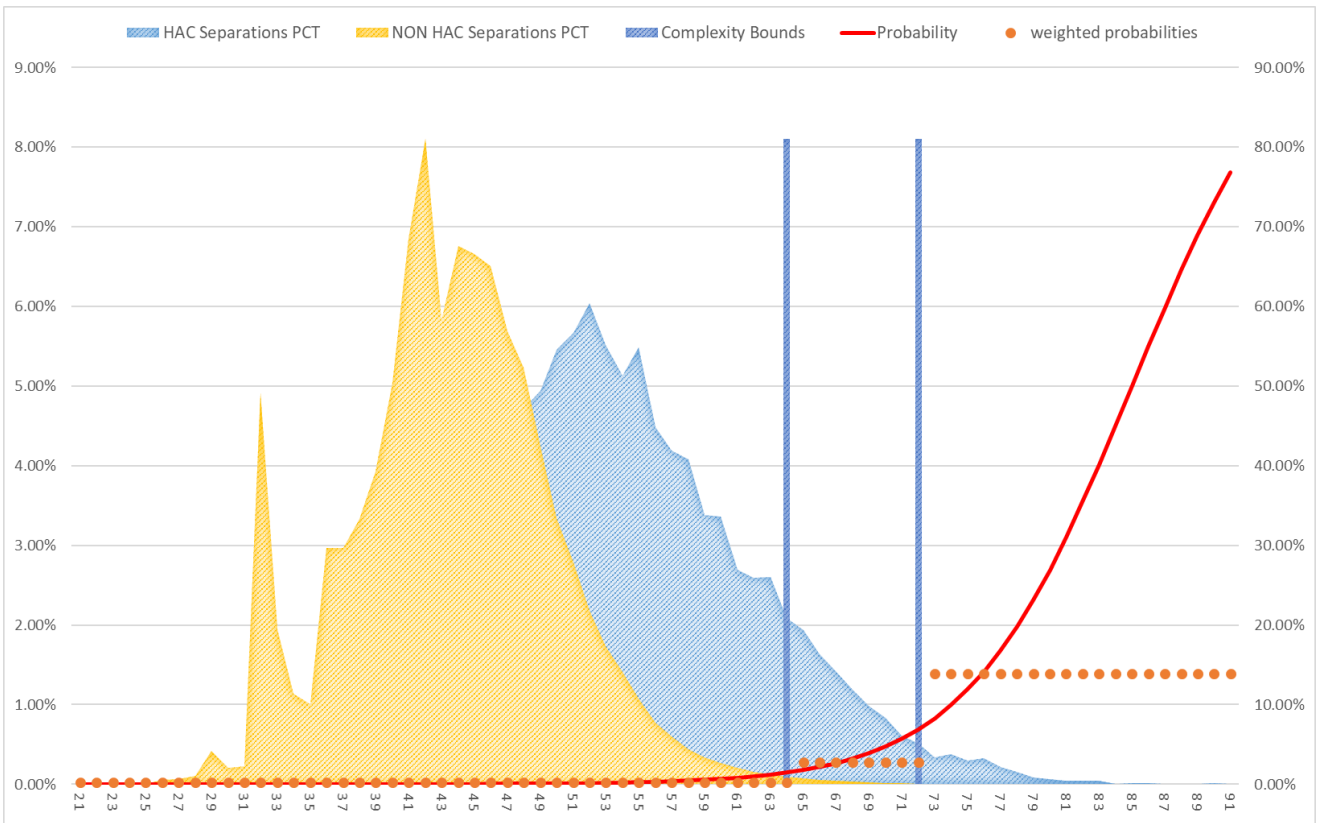


Figure 13: HAC10 – Medication complications – Complexity bounds

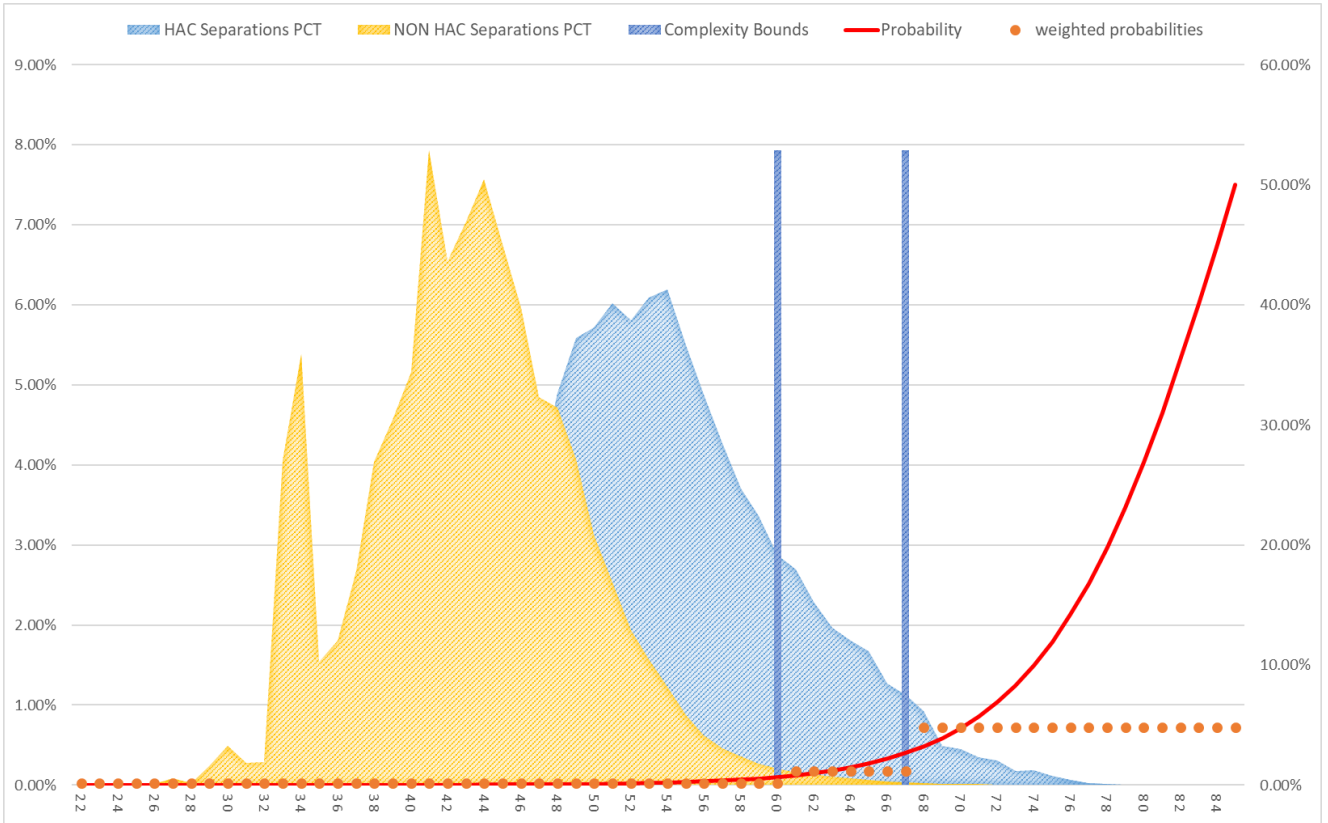


Figure 14: HAC11 – Delirium – Complexity bounds

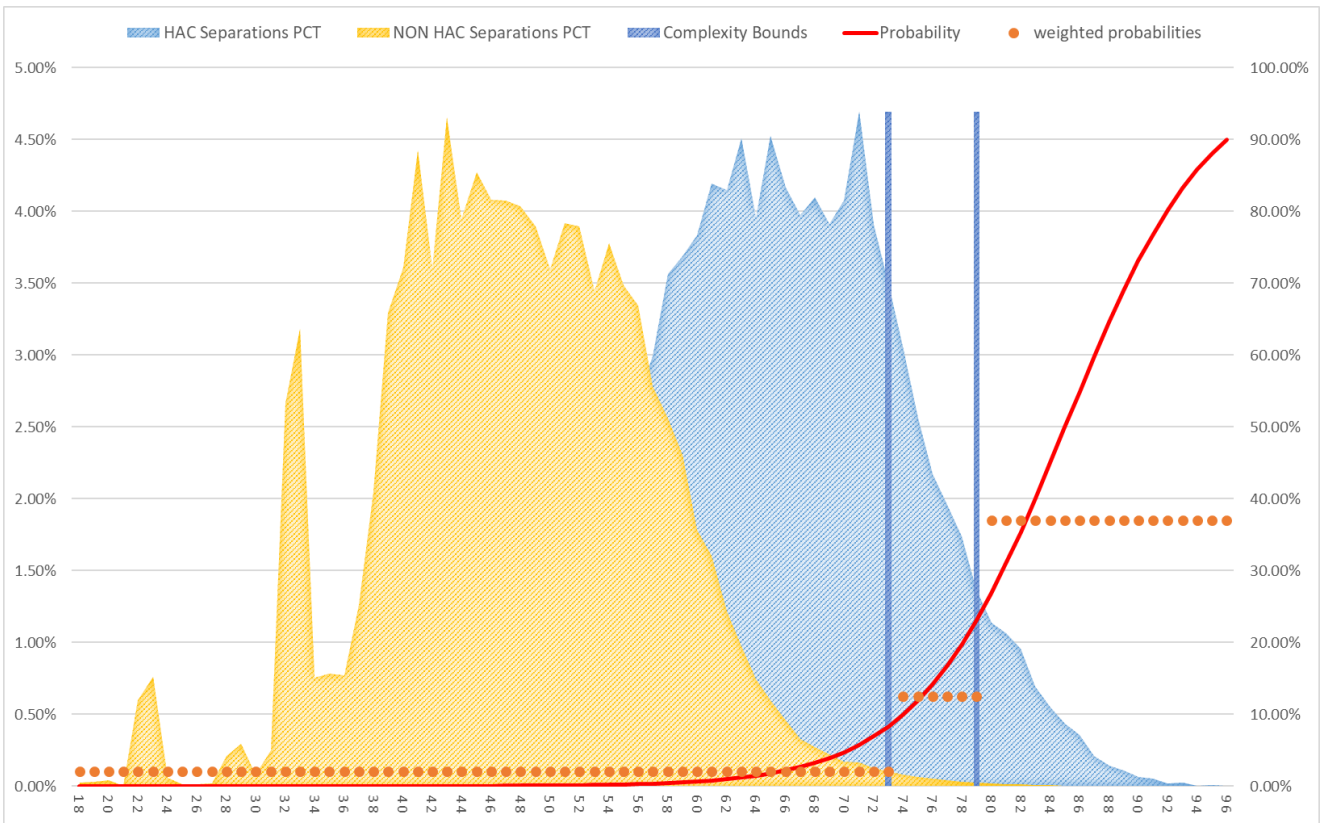


Figure 15: HAC12 – Incontinence – Complexity bounds

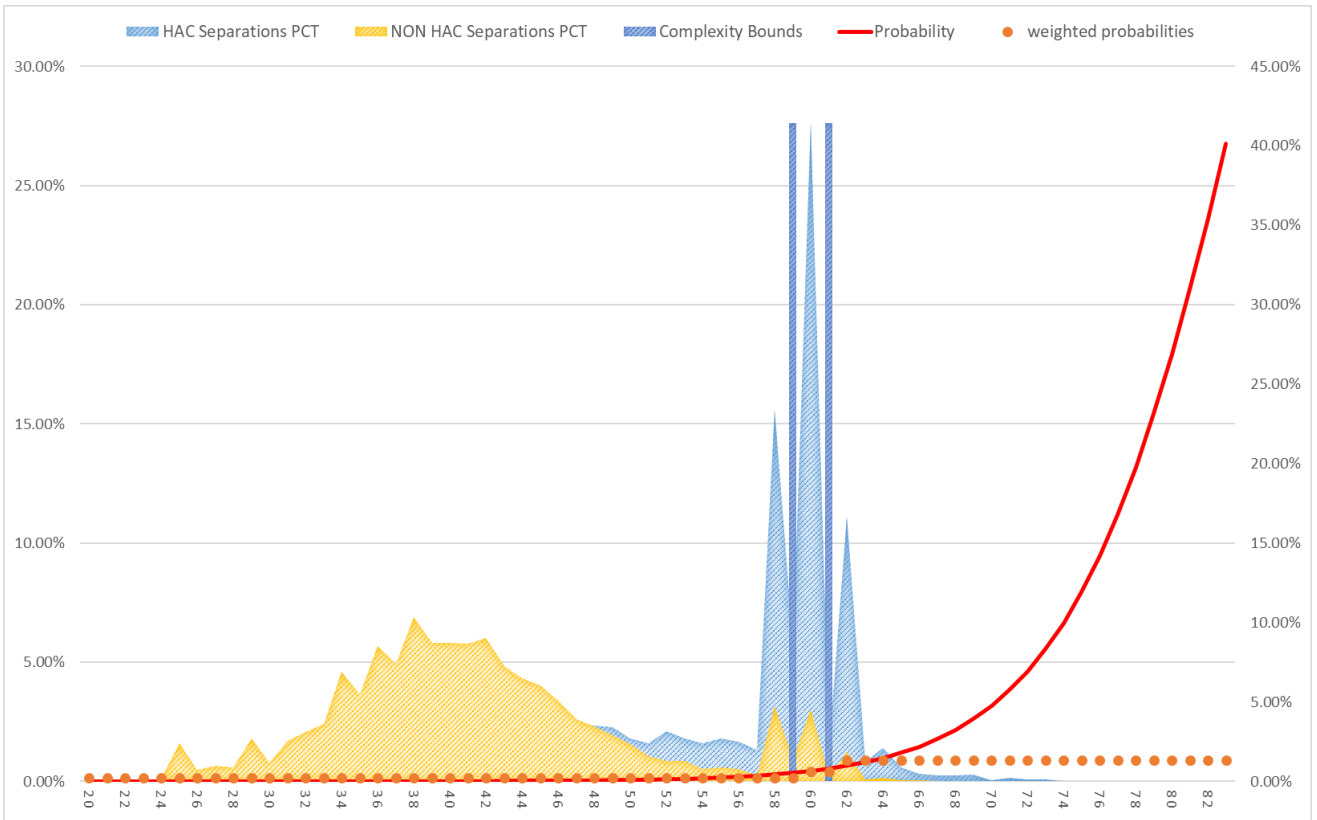


Figure 16: HAC13 – Endocrine complications – Complexity bounds

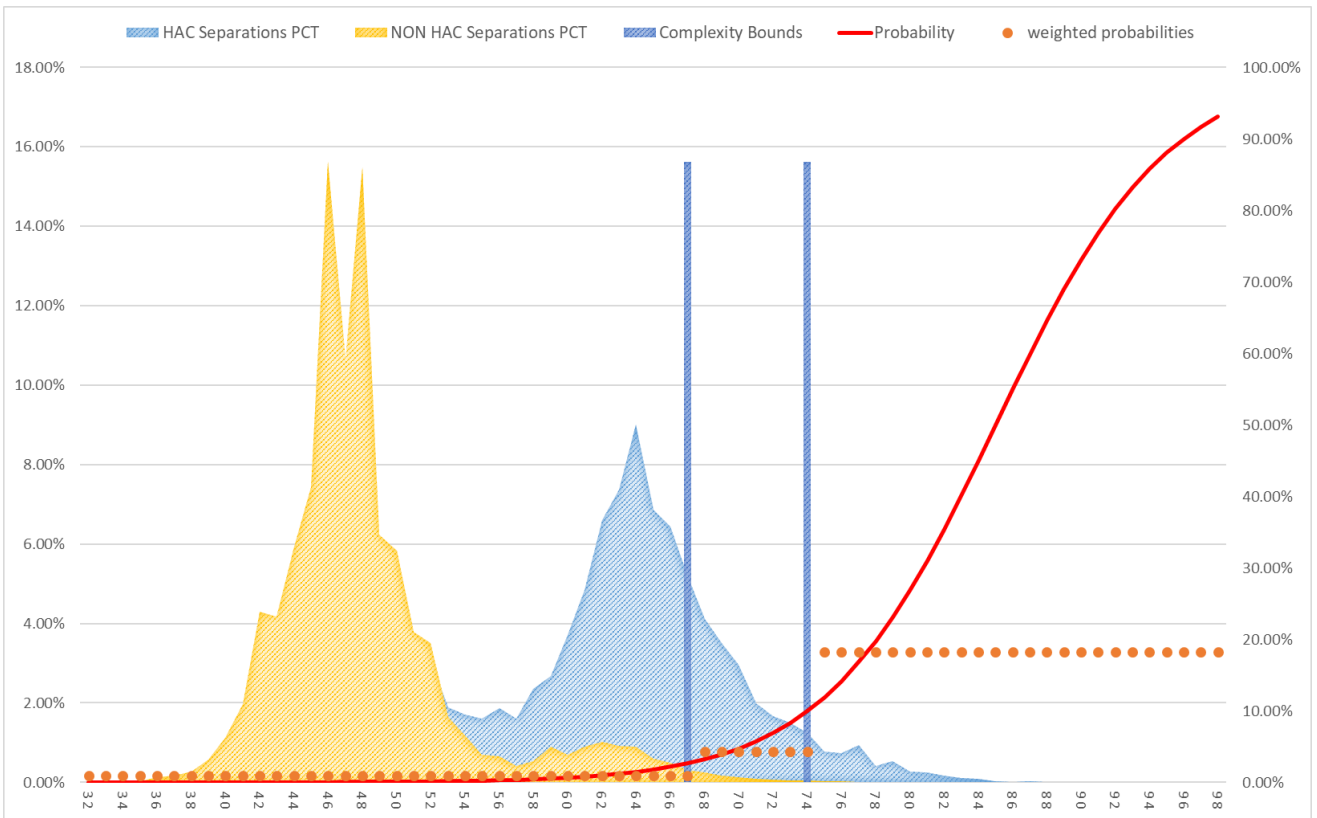


Figure 17: HAC14 – Cardiac complications – Complexity bounds

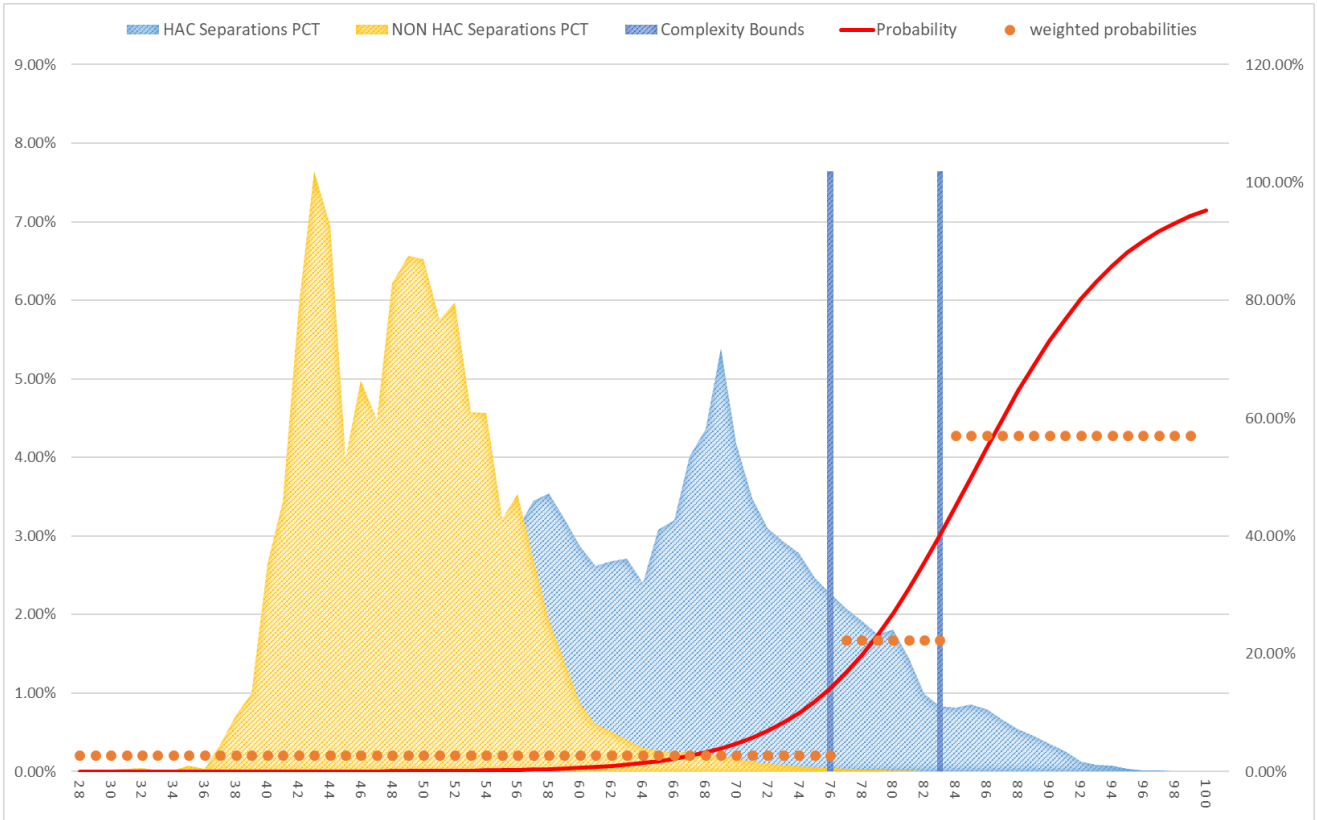
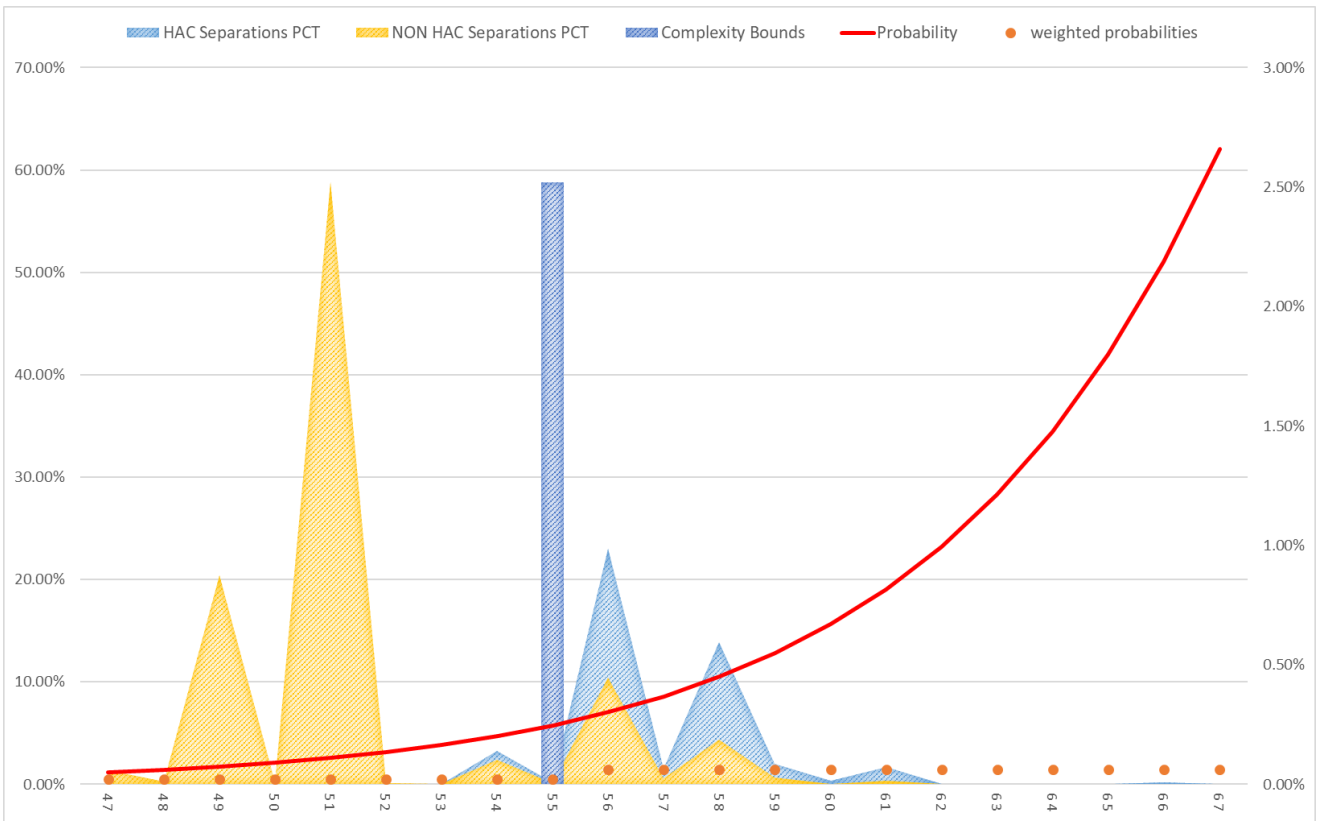


Figure 18: HAC15.02 – Fourth degree perineal laceration during delivery – Complexity bounds





IHACPA

Independent Health and Aged Care Pricing Authority

Level 12, 1 Oxford Street
Sydney NSW 2000

Phone 02 8215 1100

Email enquiries.ihacpa@ihacpa.gov.au

Twitter [@IHACPAnews](https://twitter.com/IHACPAnews)

www.ihacpa.gov.au