Fundamental Review of the National Efficient Price

Final summary report

Independent Hospital Pricing Authority

27 August 2019

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1. Executive Summary

1.1 Background and scope

The National Health Reform Act 2011 (the Act) and National Health Reform Agreement (NHRA) specify the functions of the Independent Hospital Pricing Authority (IHPA). This includes the determination of the National Efficient Price (NEP) for services provided by public hospitals where the services are funded on an activity basis. Collectively, the Act, NHRA and Pricing Guidelines outlined in the Pricing Framework for Australian Public Hospital Services comprise the policy framework that underpins the determination of the NEP.

Independent of the annual process to validate the pricing model underpinning the NEP, Ernst & Young (EY) was engaged in September 2018[1] to undertake a fundamental review of the NEP. The Fundamental review includes a literature review, review of all current processes and statistical techniques and development of a list of recommended improvements.

1.2 Purpose of this document

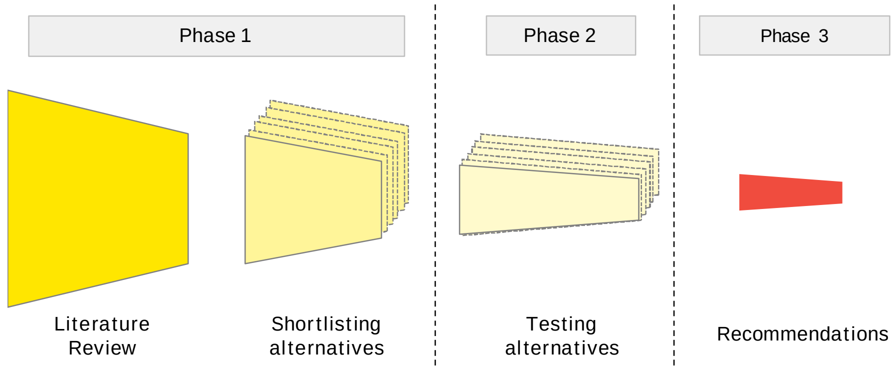
During Phase 1 of the Fundamental Review of the NEP, EY outlined a set of alternative techniques for further testing during Phase 2[2]. EY's prior reports[3] detailed the approach for implementation of these alternatives, as well as the results of testing and recommended next steps for IHPA.

This report summarises all recommendations made throughout our review of current process and statistical techniques, providing a combined assessment of the impact of implementing recommended alternatives within the model.

1.3 Approach to review

The review followed an iterative approach to short-listing and testing across all methodology areas of the national pricing models. This process is summarised in the below diagram.

Figure 1: EY's approach to Fundamental Review of the NEP



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[1] IHPA engaged EY in accordance with the official order dated 17 September 2018 under Deed of Standing Offer (Head Agreement for Services) 14/1213-37 between IHPA and EY dated 3 December 2014 and previously varied 27 May 2016.

[2] EY, Fundamental Review of the National Efficient Price: Literature Review Final Report, 6 December 2018.

[3] 'EY, Fundamental Review of the National Efficient Price: Data preparation and base price weight calculation interim report, 24 April 2019'; 'EY, Fundamental Review of the National Efficient Price: Adjustments and Stabilisation interim report, 27 May 2019' and 'EY, Fundamental Review of the National Efficient Price: Transformation to pricing models and back-casting interim report, 27 June 2019'.

The testing process considered the appropriateness and relevance to IHPA's context, the level of data available and the impact of the alternative techniques on the performance of the pricing models. The result of the staged process literature review to final recommendations is described below:

- A total of 48 alternative techniques were identified in the Literature review, for potential consideration in testing.
- These techniques were subsequently short-listed in conjunction with IHPA for testing within the pricing models. This short-listing approach identified 16 alternative techniques for testing within the pricing models.
- Of the 16 alternative techniques considered, 6 were not recommended for implementation based on the results of the testing phase. Interim recommendations were made regarding the potential for implementation for the remaining 10 alternative techniques.
- Of these 10 alternative techniques, final recommendations were put forward for the implementation of 4 alternative techniques, after a process of stakeholder engagement and prioritisation. Recommendations for further analysis were made with respect to 5 of the alternative techniques. The remaining alternative technique – credibility theory to stabilise prices and adjustments – was deprioritised due to feedback from jurisdictions that a non-statistical approach to stabilisation is preferred, to improve transparency in the process.

1.4 Final recommendations for implementation

The following four alternatives are recommended for implementation within the pricing models. For each of the alternatives, additional areas of analysis are identified to accompany the implementation.

Table 1: Final list of alternatives recommended for implementation in the pricing models

Ref	Methodology Area	Alternative	Recommendation	Additional investigation	Why implement?
1	Data preparation Identification and treatment of outliers for all models	Retention of outliers, incorporating reduced weighting; outlier detection on log transformed data	Perform a log transformation on the data prior to identifying outliers, and utilise a studentised residual approach to identify outliers in the log transformed data	► Undertake further investigation of outliers removed ► Investigate the application of a similar outlier approach in the other pricing models ► Investigate appropriateness of the application of a log-transformation to the cost data throughout pricing.	Applying a log transformation addresses the skewness of the cost data. This leads to more consistent identification of both low and high cost outliers.
2	Base price weight calculation Use of same day, short stay outlier, inlier, and long stay outlier methodology in subacute and acute cost models	Use of median for the price weight within all individual service categories	Use median cost to calculate base price weights for inlier admitted activity and emergency activity	► Investigate use of a median based approach to calculate the SSO and LSO per diems and same-day price ► Investigate use of median cost in non-admitted as data matures	Median is less sensitive to observed high cost outliers and the skewness of the underlying cost data. Therefore, use of median provides jurisdictions with more stable comparisons between DRGs that help them to manage toward greater cost efficiency.

Ref	Methodology Area	Alternative	Recommendation	Additional investigation	Why implement?
3	Base price weight calculation Use of multiple years and different sources of data, in the non-admitted model and block funded cost model;	Application of credibility theory in calculating Non-admitted base price weights	Implement a credibility theory based approach to combining non-admitted data sources.	▶ Investigate discrepancies in prices determined from use of NHCDC in place of the costing study	Credibility theory reduces reliance on external data sources by facilitating a gradual shift towards NHCDC cost data, as it matures and stabilises.
4	Adjustments Adjustments for legitimate and unavoidable variation in costs, as specified in the 2018-19 NEP Determination	Calculation of adjustments in a single model and consideration of their interactions	Implement all patient level adjustments within a single multiplicative (gamma) GLM model within the National Pricing Models	▶ Investigate additional interaction effects identified	Implementation of adjustments in a single model considers the dependence between adjustment factors and improves understanding of the adjustment values.

These alternatives were concurrently tested to assess the combined impact of the recommendations on the fit of the pricing models. This impact was considered with regards to the overarching model fit metrics r-squared and SMAPE.

In addition to the benefits outlined above, it was found that the combined implementation of the recommendations had minimal impact on the overall model fit.

Table 2: Change in overarching metrics, application of the four alternatives recommended for implementation

Metric	Acute	Subacute	Non-Admitted	Emergency Department
SMAPE*	9.5% (< +0.1%)	15.0% (<+0.1%)	26.4% (-0.2%)	13.0% (+0.1%)
R-squared*	81.6% (+2.3%)	80.8% (-0.2%)	3.0% (+0.1%)	25.9% (-0.5%)

*Number in brackets reflects difference from IHPA baseline run

1.5 Final recommendations for further analysis

Recommendations for further analysis were made with respect to 5 alternative techniques. These recommendations relate to the implementation of monitoring techniques, as well as identification of the need for refinements to the broader process, prior to implementing changes. These are summarised in Table 3.

Table 3: Final recommendations for further analysis of potential alternative techniques

Ref	Methodology Area	Alternative	Additional investigation
1	Data preparation PBS data linking and removal of costs from linked episodes	Targeted pharmaceutical matching	▶ Investigate drivers of discrepancies between NHCDC reported costs and matched pharmaceutical records ▶ Following improvements in the integrity of reported pharmaceutical costs, include date restrictions to the matching process for the unique matching steps
2	Data preparation Identification and treatment of outliers for all models;	Retention of outliers, with bootstrapping to determine price	▶ Utilise a bootstrapping approach to develop an understanding of the distribution of the calculated costs in the Acute model ▶ Undertake further investigation of anomalous end classes in conjunction with jurisdictions

Ref	Methodology Area	Alternative	Additional investigation
3	Stabilisation Evaluation of DRG and SNAP class comparability across classification versions for the purposes of stabilisation of acute and subacute price weights	Stabilisation across classification versions using weighted average price weights	▶ Monitor shifts in price weights in future years, where a change in classification versions takes place
4	Transformation to pricing models Calculation of the indexation rate	Comparison of derived rates with external indices and historical experience	▶ Monitor trends in external prices indices ▶ Monitor actual growth rates against predicted indexation
5	Transformation to pricing models Calculation of the indexation rate	Regression of growth against drivers of indexation	▶ Monitor and validate the projected indexation rate through comparison to the output of a regression on PPI

2. Introduction

2.1 Background and scope

The National Health Reform Act 2011 (the Act) and National Health Reform Agreement (NHRA) specify the functions of the Independent Hospital Pricing Authority (IHPA). This includes the determination of the National Efficient Price (NEP) for services provided by public hospitals where the services are funded on an activity basis. Collectively, the Act, NHRA and Pricing Guidelines outlined in the Pricing Framework for Australian Public Hospital Services comprise the policy framework that underpins the determination of the NEP.

IHPA has developed a set of National Activity Based Funding (ABF) Cost and Pricing Models that underpin the NEP determination (the Models). The Models are subject to an annual validation process to provide IHPA with quality assurance that the Models are 'fit for purpose'.

In performing its functions, IHPA is obligated to consider a range of fundamental factors specified in the Act, NHRA and Pricing Guidelines. Independent of the model validation process, to provide IHPA with an external review of these fundamental factors throughout the NEP determination process, Ernst & Young (EY) was engaged in September 2018[4] to undertake a fundamental review of the NEP. The Fundamental review includes a literature review, review of all current processes and statistical techniques and development of a list of recommended improvements.

2.2 Purpose of this document

During Phase 1 of the Fundamental Review of the NEP, EY outlined a set of alternative techniques for further testing during Phase 2[5]. EY's prior reports[6] detailed the approach for implementation of these alternatives, as well as the results of testing and recommended next steps for IHPA.

This report summarises all recommendations made throughout our review of current process and statistical techniques, providing a combined assessment of the impact of implementing recommended alternatives within the model. Specifically, this report summarises the:

- Approach to the review, encompassing the literature review, testing phases and process to determine recommendations;
- Alternatives recommended for implementation within the pricing models; and
- Alternatives recommended for further investigation.

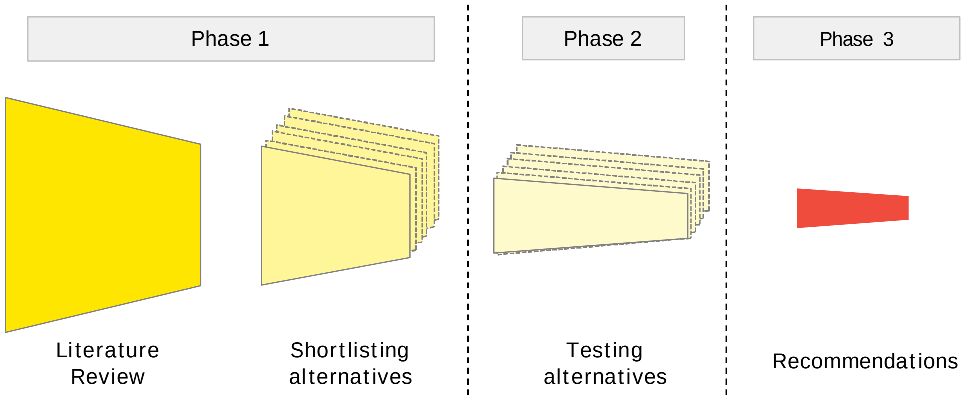
[4] IHPA engaged EY in accordance with the official order dated 17 September 2018 under Deed of Standing Offer (Head Agreement for Services) 14/1213-37 between IHPA and EY dated 3 December 2014 and previously varied 27 May 2016.
[5] EY, Fundamental Review of the National Efficient Price: Literature Review Final Report, 6 December 2018.
[6] 'EY, Fundamental Review of the National Efficient Price: Data preparation and base price weight calculation interim report, 24 April 2019'; 'EY, Fundamental Review of the National Efficient Price: Adjustments and Stabilisation interim report, 27 May 2019' and 'EY, Fundamental Review of the National Efficient Price: Transformation to pricing models and back-casting interim report, 27 June 2019'.

3. Approach

The review followed an iterative approach to short-listing and testing, underpinned by the six key methodology areas of the national pricing models. A number of alternative techniques were identified in the initial Literature Review, with these techniques subsequently short-listed in conjunction with IHPA for testing within the pricing models. Recommendations on the implementation of alternatives as well as areas for further analysis were ultimately identified based on the outcomes of testing.

This process is summarised in the below diagram and is detailed in the following sections.

Figure 2: EY's approach to Fundamental Review of the NEP



3.1 Literature review

The initial phase of the Fundamental Review of the NEP consisted of a literature review of modern data analysis and statistical modelling techniques, applicable to activity based funding of hospital services. Considerations were made of both techniques utilised in the context of health funding, as well as those documented in broader literature.

The key steps undertaken during the Literature Review included:

1. Review of current methodology – desktop review of IHPA documentation to understand the purpose of current processes / techniques and identify any key challenges.
2. Development of research plan – a set of key research questions and search phrases were defined in the research plan to guide the literature review.
3. Identification of a ‘long list’ of alternative techniques – a compilation of findings across three research streams to produce a ‘long list’ of alternative techniques. The three research streams were statistical focused, sector focused, and leveraging prior review knowledge.
4. High level assessment for Phase 1 short-list – criteria were applied in order to identify alternative techniques to be considered in Phase 2 of the review. These criteria included ease of implementation, ease of understanding, expected impact with regards to agreed modelling principles, and alignment with purpose.
5. Identification metrics for quantitative testing – assess the feasibility and appropriateness of identified metrics relevant to each methodology stage.

A total of 48 techniques were identified in the Literature review, for potential consideration in testing.

3.2 Shortlisting alternatives

In consultation with IHPA, the alternatives identified in the Literature Review were prioritised for further consideration in Phase 2. The prioritisation approach made consideration of the following factors:

- Outcomes of the initial high-level assessment performed in the literature review;
- Focus areas for IHPA, including items recurrently mentioned in consultations with jurisdictions;
- Spread of techniques across the six methodology areas;
- Estimated time required for testing; and
- Alignment with the alternatives prioritised for testing by other providers participating in the review.

This short-listing approach identified 16 techniques for testing within the pricing models. By methodology area, these alternatives are as follows:

Table 4: The 16 alternatives short-listed for testing within the pricing models, by methodology area

Methodology Area	Short-listed alternative
1. Data preparation	Targeted pharmaceutical claim matching
	Logistic regression to scale Hospital Casemix Protocol (HCP) data
	Retention of outliers, incorporating reduced weighting
	Retention of outliers, with bootstrapping to determine price
2. Base price weight calculation	Use of median for the price weight within all individual service categories
	Calculation of inlier bounds using percentiles
	Application of credibility theory in calculating non-admitted base price weights
3. Adjustments	Calculation of adjustments in a single model and consideration of their interactions
	Fixed incremental dollar amounts for selected adjustments
	Clustering technique to identify groups of variation in the data
4. Stabilisation	Stabilisation across classification versions using weighted average price weights
	Credibility theory to stabilise prices and adjustments
5. Transformation to Pricing Models	Analysis of historical deviation between IHPA's projected indexation and external indices; Analysis of historical deviation between IHPA's projected indexation and actual inflation
	Regression of growth against drivers of indexation
	ARIMA (time series) modelling of growth
6. Back-casting[7]	Smoothing of volume multipliers, using multiple base years for calculation

[7] Note that for the purpose of the Fundamental Review, the definition of back-casting refers to the standard annual process of adjusting both NWAU and NEP for changes in modelled prices. Ad-hoc retrospective adjustments (which have also been termed back-casting previously) are considered out of scope. These adjustments are reviewed independently and, given their ad-hoc nature, there is no standard statistical technique available to perform such adjustments.

3.3 Testing

For each of the 16 techniques short-listed in Phase 1, alternative approaches were implemented within the pricing models in place of the current approach. This testing was performed to assess the impact of implementing the alternatives. The relative merits of the alternatives were assessed using agreed metrics, which included overarching assessments of goodness-of-fit as well as measures specific to the methodology review areas where relevant. Detail around the metrics used to assess each alternative are contained in the accompanying metrics document.

The following overarching metrics were utilised to understand the impact of the alternatives on the goodness of fit of the models, at both an individual service and facility level. The goodness of fit refers to the extent to which the modelled cost reflects the underlying cost data. Historically, IHPA has used these standard statistical measures as performance benchmarks in developing the Pricing Models. These goodness-of-fit metrics were applied consistently across all alternatives to the extent possible[8].

Table 5: Overarching metrics used to assess the impact of all alternatives

Metric	Description
Change in cost ratios	Summarises the difference between modelled and actual cost across facilities and services in a meaningful way, accounting for differences in complexity of service.
R-squared	Statistical measures of goodness of fit to the actual costs.

Of the 16 alternative techniques considered, 6 were not recommended for implementation based on the results of the testing phase. For the other 10 techniques, interim recommendations were made regarding the implementation of alternative statistical techniques within these pricing models. These recommendations included both:

- Recommendations to implement the alternative technique, as performed during the testing phase; and
- Identification of areas for further analysis, which can be used to refine the alternative technique or provide a more robust assessment of the relative merits of the alternative.

These interim recommendations were shared and discussed with jurisdictions through the Fundamental Review Working Group (FRWG) and Technical Advisory Committee (TAC) meetings.

3.4 Final Recommendations

Following results of the testing phase and feedback from jurisdictions, further short-listing of recommendations was undertaken to prioritise alternatives for implementation within the pricing model. Updating techniques concurrently enabled an assessment of the combined impact of these alternatives on overall model metrics, accounting for interactions between the changes.

Feedback from TAC and IHPA on the 10 interim recommendations yielded:

- Recommendations for implementation of 4 alternative techniques. These alternatives are concurrently implemented in the final phase.

[8] For the purpose of assessing the overall model impact of concurrent implementation of final recommendations, only goodness of fit statistics which can provide an end-to-end view of impact are considered. Section specific metrics consider specific points of the process and are not fit for purpose.

- Recommendations for further analysis with respect to 5 of the remaining 6 alternative techniques. These are longer term recommendations which relate to monitoring techniques or require data improvements.
- De-prioritisation of 1 alternative technique – credibility theory to stabilise prices and adjustments. This alternative was deprioritised due to the feedback received from jurisdictions during consultations. Jurisdictions indicated that it is preferred that changes in costs are reflected through changes in price weights, rather than the price weights being automatically stabilised through complex statistical processes.

A summary of final recommendations by alternative is provided in Table 6.

Table 6: Summary of final recommendations by alternative - implementation recommendations and recommendations for further analysis

Methodology Area	Short-listed alternative	Final Recommendation			
		Recommend implementation[9]	Recommend for monitoring	Recommend following data improvements	Not recommended
1. Data preparation	Targeted pharmaceutical matching			✓	
	Logistic regression to scale Hospital Casemix Protocol (HCP) data				×
	Retention of outliers, incorporating reduced weighting; outlier detection on log-transformed data	✓			
	Retention of outliers, with bootstrapping to determine price		✓		
2. Base price weight calculation	Use of median for the price weight within all individual service categories	✓			
	Calculation of inlier bounds using percentiles				×
	Application of credibility theory in calculating non-admitted price weights	✓			
3. Adjustments	Calculation of adjustments in a single model and consideration of interactions	✓			
	Fixed incremental dollar amounts for selected adjustments				×
	Clustering technique to identify groups of variation in the data				×
4. Stabilisation	Stabilisation across classification versions using weighted average PWs		✓		
	Credibility theory to stabilise prices and adjustments				×
5. Transformation to Pricing Models	Analysis of deviation between IHPA's projected indexation, external indices, and actual inflation		✓		
	Regression against indexation drivers		✓		
	ARIMA (time series) modelling				×
6. Back-casting	Smoothing of volume multipliers, using multiple base years for calculation				×

[9] Further analysis accompanying implementation is recommended, to confirm appropriateness of the approach across different years' data and extend the alternative to other relevant components of the models.

4. Final recommendations

Interim recommendations were provided during the testing phase. Following stakeholder consultation with the FRWG and TAC, feedback regarding the interim recommendations was collected and incorporated. From this, a short list of recommendations was prioritised for implementation in the pricing models, to account for alignment and interactions between recommendations.

The four alternatives recommended for implementation were applied concurrently in the pricing models. This enabled an assessment of the combined impact of the recommended alternatives on overall model fit metrics, specifically r-squared and SMAPE. The four alternatives implemented concurrently were:

- Retention of outliers, incorporating reduced weighting; outlier detection on log transformed data;
- Use of median for the price weight within individual service categories;
- Application of credibility theory in calculating Non-admitted base price weights; and
- Calculation of adjustments in a single model and consideration of their interactions.

A summary of the impact of these alternatives on the model fit is provided in Table 7. It is evident that the combined implementation of these alternatives had only minor impacts to overall model fit. The greatest differences are observed in the Acute model, reflecting a small improvement.

Table 7: Change in overarching metrics, application of the four alternatives recommended for implementation

Metric	Acute	Subacute	Non-Admitted	Emergency Department
SMAPE*	9.5% (< +0.1%)	15.0% (<+0.1%)	26.9% (+0.3%)	13.0% (+0.1%)
R-squared*	81.6% (+2.3%)	80.8% (-0.2%)	3.1% (+0.2%)	25.9% (-0.5%)

*Number in brackets reflects difference from IHPA baseline run

The final recommendations, and associated findings of the testing phase, are detailed below by alternative. Detail on the purpose, challenges and implementation of each alternative is provided in Appendix B.

4.1 Recommendations for implementation

The following four alternatives are recommended for implementation within the pricing models. These alternatives were concurrently implemented in the final phase, to assess the combined impact of the recommendations on the output of the pricing models.

For details around the purpose, current challenges and testing performed please refer to Appendix B.

Note that for each of the recommended alternatives, additional areas of analysis are identified to accompany the implementation.

4.1.1 Retention of outliers, incorporating reduced weighting; outlier detection on log transformed data

The current approach to identifying and treating outliers varies by service category, with a combination of jurisdictional advice and extreme cost analysis applied to the raw cost data. The current approach presents challenges as it relies on the assumption of normality of costs, leading to the identification of more outliers in low volume end classes as well as identification of a higher proportion of low cost outliers than high cost outliers.

Refer to Appendix B for detail on the purpose, challenges and implementation of the alternative.

Alternative: Retention of outliers, incorporating reduced weighting; outlier detection on log transformed data
Results of testing The alternative approach identifies both low and high cost outliers, while the current approach appears to identify very few high cost outliers ► Each scenario considered under the alternative approach result in the identification and removal or (down-weighting) of a higher proportion of outliers than the current approach. The alternative approaches reduce the average cost by 1-3% after removal (or down-weighting) of outliers, reflecting that more higher cost anomalies are trimmed compared to the current methodology. The current methodology implements a selection of statistical techniques that rely on the assumption that NHCDC cost data follows a normal distribution. However, NHCDC cost data in general is right skewed and non-symmetrical. This can result in disproportionate impacts across end classes of different volumes. ► The median proportion of, and range of, outliers observed is relatively stable across different end class volume groups for the alternative approaches. This indicates the alternative approaches provide a more consistent treatment across end classes of different volumes. The model fit under the alternative outlier detection approaches does not materially change when compared to the current approach.
Recommendations for implementation 1. Perform a log transformation on the data prior to identifying outliers, and utilise a studentised residual approach to identify outliers in the log transformed data Application of a log transformation addresses the skewness of the underlying NHCDC cost data, improving the efficacy of statistical outlier detection techniques which implicitly assume symmetry. However, if a log transformation is implemented for outlier identification only, inconsistencies with the broader pricing approach may develop. IHPA should investigate other instances where normality is assumed, to determine if there are implications on the appropriateness of the broader approach.
Recommendations for further analysis 1. Undertake further investigation of outliers removed Additional analysis is recommended to determine whether the identified outliers are likely to be valid high cost outliers or anomalous data points. This investigation should be undertaken in conjunction with jurisdictions, to resolve the cause of anomalies. 2. Investigate the application of a similar outlier approach in the other pricing models The outlier approach should be consistently implemented across the four pricing models, where relevant. 3. Investigate the appropriateness of the application of a log-transformation to the cost data throughout the pricing process The cost data exhibits characteristics of non-symmetrical data. As such, it is recommended that IHPA consider the use of log-transformed cost data in determining price-weights. This should be considered with regards to the ease of implementation of the change.

4.1.2 Use of median for the price weight within all individual service categories

The current approach to base price weight calculation uses the mean cost as the basis for pricing inlier services, as well as ED activity. The current approach presents challenges as the underlying NHCDC cost data is in general right-skewed. This results in the calculation of a benchmark for cost efficiency which is greater than the cost of service delivery for more than half of all services. In addition, this calculation is sensitive to high cost outliers, potentially skewing results.

Refer to Appendix B for detail on the purpose, challenges and implementation of the alternative.

Alternative: Use of median for the price weight within all individual service categories
Results of testing The alternative approach provides jurisdictions with more consistent comparisons between DRGs that help them to manage toward greater cost efficiency ► The median to mean ratio is less than 1 for a high proportion of end classes across all service categories. The median provides more consistent relativities between DRGs, such that an equal proportion of services have higher or lower costs. ► The use of median reduces sensitivity to high cost outliers. The model fit under the alternative remains largely consistent with the current approach. ► Only one hospital experiences a change in cost ratio of more than 4% for both Acute and Emergency. For Subacute, no hospital level changes greater than 1.7% are observed. Greater variation is observed in the hospital level changes for Non-admitted activity. This is a result of the provision of aggregate level data. ► For admitted care, use of median results in a cost ratio closer to 1 across all separation categories, except for Same Day separations in Acute. This reflects greater equity across the separation categories under the alternative approach. ► The use of median slightly improves the model fit (r-squared and SMAPE) at an aggregate level, except for Emergency where the model fit reduces marginally.
Recommendations for implementation 1. Use median cost to calculate base price weights for inlier admitted activity and emergency activity Median reduces sensitivity to outliers and is expected to reduce reliance on the stabilisation process. This improves transparency of price weights and stability between years. Price weights reduce for services with large outlier costs and increase for more consistent cost-efficient services. This increases the incentive for cost-efficiency and improves the accuracy of comparisons of hospital service efficiency using price weights. If IHPA elects to implement the median approach to pricing inlier separations only, it is recommended that the calibration process is applied to Same Day, SSO and Inlier parameters only. This prevents artificial over-inflation of LSO per diems due to differences between the median and mean inlier price. Such over-inflation would reduce the intended incentive for shorter stay separations, by allocating a higher price to LSO.
Recommendations for further analysis 1. Investigate use of a median based approach to calculate the SSO and LSO per diems and same-day price The implementation of the alternative currently only considers the Inlier price for admitted activity. An alternative median based approach should be explored for SSO and LSO per diems as well as the same-day price. The selected approach should maintain the current incentivisation structure while adequately compensating longer stay separations. 2. Investigate use of median cost in non-admitted as data matures The efficacy of the use of median for non-admitted is reduced due to the provision of aggregate rather than patient level data. Instead of taking a median approach, IHPA should consider the use of credibility within the non-admitted service category prior to the availability of stable patient level cost data.

4.1.3 Application of credibility theory in calculating non-admitted base price weights

The current approach to combining multiple non-admitted cost data sources follows a hierarchical assignment of data source, depending on whether the data source achieves required thresholds for the given clinic. This presents challenges as it can drive price instability between years, with a step change in the assigned price weight occurring when data sources change.

This recommendation directly interacts with the recommendation to use median price weights across all service categories. For the purposes of the combined implementation, the calibrated median price weight from the NHCDC data was not implemented for the non-admitted service category. A transition phase, whereby credibility theory is used in lieu of the median price weight, may be appropriate for the non-admitted service category in the absence of stable and mature patient level cost data. This had an immaterial impact on model fit.

Refer to Appendix B for detail on the purpose, challenges and implementation of the alternative.

Alternative: Application of credibility theory[10] in calculating non-admitted base price weights
Results of testing The alternative increases alignment between the base price weight calculation and the current cost of service delivery, as reported in the NHCDC ► The use of credibility theory results in prices which are generally within 20% of the currently assigned prices. However, outliers are observed, with 5 clinics assigned a price which is more than double that of the current approach under scenario 1. These clinics are priced used the costing study under the current methodology. ► Under the credibility theory approaches to pricing, a higher proportion of clinics have a price which aligns to the NHCDC reported cost. In addition, there are fewer clinics with extreme cost ratio values. The proportion of clinics with a cost ratio greater than 150% reduces from 13% under the current approach to 5% and 6% under scenario 1 and scenario 2 respectively. There is a reduction in volatility in price weights between years, which currently arises due to step changes in source datasets used in the calculation of non-admitted price weights ► The number of clinics requiring stabilisation is reduced from 25% to 19% of clinics, under each of the credibility theory scenarios.
Recommendations for implementation 1. Implement a credibility theory based approach to combining non-admitted data sources This increases the use of NHCDC cost data in the base price weight calculation, minimising reliance on previous costing studies which may reflect out of data clinical practice or costings for non-admitted services. It is recommended that scenario 2 is implemented. This scenario has stricter conditions which are required to be met prior to the use of NHCDC data.
Recommendations for further analysis 1. Investigate discrepancies in prices determined from use of NHCDC in place of the costing study It is recommended that, in implementation, IHPA investigates clinics with a significant change in average cost when compared to previous average costs identified in the costing study. Cost discrepancies should be investigated to determine if these differences are due to changes in clinical practice or if the change is due to potentially inaccuracies in the cost data sources. IHPA should consider the application of manual adjustments in implementation, where required, following the results of this further investigation.

[10] Please refer to Appendix C for detail on credibility theory

4.1.4 Calculation of adjustments in a single model and consideration of their interactions

The current approach to calculating adjustments for legitimate and unavoidable variation in costs involves a step-by-step calculation of each adjustment individually. This presents challenges as it may not appropriately reflect correlations between adjustment factors, and results in a difficult to interpret pricing formula.

Refer to Appendix B for detail on the purpose, challenges and implementation of the alternative.

Alternative: Calculation of adjustments in a single model and consideration of their interactions
Results of testing Correlations between adjustment factors are identified. The alternative approach considers these interactions through implementation in a single model. A similar level of equity is maintained, compared to the current model ► There is marginal impact on hospital-level cost ratios of implementing a GLM-based adjustment calculation approach, with absolute changes in hospital cost ratios generally less than 1%. ► Under both the additive and multiplicative model options, Northern Territory and Western Australia are observed to have mostly increased hospital cost ratios. This is in part driven by the Patient Remoteness Area, Treatment Remoteness Area mix within hospitals in these jurisdictions. However, the magnitude of the positive effect is less pronounced within the multiplicative GLM. ► Five out of 246 hospitals experience a change of more than 1%, with a maximum absolute change in cost ratio of 1.9% and 1.8% in the additive and multiplicative models respectively. The alternative approaches provide a similar level of goodness of fit to the current methodology, as measured by R-squared and SMAPE. A summary of the adjustments resulting under the alternative are included in Appendix D.
Recommendations for implementation 1. Implement all patient level adjustments within a single multiplicative (gamma) GLM model within the National Pricing Models Implementing the patient level adjustments only within the GLM will prioritise Patient Residential Remoteness above Patient Treatment remoteness. Any remaining variation by Patient Treatment Remoteness, not explained by the patient level adjustments, will be accounted for as per the current approach. This ensures that precedence is given to the patient level adjustments ahead of the hospital level adjustments. The multiplicative model, assuming a gamma distribution of costs, is recommended as the preferred model due to ease of interpretation for end users. This provides improved consistency in the application of adjustments to the base price weight, specifically allowing consistency with the multiplicative application of the patient treatment remoteness adjustment. In addition, it improves transparency in the framework for adjustments, accounting for the potential interrelationships between factors. The adjustments resulting from the GLM should additionally be applied within the Subacute, Non-Admitted and ED service categories, where any adjustments are sourced from the Acute model.
Recommendations for further analysis 1. Investigate additional interaction effects identified IHPA should investigate and consult with jurisdictions on the additional interactions between Indigenous status and Radiotherapy, and between Indigenous status and MDC 19 & 20 Mental Health services for patients 17 years and younger within specialised paediatric hospitals.

4.2 Recommendations for further analysis

Recommendations for further analysis were made with respect to an additional five alternative techniques. These recommendations related to the implementation of monitoring techniques, as well as identification of the need for refinements to the broader process, prior to implementing changes.

These alternatives were not implemented concurrently in the final phase.

4.2.1 Targeted pharmaceutical matching

The current approach to matching pharmaceutical costs involves an iterative approach which matches benefits to activity using a combination of medicare pin, establishment identifier, gender and date of birth. Any unmatched costs are spread across the activity according to the matched distribution. This presents challenges as a low number of unique matches are achieved using the current match variables, therefore benefits cannot be confidently attributed to activity items.

Refer to Appendix B for detail on the purpose, challenges and implementation of the alternative.

Alternative: Targeted pharmaceutical matching
Results of testing Inclusion of date in the matching criteria improves the unique match rate of benefits to activity ► Inclusion of prescription date in the matching rules improves the unique match rate of pharmaceutical benefits to hospital activity from 6% to 32%. The improvement in unique match rate for the alternative approach indicates that the current methodology may inadvertently assign pharmaceutical benefits to unrelated hospital activity records, due to a smaller set of unique matches. ► The overall rate of anomalous matches increases slightly from 72% to 74% of pharmaceutical benefits under the alternative approach. However, the rate of anomalous matches reduces for unique matches (i.e. steps 1 and 2) under the alternative approach. Anomalous matches (whereby the matched benefit is greater than the NHCDC reported cost) continue to be observed under the alternative approach, indicating data integrity issues. ► The incidence of anomalous matches after inclusion of prescription date in the matching process suggests that either additional refinements are required to the matching rules to accurately assign benefits to originating hospital activity; or national inconsistencies may exist in the implementation of the Australian Hospital Patient Costing Standards with respect to pharmaceutical costs.
Recommendations for implementation No recommendations for implementation were determined.
Recommendations for further analysis 1. Investigate drivers of discrepancies between NHCDC reported costs and matched pharmaceutical records Both the current and alternative approaches result in a high rate of anomalous matches. This indicates inconsistencies in the implementation of the Australian Hospital Patient Costing Standards with respect to pharmaceutical costs. This hypothesis is supported by jurisdictions' feedback, where it has been advised that pharmaceutical costs need to be imputed across patient records due to an inability to perform one-to-one matching. IHPA should work to understand the jurisdictions' approaches to matching pharmaceutical benefits. These approaches can be replicated to effectively remove benefits when undertaking pricing. 2. Following improvements in the integrity of reported pharmaceutical costs, include date restrictions to the matching process for the unique matching steps More targeted matching of pharmaceutical benefits to activity increases confidence that the pharmaceutical costs are appropriately offset against the originating activity. However, this will only be effective if jurisdictions have similarly matched these benefits to the appropriate activity.

4.2.2 Retention of outliers, with bootstrapping to determine price

The current approach to identifying and treating outliers varies by service category, with a combination of jurisdictional advice and extreme cost analysis applied to the raw cost data. The current approach presents challenges as it is deterministic in nature, and provides little insight into the underlying distribution of the cost data.

Refer to Appendix B for detail on the purpose, challenges and implementation of the alternative.

Alternative: Retention of outliers, with bootstrapping[11] to determine price
Results of testing The alternative approach considers variability of the underlying distribution, providing improved transparency around the stability of calculated price weights. ► Across all service categories, the base price is most likely to fall near the middle of the bootstrapped confidence interval for the mean cost (i.e. between the 40th and 60th percentile). The base price for Sameday separations is more likely to fall towards the upper end of the Confidence Interval than the base price of other separation categories. The SSO base price appears lower in volatility than the other separation category prices. ► Inlier prices display the greatest variability, with the inlier price for 25% of DRGs falling between the 20th and 40th percentile of the confidence interval. IHPA can use this insight to investigate drivers of volatility and make any necessary adjustments to the current approach to pricing. The base price falls outside the confidence interval for the mean cost for 2% of end classes for the Inlier base price and 3% of end classes for the Sameday base price.
Recommendations for implementation No recommendations for implementation were determined.
Recommendations for further analysis 1. Utilise a bootstrapping approach to develop an understanding of the distribution of the calculated costs in the Acute model This can be used to assess appropriateness of outlier trimming, as well as adequacy and efficiency of cost. In instances where the currently calculated cost parameters fall outside the derived Confidence Interval, IHPA may consider utilising the bootstrapped central estimate instead. 2. Undertake further investigation of anomalous end classes in conjunction with jurisdictions This investigation can be used to understand if outliers are valid high cost data points or should be excluded from calculations in the national pricing models. Note that given this technique is recommended for monitoring, there is no immediate impact on model output.

[11] Bootstrapping is a re-sampling approach which can be used to understand the distribution of the base price weight

4.2.3 Stabilisation across classification versions using weighted average price weights

The current approach to stabilising DRG and SNAP price weights across classification versions relies on the existence of near one-to-one mappings between the two classification versions. The current approach presents challenges as these near one-to-one mappings are uncommon, with only 119 of the approximately 800 end classes considered comparable between DRG v8.0 and v9.0. Those end classes in v9.0 without a comparable end class in v8.0 were not subject to the stabilisation process, introducing volatility.

Refer to Appendix B for detail on the purpose, challenges and implementation of the alternative.

Alternative: Stabilisation across classification versions using weighted average daily price weights
Results of testing The alternative approach better addresses the primary purpose of the stabilisation process, increasing the stability of price weights across years ► Using a weighted average daily price weight approach increases the number of end classes in the Acute model that are stabilised under each scenario compared to the current approach. ► Under the alternative, 72 end classes have a change in price weight greater than 20% and 45 would be stabilised under the current methodology. The current approach results in stabilisation of only 1 end class. A similar level of equity is maintained, when compared to the current model ► Generally, there is a marginal impact (i.e. less than 1%) on hospital cost ratios of stabilising Acute end classes using average weight per day and no notable jurisdictional deviations. The alternative approach provides a similar level of goodness of fit to the current methodology as measured by R-squared and SMAPE.
Recommendations for implementation No recommendations for implementation were determined.
Recommendations for further analysis 1. Monitor shifts in price weights in future years, where a change in classification versions takes place This alternative was recommended as a monitoring technique, rather than for direct implementation, due to the feedback received from jurisdictions during consultations. Jurisdictions indicated that it is preferred that changes in costs are reflected through changes in price weights, rather than the price weights being automatically stabilised through statistical processes. As a result, it is recommended that IHPA instead sense check shifts in price weights using the weighted average inlier price weight per day, for comparability between years when there is a change in classification. Any anomalous shifts can subsequently be discussed with relevant stakeholders. This will enhance the stabilisation process and improve funding certainty for hospitals and LHNs. Note that given this technique is recommended for monitoring, there is no immediate impact on model output.

4.2.4 Comparison of derived rates with external indices and historical experience

The current approach to calculating the indexation rate projects forward the change in cost per NWAU over time, leveraging historic data as the basis. The current approach presents challenges as prior years may not be reflective of future years' experience, which can lead to under- or over-estimation of the rate of indexation. This is particularly evident in earlier years of the NEP, where the indexation rate was skewed upwards due to anomalous growth in 2007/08 and 2008/09.

Refer to Appendix B for detail on the purpose, challenges and implementation of the alternative.

Alternative: Comparison of derived rates with external indices and historical experience
Results of testing Preliminary analysis comparing IHPA's indexation rate to external indices reveals differences in both level of growth and the trend in growth rates. ► The IHPA indexation rate has been decreasing over time, at a greater rate than the trends observed in the 3-year Health PPI and Public Wage PI. The forecast IHPA indexation rate has exceeded the actual growth rate for all funding years. Anomalous increases in cost that persist for 1-2 funding years can result in potential over-pricing through over-estimation of the future indexation rate.
Recommendations for implementation No recommendations for implementation were determined.
Recommendations for further analysis 1. Monitor trends in external prices indices IHPA should compare the level of, and trends in, external indices against IHPA's published indexation rate over time. This will assist in identification of anomalies prior to publishing the rate. 2. Monitor actual growth rates against predicted indexation IHPA should retrospectively compare the historic IHPA published indexation rates against actual growth in costs over time. This should lead to refinements to the indexation process to address identified ongoing inconsistencies. Note that given this technique is recommended for monitoring, there is no immediate impact on model output.

4.2.5 Regression of growth against drivers of indexation

The current approach to calculating the indexation rate projects forward the change in cost per NWAU over time, leveraging historic data as the basis. The current approach presents challenges as prior years may not be reflective of future years' experience, which can lead to under- or over-estimation of the rate of indexation. This is particularly evident in earlier years of the NEP, where the indexation rate was skewed upwards due to anomalous growth in 2007/08 and 2008/09.

Refer to Appendix B for detail on the purpose, challenges and implementation of the alternative.

Alternative: Regression of growth against drivers of indexation
Results of testing Preliminary analysis has found a significant relationship between external indices and the IHPA indexation rates ► The external indices are all significant at a 95% level of significance in predicting the growth in price between years, however particular technical challenges are posed in the use of each index to predict future growth in the cost of delivering hospital services per NWAU. IHPA's rate does not appear unreasonable when compared to external indices, given the number of available data points ► The overall predicted growth rate for each model is less than the current indexation rate of 1.6%, which may suggest potential over-pricing under the current approach. ► However, IHPA's projected rate of 1.6% falls within the prediction interval for the indexation rate, calculated based upon the results of the PPI regression.
Recommendations for implementation No recommendations for implementation were determined.
Recommendations for further analysis 1. Monitor and validate the projected indexation rate through comparison to the output of a regression on PPI It is recommended that IHPA monitor the projected Indexation Rate against the modelled rate resulting from regression on the PPI. This includes confirming that the projected indexation rate falls within the 95% prediction interval for the actual indexation rate. As more data becomes available, IHPA should revisit the use of regression based on external indices as an alternative for projecting indexation. While PPI has been selected as the comparator, due to the observed trend and its representation of the cost of production, there are limitations in utilising solely PPI in assessing the appropriateness of the indexation rate. In consultation, jurisdictions have raised concerns that PPI would not appropriately reflect the full range of costs incurred in the provision of hospital services. IHPA could consider using a range of indices in its assessment, including alternative government indices and projections which are not made publicly available. Note that given this technique is recommended for monitoring, there is no immediate impact on model output.

4.3 De-prioritised alternatives

The following alternatives were shortlisted for further testing but were not recommended for implementation or further analysis. An explanation for the de-prioritisation of these alternatives is provided in Table 8.

Table 8: Reason for de-prioritisation of 7 alternatives shortlisted during the Literature Review, but not recommended for implementation or further analysis

Methodology area	Alternative	Reason for de-prioritisation
1. Data preparation	Logistic regression to scale Hospital Casemix Protocol (HCP) data	Preliminary analysis found that less than 1% of private patients have a reported ancillary benefit. The value of these benefits is immaterial to the total cost of hospital services and private medical benefits overall. As a result, the alternative was not considered for further analysis.
2. Base price weight calculation	Calculation of inlier bounds using percentiles	It was found that the use of percentiles does not reduce the large range between inlier bounds which is observed for several admitted end classes. Additionally, the percentile approach results in a number of end classes with a range of 0 days between inlier bounds. These shortcomings lead to the conclusion that this alternative is not appropriate in practice, as it does not adequately incentivise efficient delivery of services.
3. Adjustments	Fixed incremental dollar amounts for selected adjustments	Implementation of fixed dollar adjustments led to deterioration in model fit. This is in part due to the need to weight residuals by predicted cost. In our analysis we did not weight residuals by predicted cost, which resulted in a level of under-pricing. Alternatively, testing including the weighting procedure resulted in a significant increase in fixed dollar adjustments and general over-pricing of services to which fixed dollar adjustments are applied.
	Clustering technique to identify groups of variation in the data	Preliminary correlation analysis did not uncover any new relationships that are not already identified and incorporated in the National Pricing Model. Additionally, first-pass cluster analysis did not immediately identify any new unidentified groups of variation. The preliminary analysis and first-pass cluster analysis confirmed known relationships used to adjust for patient and treatment related factors.
4. Stabilisation	Credibility theory to stabilise prices and adjustments	Jurisdictions indicated that it is preferred that changes in costs are reflected through changes in price weights, rather than the automatic stabilisation of price weights through complex statistical processes.
5. Transformation to Pricing Models	ARIMA (time series) modelling	The IHPA indexation rate since its inception has consistently decreased from year to year while now remaining relatively steady, changing by only 0.2% between NEP17 to NEP19. Due to the small number of data points and the prolonged downtrend, the moving average and autoregressive error were both insignificant at a 95% level of statistical confidence in predicting future indexation. As a result, using ARIMA modelling on IHPA's previous indexation rates to forecast future rates was not successful.
6. Back-casting	Smoothing of volume multipliers, using multiple base years for calculation	Back-casting multipliers estimated using the current approach align better to actual back-casting multipliers, for all service categories except subacute. Changes in the service mix over time drives these differences, with the most recent year of activity data available more reflective of the base year's activity. As activity stabilises and matures, these differences will reduce.

Appendix A Glossary

Term	Definition
ABF	Activity Based Funding
AIHW	Australian Institute of Health and Welfare
AN-SNAP	Australian National Subacute and Non-Acute Patient classification system
APC	Admitted Patient Care
ARIMA	Autoregressive Integrated Moving Average; this is a time series modelling technique which utilises prior values to predict future values in the series.
CPI	An index reflecting the change in the weighted average price of a basket of consumer goods and services
DRG	Diagnosis Related Group
ED	Emergency Department
FRWG	Fundamental Review Working Group, including representatives from each jurisdiction
GFCE	An index reflecting the growth in Government Final Consumption Expenditure on hospitals and nursing homes
IHPA	Independent Hospital Pricing Authority
National Pricing Models	The set of national models comprising the Activity Based Funding and Block Funded pricing models
MDC	Major Diagnostic Category
NEP	National Efficient Price
NHCDC	National Hospital Cost Data Collection
NHFB	National Health Funding Body
NHRA	National Health Reform Agreement
NWAU	National Weighted Activity Unit; a measure of health service activity expressed as a common unit
P-value	A statistical measure which illustrates whether a variable is significant, with a p-value of less than 5% suggesting that the result is significant at a 95% confidence level
PPI	An index reflecting the average movement in selling prices from domestic production over time
R-squared	A statistical measure which is used to assess model fit. Specifically, it represents the proportion of variance of a dependent variable which is explained by an independent variable
SMAPE	Symmetric Mean Absolute Percentage Error
TAC	Technical Advisory Committee, including representatives from each jurisdiction
UDG	Urgency Disposition Group
URG	Urgency Related Group

Appendix B Purpose, Challenges and Implementation

The following tables summarise the purpose and challenges of the current approach, for those methodology areas where an alternative has been recommended for implementation or further analysis. In addition, detail around the implementation of the alternatives for testing is provided.

Alternative: Retention of outliers, incorporating reduced weighting; outlier detection on log transformed data
Purpose 1. Identify activity-level cost data that is fit for purpose to develop National Pricing Models – the activity-level cost data is split into two groups: a group that is fit-for-purpose for the development of cost profiles for each end class in the National Pricing Models and a second group that is not fit-for-purpose to develop cost profiles. For the National Pricing Models, cost data is considered fit-for-purpose if it is not erroneous and is relatively homogenous by end class.
Current challenges 1. Consistency: The current methodology appears to identify more outliers in low volume end classes than in higher volume end classes. Differences in the proportion of outliers identified within each of the outlier trimming steps highlights that very few high cost outliers are identified. 2. Equity: The current methodology applies some statistical techniques that implicitly assume a symmetric distribution in the NHCDC cost data. This can introduce bias into the identification of outliers, excluding cost data from the National Pricing Models that is fit for purpose. If a bias in outlier detection and removal exists it impacts equity by causing an unequal and/or disproportionate impact across end classes and/or hospitals.
Implementation Five potential outlier detection and weighing scenarios were considered during testing. The preferred alternative outlier detection technique involved the removal of costs deemed outliers based on the studentised residual value, with a threshold of 3 imposed[12]. Studentised residuals take into consideration an estimate of the residuals standard deviation and are a method commonly applied to detect and remove outliers. All alternative outlier detection and weighting scenarios considered (Huber, Tukey and Studentised residuals) utilise statistical techniques that assume a normal distribution. The NHCDC cost data is generally positive (right) skewed and non-symmetrical. Therefore, a log transformation was applied to the data to enhance normality. Following application of a log transformation, the cost data distribution by end class generally improved in both skewness and kurtosis producing results that more closely align to those expected from a normal distribution. To test the alternative approach, the outlier detection and weighting scenarios were implemented for the acute admitted National Pricing Model. The following outlier detection steps in the current methodology were retained prior to testing the alternative approach: ► Jurisdictional advice – to exclude known erroneous data. ► Hospital DRG outliers – to exclude outlying hospitals, as associated data may not be identified as outlier when considered at an individual level.

[12] This threshold reflects the distribution of studentised residuals, with the probability of a studentised residual exceeding this threshold of less than 1 percent. See: IBM; Studentized residual test; <https://www.ibm.com/support/knowledgecenter/en/SSEP7J_11.1.0/com.ibm.swg.ba.cognos.ug_ca_dshb.doc/studentized_residual_test.html>

Alternative: Use of median for the price weight within all individual service categories
Purpose 1. Provide a single unit of measure - to reflect the clinical complexity of health services provided, as evidenced by recorded resource utilisation and cost; 2. Facilitate accurate comparison and assessment of health service efficiency - to improve the value of public investment in hospital care and ensure a sustainable and efficient network of hospital services; 3. Demonstrate unwarranted variation and incentivise management by jurisdictions for relatively homogeneous 'bundles' of activity. Admitted activity is bundled by length of stay, enabling hospitals to innovate and trial different models of care. This allows jurisdictions, Local Health Networks and hospitals to share the risk of variation in cost. 4. Determine the price to be paid for hospital services – price weights are used in the calculation of the efficient price for an Activity Based Funding (ABF) hospital activity outlined in the NEP determination. Ultimately, the price weights inform calculation of National Weighted Activity Units (NWAU) that are used by the Administrator of the National Health Funding Pool to determine Commonwealth ABF contributions for public hospital services under the National Health Reform Agreement.
Current challenges 1. Efficiency: The mean cost may not be considered an appropriate measure for cost-efficiency for National Hospital Cost Data Collection (NHCDC) cost data. Given the skewness of cost data, the median (i.e. 50th percentile) provides a lower benchmark for efficiency compared to the mean, with an equal number of services with costs above and below the efficient cost. Therefore, use of median provides jurisdictions with more stable and consistent comparisons between DRGs that help them to manage toward greater cost efficiency. 2. Stability: Price weights should facilitate comparisons to actual cost for relatively homogenous 'bundles' of services within an end class. Price weights calculated using the mean cost may not provide a stable and consistent reference point between pricing years, due to sensitivity to high cost outliers.
Implementation Use of median in the calculation of the inlier price weights requires a different approach for each service category. These differences are required to account for the use of separation categories in admitted care, where separations are priced according to length of stay. For admitted care, the inlier bounds are determined using the L3H3 and L1.5H1.5 methodologies which are utilised under the current approach. The median approach has not been implemented for SSO and LSO, however the prices assigned to these outlier separations have been updated to maintain integrity of the price curve. This ensures that the SSO and LSO prices meet the inlier price at the inlier boundaries. Calibration is applied at a DRG level, which offsets some of the impact of the use of median as any difference between modelled and actual cost is removed. Calibration of all parameters, including the LSO per diem, may generate unintended incentives to extend the length of stay of LSO activity. As such, the alternative applies the calibration process to Same Day, SSO and Inlier parameters only. This results in no change in the LSO per diems from the raw calculation. This approach may reduce the LSO per diem when compared to the mean approach, potentially over-penalising LSOs. For Emergency care, a single price is assigned per end class. Therefore, the actual cost is not calibrated to the modelled cost at an end class level in these cases as this would revert the price weight to the mean approach.

Alternative: Application of credibility theory in calculating non-admitted base price weights
Purpose 1. Provide a single unit of measure - to reflect the clinical complexity of health services provided, as evidenced by recorded resource utilisation and cost; 2. Facilitate accurate comparison and assessment of health service efficiency - to improve the value of public investment in hospital care and ensure a sustainable and efficient network of hospital services; 3. Determine the price to be paid for hospital services – price weights are used in the calculation of the efficient price for an Activity Based Funding (ABF) hospital activity outlined in the NEP determination. Ultimately, the price weights inform calculation of National Weighted Activity Units (NWAU) that are used by the Administrator of the National Health Funding Pool to determine Commonwealth ABF contributions for public hospital services under the National Health Reform Agreement.
Current challenges 1. Equity and Access: The current methodology to derive non-admitted price weights leverages cost studies from prior years, which may not accurately reflect the costs of the current models of care. Under the current approach 59% of clinics have a cost ratio greater than 1, where the assigned price is less than the average cost of service delivery in the NHCDC. Most of these clinics are set using the costing study in the current methodology. 2. Stability: The current approach to combining the various available datasets is hierarchical, with a switch between data sources occurring once required data thresholds are met. This can drive instability between years.
Implementation Application of credibility theory to combine the various cost sources in the derivation of the non-admitted base prices weights is tested as an alternative to the current methodology. This will enable a blended use of data sources, with a gradual movement towards the NHCDC cost data as stability improves and the volume of the dataset increases. This will improve consistency across years through greater stability in the price weights. Credibility theory involves taking a weighted average of two data sources, with the weights determined according to a defined formula. A classic credibility approach has been taken, with weights defined such that full weight is given to the NHCDC data once the volume is sufficient, given the level variability of the data. This means that where there is low variation observed in the costs for a clinic, a lower volume of cost records is required to provide confidence in the accuracy of the data. Credibility theory is explained in greater detail in Appendix C.

Alternative: Calculation of adjustments in a single model and consideration of their interactions

Purpose

1. Reflect legitimate and unavoidable variations in the cost of delivering health care services. Clause B13 of the NHRA outlines IHPA's obligation to consider variations in cost in the calculation of the price due to factors such as hospital type and size; hospital location; and patient complexity.

Current challenges

1. Minimising undesirable and inadvertent consequences: The current methodology implements adjustments through a step-by-step process. As a result, each adjustment is influenced by previous adjustments. In the case of any correlation between patient or treatment characteristics, this can introduce multicollinearity into the National Pricing Models and create distortion in the estimated adjustment factors.

   Adjustment factors observed to have correlation include Patient Residential Remoteness Area and Indigenous status; Patient Treatment Remoteness Area and Indigenous status; and Patient Residential Remoteness Area and Patient Treatment Remoteness Area.

2. Consistency: IHPA has developed the Assessment of Legitimate and Unavoidable Cost Variations Framework in 2013 to standardise the process of applications for consideration of services with legitimate and unavoidable cost variations not adequately recognised in the National Pricing Models. This creates a consistent and streamlined way to consider potential additional adjustments, however, a consistent approach to treating the adjustments in one model and considering potential interactions, may improve the transparency of IHPA's approach to assessing new adjustments requested by jurisdictions in a consistent manner.

Implementation

Adjustments for the Acute service category have been fitted within a single GLM to estimate the adjustments concurrently. The GLM is used to test for any significant interactions between the adjustments and to identify any potential differences in adjustments under the alternative approach compared to the current methodology.

In implementation of the alternative approach, all patient level percentage based adjustments in the Acute admitted model that are applied directly to the base price weight have been considered. Adjustments that are applied based on other factors (i.e. DRG, ICU hours, etc.) have been omitted as they require calculation at different levels of granularity. The adjustments omitted include: Paediatric, Private Patient Service, Private Patient Accommodation, ICU and HAC. Note that Patient Treatment Remoteness Area is also applied separately, so that precedence is given to the Patient Residential Remoteness Area.

The GLM model option recommended for implementation assumes a gamma distribution of costs (with a log link function in the GLM procedure). The use of a log link function allows for a multiplicative format, which is consistent with the subsequent application of the patient treatment remoteness adjustment.

The resulting formulae for application of adjustments to the base price weights under each model is outlined below:

$$PW \times (1 + I_{Res(or)} \times A_{Res(or)}) \times (1 + I_{Res(rem)} \times A_{Res(rem)}) \times (1 + I_{res(vrem)} \times A_{res(vrem)}) \times (1 + I_{Ind} \times A_{Ind}) \times (1 + I_{RT} \times A_{RT}) \times (1 + I_{Dia} \times A_{Dia}) \times \times (1 + I_{SPA(1)} \times A_{SPA(1)}) \times (1 + I_{SPA(2)} \times A_{SPA(2)}) \times (1 + I_{SPA(3)} \times A_{SPA(3)}) \times (1 + I_{SPA(4)} \times A_{SPA(4)}) \times (1 + I_{SPA(5)} \times A_{SPA(5)})$$

The price weight (PW) is the base price weight adjusted for the paediatric adjustment; the intercept and A variables are parameters from the GLM for the adjustment amounts; and the I variables are flags (0 or 1) that indicate whether the patient meets the associated characteristics for the adjustment. The relationship is multiplicative.

Alternative: Targeted pharmaceutical matching
Purpose 1. Exclude benefits provided under Commonwealth programs – Clauses A6 and A7 of the National Health Reform Agreement (NHRA) outline circumstances where the Commonwealth will not fund services under the NHRA, as funding is provided under other Commonwealth programs. Costs reported in the National Hospital Cost Data Collection (NHCDC) for these services are considered out of scope and must be removed prior to development of the National Pricing Models. For example, this includes: a. Blood costs reported in the NHCDC; b. Benefits provided under the Pharmaceutical Benefits Scheme (PBS) and other Commonwealth pharmaceutical programs; and c. Medicare Benefits Schedule (MBS) benefits associated with public hospital services, such as revenue received for medical and prosthesis costs for private patient admitted hospital services provided in a public hospital.
Current challenges 1. Minimising undesirable and inadvertent consequences: In cases where a unique match between Commonwealth pharmaceutical benefits and hospital activity cannot be derived, the current methodology equally apportions benefits across all matched hospital activities. As a result, the current methodology may not accurately exclude Commonwealth pharmaceutical out of scope costs from the related activity in the development of the National Pricing Models. It is possible that this could provide incentives for hospitals to make increased Commonwealth pharmaceutical claims, as benefits may not be fully offset against the cost of these services through the National Efficient Price (NEP) determination process. 2. Equity: The current methodology may also inadvertently exclude pharmaceutical benefits from NHCDC costs reported for services where no Commonwealth pharmaceutical benefits were claimed. If there is variation nationally in Commonwealth pharmaceutical benefit claims by hospitals, this may have an uneven impact across hospitals in the National Pricing Models.
Implementation A targeted deterministic matching approach is tested as an alternative to the current methodology. Under the alternative approach, the prescription date is included in the matching rules in steps 1 and 2. The remaining unmatched pharmaceutical benefits are equally apportioned across hospital activity as defined in the current methodology (i.e. steps 3 and 4 of the matching rules). Any matched hospital activity records are retained for matching in subsequent steps, as multiple pharmaceutical records can be matched to the same activity record. This is not a feature of the current approach. To test the alternative approach, an updated set of matching rules were implemented including prescription date. However, all other components of the data preparation methodology were held constant. No corresponding updates were implemented through the pharmaceutical cost imputation. However, it is expected that the alternative approach will cause downstream impacts to the pharmaceutical imputation process which should be considered during implementation. Additionally, any revisions to pharmaceutical items listed on the drug allocation mapping table are expected to impact this process. Prior to implementation of this alternative, it is recommended that the drug allocation mapping table is updated following clinical consultation.

Alternative: Retention of outliers, with bootstrapping[13] to determine price

Purpose

1. Identify activity-level cost data that is fit for purpose to develop National Pricing Models – the activity-level cost data is split into two groups: a group that is fit-for-purpose for the development of cost profiles for each end class in the National Pricing Models and a second group that is not fit-for-purpose to develop cost profiles. For the National Pricing Models, cost data is considered fit-for-purpose if it is not erroneous and is relatively homogenous by end class.

Current challenges

1. Consistency: The current methodology appears to have variable performance for end classes with high and low volumes of activity and within each of the outlier trimming steps. The current methodology may not consistently identify fit for purpose data for development of the National Pricing Models for all end classes. This is illustrated by the following summarised observations:

    a. The current methodology appears to identify more outliers in low volume end classes than in higher volume end classes.

    b. Differences in the proportion of outliers identified within each of the outlier trimming steps highlights that very few high cost outliers are identified.

2. Equity: The current methodology applies some statistical techniques that implicitly assume a symmetric distribution in the NHCDC cost data. This can introduce bias into the identification of outliers, excluding cost data from the National Pricing Models that is fit for purpose. If bias in outlier detection and removal exists it impacts equity by causing an unequal and/or disproportionate impact across end classes and/or hospitals. This is illustrated by the following summarised observation:

Implementation

Bootstrapping (a re-sampling approach) is utilised to determine the distribution of the base price weight. To illustrate its potential application, 200 random samples of equal size to the total activity in the cost dataset were taken with replacement and stratified by DRG from the NHCDC cost data. WIP and population weights assigned to hospital activity were used to weight the selection, to generate an approximation of the distribution of the mean by end class and separation category. This provides insight into the underlying volatility of the cost data being used to generate the base price weights.

The bootstrapped central estimate can be considered in place of the mean cost in all cases, or alternatively it can be used in place of the mean cost for price weights where cost parameters calculated under the current methodology fall outside the derived Confidence Interval. The alternative approach is anticipated to improve the stability of the base price weight calculation and provide insight into the volatility of the costs incurred by hospitals.

This approach utilises the base cost data, trimming only those separations which are removed due to jurisdictional advice or which have non-positive NHCDC reported costs, with this data assumed to be erroneous. This alternative technique has been tested for the Acute model only, in deriving the initial price parameters for Same Day, SSO, Inlier and LSO separations.

[13] Bootstrapping is a re-sampling approach which can be used to understand the distribution of the base price weight

Alternative: Stabilisation across classification versions using weighted average daily price weights
Purpose 1. Provide jurisdictions with funding stability and predictability - the IHPA Pricing Guidelines outline the policy intent for the National Pricing Models including Stability. It specifically requires that payment relativities are stable over time. 2. Minimise the impact of statistical noise in the National Pricing Model – the National Pricing Model Stability policy outlines that only observed changes related to activity and/or cost variations in Australian public hospitals should be reflected in the pricing models. The stabilisation process mitigates the impact of sources of statistical noise such as: changes in coding behaviours, technology changes and modifications to the classification systems.
Current challenges 1. Stability: Stabilisation for Acute end classes only occurs when there are comparable end classes. In the development of NEP18, 119 of approximately 800 end classes were considered comparable between DRG v8.0 and DRG v9.0. Once the change in bounds and volume rules are applied, only one end class is stabilised. This may contribute to increased volatility in the price weights of the end classes that are not subject to the stabilisation process. Additionally, unexpected changes in patterns of clinical coding practice have the potential to further exacerbate the impact of volatility in price weights that are not subject to the stabilisation process. Instability in price weights across years impacts Activity Based Funding contributions under the NHRA determined by the Administrator of the National Health Funding Pool. These changes ultimately contribute to uncertainty in the funding environment for jurisdictions, LHNs, and hospitals across the health system.
Implementation To test the relative merits of the alternative approach, a weighted average approach is implemented to stabilise inlier price weights for DRGs in the Acute National Pricing Model without a one-to-one mapping between DRG V8.0 and DRG V9.0. The approach uses the distribution of DRG V8.0 inlier episodes across the various end classes that map to the corresponding DRG V9.0 classification code. This approach is expected to increase the number of end classes that are stabilised when there is a classification change, enhancing the stability in price weights. Three weighted average approaches have been implemented to generate corresponding weights for DRG V8.0 codes to stabilise DRG V9.0 codes with no direct mappings available. The preferred scenario involves the determination of a weighted average of the previous inlier daily rates (dividing the previous year's inlier weight by the previous year's mean length of stay) multiplied by the new mean length of stay to create an equivalent weight for comparison.

Alternative: Comparison of derived rates with external indices and historical experience
Purpose 1. Forecast the cost of service provision in the funding year. Due to the timeframe for provision of cost and activity data to IHPA, the national cost models must be developed using cost data from three years prior. The costs are forecast across this three-year period to define the National Efficient Price on the basis of the estimated cost of service delivery per NWAU in the funding year.
Current challenges 1. Equity and access: A price is considered equitable if it fairly compensates for factors outside the control of providers. The current model predicts growth over the next three years using data from up to five years prior. However, the growth in recent years may not be reflective of future years' experience, which can lead to under- or over-statement of the rate of indexation. The indexation rates for earlier funding years are skewed upwards due to anomalous growth rates of 5.6% between 2007 and 2008, and 7.2% between 2008 and 2009[14]. The actual growth in costs for early periods was lower than this, as evidenced by reduction in and stabilisation of the projected indexation for later years[15]. IHPA's annual approach to calculating indexation does not incorporate reconciliation between actual experience and historic indexation rates. The available cost data up to 2016/17 can be used to understand how the prior indexation rates differ from the actual cost increases. Additionally, there is no published breakdown by drivers of the price growth, nor a clear relationship with alternative external indices. Such checks could assist in identifying anomalous data prior to issuing the determination.
Implementation Comparison to external indices The initial scoping paper 'Towards a Pricing Framework' proposed the 'Government Final Consumption Expenditure hospitals and nursing home deflator' (GFCE) to be used as the measure of price indexation. In addition to this index, which is currently published by AIHW, other public indices have been considered. The following external indices have been identified for comparison to IHPA's derived indexation rate: Health CPI, CPI, Public Wage Index, PPI, Health PPI and GFCE on hospitals and nursing homes. These indices were selected as they reflect a mix of output and input indices, as well as general and health specific price growth. Comparison to historical rates IHPA's forecast indexation rates derived under the current methodology were compared to the actual indexation rates that eventuate once the cost data becomes available. This comparison can highlight whether the current IHPA indexation model has any biases. The actual year-on-year growth is calculated using the growth factors output from application of NEP18 model. These rates are accumulated over three years and compared to the indexation rates published in the NEP determination in each year.

[14] Calculated through application of the NEP18 model to historic cost data.

[15] In later funding years 2007/08 and 2008/09 are not referenced in constructing the price index, as these are more than 5 years prior.

Alternative: Regression of growth against drivers of indexation
Purpose 1. Forecast the cost of service provision in the funding year. Due to the timeframe for provision of cost and activity data to IHPA, the national cost models must be developed using cost data from three years prior. The costs are forecast across this three-year period to define the National Efficient Price on the basis of the estimated cost of service delivery per NWAU in the funding year.
Current challenges 1. Equity and access: A price is considered equitable if it fairly compensates for factors outside the control of providers. The current model predicts growth over the next three years using data from up to five years prior. However, the growth in recent years may not be reflective of future years' experience, which can lead to under- or over-statement of the rate of indexation. The indexation rates for earlier funding years are skewed upwards due to anomalous growth rates of 5.6% between 2007 and 2008, and 7.2% between 2008 and 2009. The actual growth in costs for early periods was lower than this, as evidenced by reduction in and stabilisation of the projected indexation for later years. IHPA's annual approach to calculating indexation does not incorporate reconciliation between actual experience and historic indexation rates. The available cost data up to 2016/17 can be used to understand how the prior indexation rates differ from the actual cost increases. Additionally, there is no published breakdown by drivers of the price growth, nor a clear relationship with alternative external indices. Such checks could assist in identifying anomalous data prior to issuing the determination.
Implementation The external indices which were analysed in the comparison of derived rates against external indices have independently been considered for inclusion in a linear regression. Each index is accumulated before being tested as a predictor variable within separate linear regressions. IHPA's cumulative cost ratio[16] is the target or response variable for the regression models. A linear relationship between the indices and the cost ratio is assumed due to the use of cumulative variables to represent each. The derived regression model parameters are subsequently used to project the growth in the cost ratio, and therefore the IHPA indexation rate for future years.

[16] This cumulative cost ratio is derived in line with the current methodology (whereby the latest year in which data is available is set as 1 and the prior year values are derived by dividing the following year's value by the change in cost ratios between consecutive years).

Appendix C Credibility Theory

Credibility theory is a statistical technique commonly used to combine various data sources with differing levels of reliability. This reduces reliance on recent experience, combining these observations with other information. This approach involves taking a weighted average of two or more data sources, with the weights determined according to a defined formula.

A classic credibility approach has been considered for alternatives within the Fundamental Review. For the use of credibility theory to combine multiple data sources in deriving non-admitted price weights, the weighted average is defined such that full weight is given to the NHCDC data once the volume is sufficient, given the level variability of the NHCDC cost data. This means that where there is low variation observed in the costs for a clinic, a lower volume of cost records is required to provide confidence in the accuracy of the data.

Two formulae for defining the sufficiency of volume were considered in testing:

- Scenario 1: Calculate the required volume of NHCDC records such that the estimated average NHCDC cost for each end class is expected to be reflect the underlying distribution of costs, with 95% probability (more relaxed conditions).
- Scenario 2: Calculate the required volume of NHCDC records such that the estimated average NHCDC cost for each end class is expected to reflect of the underlying distribution of cost, with 99% probability (tighter conditions).

In both scenarios above, the NHCDC is the target dataset, with pricing transitioning to NHCDC based pricing over time. The external costing studies and radiotherapy data are used as secondary datasets, with priority given based on availability of data and volume of observations.

The approach undertaken for determining the volume required in each scenario is based on the approach often used to estimate claim severity. This leverages the coefficient of variation, calculated by the standard deviation divided by the average of the distribution[17]. As a result, the greater the volatility (standard deviation) in the cost dataset, the lower the weight that will be assigned to it under the alternative approach.

[17] The Standard for Full Credibility for Severity from Classical Credibility theory is used as per the document Mahler, C; Chapter 8: Credibility; < http://people.stat.sfu.ca/~cltsai/ACMA315/Ch8_Credibility.pdf >

Appendix D Adjustment values

The Acute adjustment values resulting from implementation of the four alternatives are summarised in Table 9.

Table 9: Adjustment values resulting from implementation of recommended alternatives

Adjustment category	Label	Value
Specialist Psychiatric Age Adjustment	≤ 17 years, in MDC 19 or 20	38.7%
	≤ 17 years, in MDC 19 or 20; Specialised Children's Hospital	13.5%
	≤ 17 years, not in MDC 19 or 20	65.5%
	≤ 17 years, not in MDC 19 or 20; Specialised Children's Hospital	64.4%
	> 17 years, not in MDC 19 or 20	36.0%
Patient Residential Remoteness Area	Outer Regional Area	7.0%
	Remote Area	20.2%
	Very Remote Area	23.0%
Indigenous	Indigenous Adjustment	2.6%
Radiotherapy	Radiotherapy Adjustment	34.0%
Dialysis	Dialysis Adjustment	22.6%
Patient Treatment Remoteness Area Adjustment	Remote Area	4.0%
	Very Remote Area	12.0%

Note that these adjustments should be considered in relation to the recommended pricing formula, which replaces the current section of the formula related to non-DRG specific adjustments. This revised formula reflects the implementation of the alternative to calculate adjustments within a single GLM model, with consideration of interactions, and is as follows:

$$PW \times \left(1 + I_{Res(or)} \times A_{Res(or)}\right) \times \left(1 + I_{Res(rem)} \times A_{Res(rem)}\right) \times \left(1 + I_{res(vrem)} \times A_{res(vrem)}\right) \times (1 + I_{Ind} \times A_{Ind}) \times (1 + I_{RT} \times A_{RT}) \times (1 + I_{Dia} \times A_{Dia}) \times \times \left(1 + I_{SPA(1)} \times A_{SPA(1)}\right) \times \left(1 + I_{SPA(2)} \times A_{SPA(2)}\right) \times \left(1 + I_{SPA(3)} \times A_{SPA(3)}\right) \times \left(1 + I_{SPA(4)} \times A_{SPA(4)}\right) \times \left(1 + I_{SPA(5)} \times A_{SPA(5)}\right) \times \left(1 + I_{Tr(rem)} \times A_{Tr(rem)}\right) \times \left(1 + I_{Tr(vrem)} \times A_{Tr(vrem)}\right)$$

Appendix E Reliance and limitations

Ernst & Young ("EY") was engaged on the instructions of the Independent Hospital Pricing Authority ("Client") to undertake a fundamental review of the National Efficient Price (NEP) including a literature review, review of processes and statistical techniques used in determination of the NEP and providing alternative techniques ("Project"), in accordance with the official order dated 17 September 2018 under Deed of Standing Offer (Head Agreement for Services) 14/1213-37 dated 3 December 2014 and previously varied 27 May 2016 including the General Terms and Conditions (“the Engagement Agreement”).

The results of EY’s work, including the assumptions and qualifications made in preparing the report, are set out in EY's report dated 27 August 2019 ("Report"). You should read the Report in its entirety including any disclaimers and attachments. A reference to the Report includes any part of the Report. No further work has been undertaken by EY since the date of the Report to update it.

EY has completed this Report during the period 17 September 2018 to 27 August 2019 based on an agreed Research Plan and Project Charter with IHPA. Our Report is limited in time and scope other more detailed reviews or investigations may identify additional issues or considerations that this Report has not. The results of our work and procedures performed do not constitute an audit, a review or other form of assurance in accordance with any generally accepted auditing, review or other assurance standards, and accordingly we do not express any form of assurance.

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Fundamental Review of the National Efficient Price

Metrics and assessment criteria

Independent Hospital Pricing Authority

Final Report

27 August 2019

Building a better working world

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1. Metrics and assessment criteria

1.1 Introduction

IHPA engaged Ernst & Young to undertake a Fundamental Review of the National Efficient Price (NEP) in accordance with the official order dated 17 September 2018 under Deed of Standing Offer (Head Agreement for Services) 14/1213-37 between IHPA and EY dated 3 December 2017 and previously varied 27 May 2016.

Throughout the Fundamental Review of the NEP, metrics and assessment criteria are used to:

- Identify any challenges with IHPA's current methodology and approach; and
- Quantify benefits of alternative techniques identified in the Literature Review.

This document outlines the agreed overarching metrics and alternative specific metrics for the Fundamental Review and should be read in conjunction with EY's prior Literature Review report dated 6 December 2018 (the Literature Review) and EY's Summary report (dated 25 July 2019) that outlines the recommendations resulting from application of these metrics during the Fundamental Review of the NEP.

1.2 Overarching metrics

The following overarching metrics are utilised to understand the impact of the alternative on the goodness of fit of the models, at both an individual service and facility level. The goodness of fit refers to the extent to which the modelled cost reflects the underlying cost data. Historically, IHPA has used these standard statistical measures as performance benchmarks in developing the Pricing Models. These metrics are applied consistently across all alternatives to the extent possible.

Table 1: Overarching metrics used to assess the impact of all alternatives

Metric	Description
Change in cost ratios	Summarises the difference between modelled and actual cost across facilities and services in a meaningful way, accounting for differences in complexity of service.
R-squared	Statistical measures of goodness of fit to the actual costs.
SMAPE	

1.3 Alternative specific metrics

The Literature Review outlines a set of assessment criteria developed and agreed with IHPA during Phase 1 of the Fundamental Review of the NEP. Through the development process, each of the Pricing Guidelines were considered and incorporated in the final assessment criteria[1].

This section outlines the additional metrics included in the Fundamental Review of the NEP to assess the expected benefits outlined for each alternative identified in the Literature Review.

1.3.1 Targeted deterministic matching of pharmaceutical claims

The assessment criteria items expected to be impacted through the use of target deterministic matching of pharmaceutical claims are Minimising undesirable and inadvertent consequences and Equity[2]. These impacts are assessed through the following metrics specific to this alternative.

[1] Refer to Appendix A for a mapping of assessment criteria to Pricing Guidelines.

[2] Refer to Appendix B for details of the expected impacts of each data preparation alternatives.

Table 2: Alternative specific metrics used to assess the impact of the use of targeted pharmaceutical matching

Assessment Criteria	Metric	Description
Minimising undesirable and inadvertent consequences	Proportion of records uniquely matched	If a pharmaceutical record matches to multiple activity records, it is equally offset against each of these records. In such circumstances, it is known that some activity records are being impacted by unrelated pharmaceutical claims. Therefore an increase in the proportion of records uniquely matched provides greater confidence in the accuracy of the process.
Equity	Anomalous matches	A match is deemed anomalous when the matched pharmaceutical benefits for a hospital activity exceeds the total in-scope costs reported in the NHCDC. This indicates that the matching process is not accurately assigning Pharmaceutical benefits to the service for which the related costs are report. If a high rate of anomalous matches is detected, the process does not equitably allocate benefits to the appropriate originating service.
Equity	Impact to adjusted in-scope cost by end class	The change in adjusted in-scope cost by end class indicates whether there are differences in the allocation of benefits to end class, between the current and alternative approach. A more targeted matching approach reduces the proportion of pharmaceutical claims which are inadvertently offset against unrelated hospital services. As a result, this metric is a useful tool to understand whether the alternative has a material impact in terms of equitable allocation of prices to services. However, in order to form a conclusion on equity other factors should also be considered, such as the inconsistency in implementation of the Australian Hospital Patient Costing Standards (AHPCS) with respect to pharmaceutical costs.

1.3.2 Logistic regression to scale Hospital Casemix Protocol data

The assessment criteria items expected to be impacted through the use of logistic regression to determine scaling factors for hospitals with partial ancillary benefits in the cost data are Minimising undesirable and inadvertent consequences, Equity and Consistency.

Preliminary analysis found that less than 1% of private patients have a reported ancillary benefit, and that the value of these benefits is immaterial to the total cost of hospital services. As a result, the alternative was not considered for further analysis and no metrics assessed.

1.3.3 Retention of outliers, incorporating reduced weights

The assessment criteria items expected to be impacted through the retention of outliers with reduced weighting are Consistency and Equity. These impacts are assessed through the following metrics specific to this alternative.

Table 3: Alternative specific metrics used to assess the impact of the retention of outliers with reduced weighting

Assessment Criteria	Metric	Description
Consistency	Proportion of costs and separations removed	This metric when analysed by volume of activity for each individual end class, provides a useful indication of the consistency of performance for outlier detection approaches across individual end classes.
Equity	Average cost under each approach	To fairly compensate for factors outside the control of providers, it is essential that the National Cost Models are not unduly influenced by erroneous data or cost anomalies that reflect unwarranted variation in the cost of service provision. Analysis of average cost under each approach is a useful tool in understanding whether potential anomalies are skewing the calculated price weights. However, in order to form a conclusion on equity other factors should also be considered, such as detailed investigation of the identified outliers to confirm the source of the discrepancy.

1.3.4 Retention of outliers, with bootstrapping to determine price

The assessment criteria items expected to be impacted through the application of bootstrapping to understand variability in the price weights are Consistency and Stability. These impacts are assessed through the following metrics specific to this alternative.

Table 4: Alternative specific metrics used to assess the impact of the use of bootstrapping in price weight development

Assessment Criteria	Metric	Description
Stability	Percentile of the base price within the Confidence Interval	The bootstrapping method generates a Confidence Interval by resampling from the data and analysing the resulting distribution. This interval represents the range of values within which the true base price is expected to lie. The location of the average cost calculated under the current approach within this interval provides insight into the potential volatility of the average cost.
Consistency		Consistency is also assessed through the percentile metric above as it is a mechanism to identify anomalous or volatile DRGs that might require further adjustment to ensure consistency of approach.

1.3.5 Use of median cost to calculate base price weights

The assessment criteria items expected to be impacted through the use of the median to calculate price weights are Efficiency, Stability and Equity[3]. These impacts are assessed through the following metrics specific to this alternative.

[3] Refer to 0 for details of the expected impacts of each base price weight calculation alternative.

Table 5: Alternative specific metrics used to assess the impact of the use of Median to calculate cost weights

Assessment Criteria	Metric	Description
Efficiency	Distribution of costs (ratio of median to mean costs by service category)	The ratio of the median to mean highlights the asymmetry, or skewness, of cost distributions. This provides insight into the number of services with a cost below the mean cost. The use of end classes addresses differences in service complexity, while safety and quality are out of scope for this assessment. Therefore, efficiency refers solely to cost efficiency.
Stability	Sensitivity of mean to outliers	This is assessed qualitatively through discussion of the characteristics of mean and median as measures of central tendency.
Equity	This is assessed through the overarching metrics, specifically change in cost ratios.	

1.3.6 Calculation of inlier bounds using percentiles

The assessment criteria items expected to be impacted through using percentiles to calculate inlier bounds are Minimising undesirable and inadvertent consequences and Efficiency. These impacts are assessed through the following metrics specific to this alternative.

Table 6: Alternative specific metrics used to assess the impact of the use of percentiles to calculate inlier bounds

Assessment Criteria	Metric	Description
Minimising undesirable and inadvertent consequences	Proportion of activity by separation category	The metric identifies the proportion of inliers and outliers by separation category, which may vary the incentives for each end class.
Efficiency	Range in bounds	The spread in the inlier bounds affects the skew of the distribution e.g. if the spread is too great, the inlier cost will be skewed upwards by longer stays, potentially reducing the incentive for efficient service delivery.

1.3.7 Credibility theory to calculate non-admitted price weights

The assessment criteria items expected to be impacted using credibility theory for non-admitted price weights are Equity and Stability. These impacts are assessed through the following metrics specific to this alternative.

Table 7: Alternative specific metrics used to assess the impact of credibility theory for non-admitted price weights

Assessment Criteria	Metric	Description
Equity	Ratio of cost under alternative approach to cost under current approach	This metric, calculated by clinic, illustrates any potential changes in funding that might result to clinics using the alternative approach. This is a useful tool to consider whether changes impact jurisdictions and facilities evenly and the equity of the alternative approach. However, in order to form a definitive conclusion on equity further consideration of other factors and investigation of NHCDC cost data is required.

Assessment Criteria	Metric	Description
Equity	Cost ratios	The cost ratio provides insight into the deviation of the pricing from available reported costs. Better alignment between the derived prices and reported costs reflects a more equitable allocation of prices across services.
Stability	Number of clinics stabilised	This metric provides insight into the level of variability resulting from the selected costing approach as the fewer clinics that require stabilization, the better stability compared to the previous year.

1.3.8 Calculation of adjustments in a single model and consideration of their interactions

The assessment criteria items expected to be impacted by calculating all adjustments within a single model and considering interaction effects are Minimising undesirable and inadvertent consequences, Equity and Consistency[4]. These impacts are assessed through the following metrics specific to this alternative.

Table 8: Alternative specific metrics used to assess the impact of calculating adjustments in a single model

Assessment Criteria	Metric	Description
Minimising undesirable and inadvertent consequences	Change in adjustment values	The change in the percentage adjustments of implementing the alternative approach indicates the extent to which adjustments under the current approach may be distorted due to any correlations between factors not being accounted. Correlation analysis is used to support these insights.
Equity and access	Change in hospital cost ratios	The cost ratio is calculated as the actual cost of delivering the services divided by the predicted cost. A change in this ratio reflects the extent to which the revised adjustments affect the calculated cost, with implications around funding for hospitals and LHNs.
Consistency	Change in adjustment values	The change in the percentage adjustments under the model options considered for the alternative approach provide a useful indicator of the impact of: application of adjustments independently, application of adjustments concurrently, and accounting for potential interaction effects between adjustments. The magnitude and direction of changes observed in adjustment values between the different model options and the current methodology assist in understanding the extent to which the alternative approach may improve the ability to accurately capture the individual impact of adjustments and their joint impact with other adjustments. Enhanced transparency of the independent adjustment effects and interaction effects offers a more consistent framework for assessment of adjustment factors.

[4] Refer to Appendix D for details of the expected impacts of each adjustments alternative.

1.3.9 Fixed ‘incremental’ dollar amounts for selected adjustments

The assessment criteria item expected to be impacted using fixed dollar amounts for select adjustments is Minimising undesirable and inadvertent consequences.

Analysis of model fit and cost ratios by jurisdiction and adjustment type illustrate that there is no material improvement compared to the current approach of implementing any of the fixed dollar adjustments tested. This is due in part to technical challenges in implementation of the alternative approach including weighting residuals by predicted cost. Due to this technical challenge and the results of the preliminary analysis, this alternative was not proceeded with for further analysis or investigation in the Fundamental Review.

However, further investigation is recommended to consider alternative methods of implementation that address the technical challenges noted, particularly for Dialysis and Radiotherapy treatments. Preliminary analysis has found that 99.9% of dialysis (excluding records that are admitted for dialysis-related DRGs) and 87.1% of radiotherapy records eligible for these adjustments have only one procedure code, which suggests that these treatments are usually provided independent of other underlying treatments and consequently may be more appropriately implemented as fixed dollar adjustments.

1.3.10 Clustering technique to identify groups of variation in the data

The assessment criteria items expected to be impacted using clustering to identify groups of variation in the data are Minimising undesirable and inadvertent consequences, Equity and access, and Consistency.

Preliminary correlation analysis did not uncover any new relationships that are not already identified and incorporated in the National Pricing Model. Additionally, first-pass cluster analysis did not immediately identify any new unidentified groups of variation. Due to the intensive iterative and exploratory nature of cluster analysis and limited insights generated from preliminary analysis, the alternative was not proceeded with for further analysis or investigation in the Fundamental Review.

1.3.11 Stabilisation across classification versions used weighted average price weights

The assessment criteria items expected to be impacted through stabilisation across Acute classification versions using weighted average price weights are Stability, Efficiency, and Consistency[5]. These impacts are assessed through the following metrics specific to this alternative.

Table 9: Alternative specific metrics used to assess the impact of stabilisation using weighted average price weights

Assessment Criteria	Metric	Description
Stability	Number of stabilised DRGs	Analysis of the number of end classes with high fluctuations in cost between years (i.e +/- 10%) that are subject to the stabilization process is a useful tool to understand overall stability of the National Pricing Models. A larger number of end classes with high fluctuations in cost between pricing years that are stabilised means that fewer of these DRGs with high fluctuations are implemented into the model without stabilisation. Therefore, there is less residual variability introduced into the National Pricing Models.

[5] Refer to 0 for details of the expected impacts of each stabilisation alternative.

Assessment Criteria	Metric	Description
Consistency	Proportion of stabilised DRGs	Analysis of the proportion of end classes with high cost fluctuations (+/- 10%) that are subject to the stabilisation process is a useful tool to understand the consistency of the methodology. A higher proportion of end classes with high cost fluctuations stabilised means that one consistent methodology is used for more of the end classes that could possibly be stabilised. Therefore, a larger proportion is indicative of a greater consistency in treatment of end classes with high cost fluctuations.
Efficiency	Due to the complexities in quantifying the impact of changes in clinic coding patterns separately from other variations in cost, the efficiency metric has not been assessed within the scope of the Fundamental Review.	

1.3.12 Credibility theory to stabilise prices and adjustments

The assessment criteria items expected to be impacted by using credibility theory to stabilise prices and adjustments are Minimising undesirable and inadvertent consequences, and Equity and access. These impacts are assessed through the following metrics specific to this alternative.

Table 10: Alternative specific metrics used to assess the impact of credibility theory to stabilise prices and adjustments

Assessment Criteria	Metric	Description
Minimising undesirable and inadvertent consequences	Percentage change in year-on-year price weights and adjustment values	This is assessed through the change in price weights and adjustment values that is due to reliance on underlying data that is more sufficient (in terms of volume) and stable (in terms of volatility), and therefore potentially more reflective of the current cost of care.
Equity and access	Change in hospital cost ratios	The cost ratio is calculated as the actual cost of delivering the services divided by the predicted cost. A change in this ratio reflects the extent to which the revised price weights and adjustments affect the calculated cost, with implications around funding for hospitals and LHNs.

1.3.13 Comparison of derived rates with external indices and historical experience

The assessment criteria item expected to be impacted by comparing derived rates to external indices and historical experience is Equity[6]. This impact is assessed through the following metrics specific to this alternative.

[6] Refer to Appendix B for details of the expected impacts of each transformation to pricing models alternative.

Table 11: Alternative specific metrics used to assess the use of comparison of derived rates with external indices and historical experience

Assessment Criteria	Metric	Description
Equity and access	Difference between external indices and IHPA rate	The difference between the external index rate and the IHPA projected indexation rate provides a useful indicator of the appropriateness of the value of the indexation rate as well as the trend of the indexation rate over time. This measure can be used to identify anomalies in the indexation rate, indicating instances where the rate may not appropriately reflect changes in the costs incurred by providers.
	Difference between historical experience and IHPA rate	The difference between the actual historic growth rates and the historic IHPA Indexation rate provides a useful indicator of the accuracy of the Indexation approach in predicting the future increase in cost of service delivery. This measure can be used to identify instances where the rate may not have appropriately compensate providers for changes in the costs incurred.

1.3.14 Regression of growth against drivers of indexation

The assessment criteria item expected to be impacted by regressing growth in cost against drivers of indexation is Equity[2]. This impact is assessed through the following metrics specific to this alternative.

Table 12: Alternative specific metrics used to assess the impact of regressing growth against drivers of indexation

Assessment Criteria	Metric	Description
Equity and Access	P-value	This statistical measure explains the significance of each predictor included in the defined regression. The p-value highlights whether the selected predictor is an appropriate indicator of the growth in the cost of service delivery. This ultimately indicates whether the external index appropriately reflects changes in cost experienced by providers.
	Prediction interval	A prediction interval can be calculated around the indexation estimate resulting from the regression. Comparison of IHPA's indexation rate to this prediction interval provides insight into whether IHPA's rate reflects the expected change in cost, and fairly compensates providers for cost changes outside their control.

1.3.15 ARIMA technique to forecast growth

The assessment criteria item expected to be impacted using clustering to identify groups of variation in the data is Equity.

Preliminary ARIMA analysis, modelling IHPAs previous indexation rates to forecast future rates, was not successful. Due to the small number of data points and the consistent downtrend, the moving average and autoregressive error were both insignificant during model. With more data points and maturing of the index then it could be possible to analyse the trends over time once the index has more time to mature.

1.3.16 Smoothing of volume multipliers, utilising multiple base years for calculation

The assessment criteria item expected to be impacted by smoothing volume multipliers utilising multiple base years is Stability[7]. This impact is assessed through the following metrics specific to this alternative.

Table 13: Alternative specific metrics used to assess the impact of smoothing volume multipliers, using multiple base years of activity data for calculation

Assessment Criteria	Metric	Description
Stability	Change in multipliers	The absolute change in back-casting multipliers calculated by jurisdiction and service category are used to provide an illustration of the volatility in case mix in activity data between base years. High changes indicate that there is likely to be more variation across years, whereas smaller changes indicate case mix is relatively stable across years.
	Comparison to actual	Comparison of the back-casting multipliers calculated to the actual back-casting multipliers derived by using NWAU calculators, in the same manner that the National Health Funding Body would through the reconciliation process, provides an illustration of the relative accuracy of the back-casting multipliers. A smaller difference indicates there will likely be greater funding stability as there will be a smaller over or under funding based on the back-casting multipliers by the NHFB up to the point where reconciliation can occur.

[7] Refer to Appendix G for details of the expected impacts of each back-casting alternative.

Appendix A Shortlisting of alternative techniques

The Pricing Guidelines outlined in the Pricing Framework for Australian Public Hospital Services can be used by governments and other stakeholders to evaluate whether IHPA is undertaking its work in accordance with the explicit policy objectives included in the Pricing Guidelines.

For the purpose of identifying a set of short-listed alternative techniques for further consideration during Phase 2 quantitative testing we have agreed a set of assessment criteria with IHPA. Each of the Pricing Guidelines have been considered and incorporated in the development of our assessment criteria through one of the following mechanisms:

1. The Pricing Guideline is incorporated into one of the agreed Assessment Criteria;
2. The Pricing Guideline is incorporated in our approach to the Literature Review; or
3. The Pricing Guideline is identified as related to a specific methodology area and will be applied in Phase 2 during the further testing of initiatives for the related methodology area.

Table 14 below summarises our approach to incorporating the Pricing Guidelines in development of the agreed assessment criteria.

Table 14: Mapping of IHPA's Pricing Guidelines against the agreed assessment criteria utilised in the Literature Review

Pricing Guideline	Description	Application to development of Assessment Criteria
Timely-quality care	Funding should support timely access to quality health services	This is incorporated in the 'Equity and access' criteria.
Efficiency	ABF should improve the value of the public investment in hospital care and ensure a sustainable and efficient network of public hospital services.	This is incorporated in the 'Efficiency' criteria.
Fairness	ABF payments should be fair and equitable, including being based on the same price for the same service across public, private or not-for-profit providers of public hospital services.	This is incorporated in the 'Equity and access' criteria.
Maintaining agreed roles and responsibilities of governments determined by the NHRA	Funding design should recognise the complementary responsibilities of each level of government in funding health services.	The delineation of responsibilities between jurisdictions and the legislated functions of IHPA define the scope of the Literature Review.
Transparency	All steps in the determination of ABF and block grant funding should be clear and transparent	This is incorporated in the 'Ease of understanding' criteria.
Administrative ease	Funding arrangements should not unduly increase the administrative burden on hospitals and system managers.	This is incorporated in the 'Ease of implementation' criteria.
Stability	The payment relativities for ABF are consistent over time.	This is incorporated in the 'Stability' criteria.
Evidence-based	Funding should be based on best available information	This is incorporated in our approach to the Literature Review which is based on a review of the evidence base.

Pricing Guideline	Description	Application to development of Assessment Criteria
Fostering clinical innovation	Pricing of public hospitals should respond in a timely way to introduction of evidence-based, effective new technology and innovations in the models of care that improve patient outcomes.	This is incorporated in the 'Efficiency' criteria.
Price harmonisation	Pricing should facilitate best-practice provision of appropriate site of care.	This is incorporated in the 'Equity and access' criteria.
Minimising undesirable and inadvertent consequences	Funding design should minimise susceptibility to gaming, inappropriate rewards and perverse incentives.	This is incorporated in the 'Minimising undesirable and inadvertent unintended consequences' criteria.
ABF pre-eminence	ABF should be used for funding public hospital services wherever practicable.	This is incorporated in our approach to the Literature Review, the scope of the review is the NEP process which by definition is ABF only.
Single unit of measure and price equivalence	ABF pricing should support dynamic efficiency and changes to models of care with the ready transferability of funding between different care types and service streams through a single unit of measure and relative weights.	This is specific to the Transformation to pricing models methodology area (i.e. calculation of the reference cost).
Patient-based	Adjustments to the standard price should be, as far as is practicable, based on patient-related rather than provider-related characteristics.	This is specific to the Adjustments methodology area
Public-private neutrality	ABF pricing should not disrupt current incentives for a person to elect to be treated as a private or a public patient in a public hospital.	This is specific to the Data preparation methodology area (i.e. for HCP matching) and Adjustments (i.e. PPSA and PPAA).

The following is the final set of assessment criteria agreed with IHPA for identifying short-listed alternative techniques for Phase 2 quantitative testing:

- Ease of implementation – considers availability of appropriate data for implementation, the extent of the methodology process affected, impact on model run times and level of model maintenance.
- Ease of understanding – considers the complexity of the statistical technique and possible challenges in explaining the technique and its rationale to stakeholders.
- Expected impact – considers expected positive or negative impacts of implementing the change with respect to the following principles:
    - Efficiency – the price assigned should reflect the efficient cost of service delivery.
    - Equity and access – the price should be the same for each service across all providers and fairly compensate for factors not in the control of providers.
    - Stability – prices and relativities should be consistent for services over time, except where expected given known changes.

- Minimising undesirable and inadvertent consequences – the price paid for services should minimise gaming, inappropriate rewards and perverse incentives.
- Consistency – a streamlined approach should be adopted for calculating the price across all service categories and services within them. Approaches should be designed such that the volume of activity at each level does not negatively impact the effectiveness of the step.

- Alignment with purpose – considers the extent to which the technique aligns with the initial purpose of undertaking the methodology

The following symbols are used to denote the assessment of each alternative against the criteria:

●	Easy to implement or explain to stakeholders
◑	Some possible challenges in implementing or explaining to stakeholders
○	Challenges in implementing or explaining to stakeholders
+	Expected positive impact
-	Expected negative impact

Where there is a blank 'expected impact', this suggests the impact is unknown at this stage.

Green (or red) highlighting is used in the following table in relation to the Assessment Criteria to denote an expected positive (or negative) impact.

Appendix B Data preparation

ID	Description	Ease of implementation	Ease of understanding	Expected impact					Alignment with purpose	Phase 1 shortlist?
				Efficiency	Equity and access	Stability	Minimising undesirable and inadvertent consequences	Consistency		
1.1 Commonwealth Pharmaceutical Programs - data linking and removal of costs from linked episodes										
Current approach: Deterministic matching of all Pharmaceutical claims, with unmatched claims distributed in line with matched claims										
1.1.1	Targeted deterministic matching of pharmaceutical claims	◑	●		+		+		Yes	Yes
1.1.2	Probabilistic matching using expectation maximization algorithm	○	◑					+	Yes	No
1.1.3	Imputation using mean of reliable data	●	●		–				Yes	No
1.1.4	Imputation using KNN method	◑	◑		+		+	+	Yes	Yes
1.2 Hospital Casemix Protocol (HCP) matching methodology and inflation of costs to reflect private patient costs that are missing from the NHCDC										
Current approach: Match HCP data at a patient level, including imputation of missing benefits based on non-missing values by classification. Offset NHCDC costs by matched/imputed benefits.										
1.2.1	Imputation of medical and ancillary benefits based on facilities with complete reporting only	●	◑		+		+	+	Yes	Yes
1.2.2	Stratification for imputing private patient costs	●	●		+			+	Yes	Yes

ID	Description	Ease of implementation	Ease of understanding	Expected impact					Alignment with purpose	Phase 1 shortlist?
				Efficiency	Equity and access	Stability	Minimising undesirable and inadvertent consequences	Consistency		
1.2.3	Scaling of matched data using logistic regression for ancillary costs	◑	◑		+		+	+	Yes	Yes
1.3 Identification and treatment of outliers for all models										
Current approach: Remove outliers using pre-defined thresholds, which are constant across classifications.										
1.3.1	Removal of outliers using studentised residuals and a defined threshold	◑	◑			+		+	Yes	Yes
1.3.2	Removal of outliers using an alternative (e.g. centroid or simple average) distance-based approach	●	◑			+		+	Yes	Yes
1.3.3	Outlier visualisation techniques such as box plots and scatter plots	○	●			–		–	Yes	No
1.3.4	Retention of outliers, without adjustment	●	●	–	+	–		+	No	No
1.3.5	Retention of outliers, using studentised residuals and reduced weights	◑	◑		+	–		+	Yes	Yes
1.3.6	Use of multiple years data, combined with a credibility theory approach	◑	●			+			Yes	Yes

ID	Description	Ease of implementation	Ease of understanding	Expected impact					Alignment with purpose	Phase 1 shortlist?
				Efficiency	Equity and access	Stability	Minimising undesirable and inadvertent consequences	Consistency		
1.3.7	Principal Component Analysis to reduce dimensions of the data	◑	○			+		+	Yes	No
1.3.8	Cluster analysis to determine groups of data points that sit at the extremes	○	◑			+		+	Yes	No
1.3.9	Robust regression to limit the influence of outliers	◑	○		+	–		+	Yes	No
1.3.10	Retention of outliers, with adjustments to be made in the calculation of the base price weight through bootstrapping	◑	◑			+		+	Yes	Yes

Appendix C Base price weight calculation

ID	Description	Ease of implementation	Ease of understanding	Expected impact					Alignment with purpose	Phase 1 shortlist?
				Efficiency	Equity and access	Stability	Minimising undesirable and inadvertent consequences	Consistency		
2.1 Use of same day, short stay outlier, inlier, and long stay outlier methodology in subacute and acute cost models										
Current approach: Activity is classified as one of the four separation types. Funding is then determined based on the separation category, with both fixed price and per diem approaches utilised.										
2.1.1	Long Stay Outlier per diems as a proportion of the average inlier cost	●	●	+	–		+	+	Yes	Yes
2.1.2	Per diem system for subacute activity, by care type	●	●			+	–	–	No	No
2.1.3	Use of median cost for the inlier price weight instead of the mean cost	●	●	+	–	+			Yes	Yes
2.1.4	Bootstrapping to determine the mean cost	◑	◑			+		+	Yes	Covered by 1.3.10
2.1.5	Stochastic Frontier Analysis to define the efficient price	○	◑	+		–			Yes	Yes
2.16	Innovation funding for new treatment methods, on application	○	●	–	+		+		No	No

ID	Description	Ease of implementation	Ease of understanding	Expected impact					Alignment with purpose	Phase 1 shortlist?
				Efficiency	Equity and access	Stability	Minimising undesirable and inadvertent consequences	Consistency		
2.2 Use of L3H3 methodology and L1.5H1.5 methodology in subacute and acute cost models										
Current approach: The average length of stay is currently utilised as the basis for deriving the inlier bounds, from which activity is classified into separation categories. For most activity these bounds are calculated as 1/3 of the ALOS and 3 times the ALOS. For activity with longer ALOS, these are calculated as 2/3 the ALOS and 1.5 times the ALOS.										
2.2.1	Cost based thresholds	○	●	+	+		+		Yes	No
2.2.2	Calculation of bounds using LOS interquartile range	●	●				–	–	Yes	No
2.2.3	Calculation of bounds using linear spline fit to LOS	◑	◑	+	+			–	Yes	Yes
2.2.4	Calculation of bounds using percentiles of gamma distribution	◑	◑				–		No	No
2.2.5	Use of LαHβ, fit to data	○	◑		+	–		–	Yes	No
2.2.6	Calculation of bounds using 10th and 95th percentiles	●	●	+			+		Yes	Yes
2.2.7	Calculation of bounds using adjusted LOS interquartile range	●	●			–	+	+	Yes	Yes

ID	Description	Ease of implementation	Ease of understanding	Expected impact					Alignment with purpose	Phase 1 shortlist?
				Efficiency	Equity and access	Stability	Minimising undesirable and inadvertent consequences	Consistency		
2.2.8	Removal of SSO threshold	●	◑	–			+		No	No
2.4 Use of multiple years and different sources of data, in the non-admitted model and block funded cost model										
Current approach: The non-admitted model leverages cost data across multiple sources and years, to account for low reporting and instability in the NHCDC										
2.4.1	Credibility theory	◑	◑		+	+			Yes	Yes

Appendix D Adjustments

ID	Description	Ease of implementation	Ease of understanding	Expected impact					Alignment with purpose	Phase 1 shortlist?
				Efficiency	Equity and access	Stability	Minimising undesirable and inadvertent consequences	Consistency		
3.1 Adjustments for legitimate and unavoidable variation in costs, including hospital eligibility criteria, as specified in the 2018-19 NEP Determination										
Current approach: Unavoidable variations in cost are currently reflected through patient level adjustments. Where appropriate, adjustments are calculated using the patient level cost ratios at the relevant step of the modelling process. This is to account for any cost variation explained by the preceding model steps										
3.1.1	GLM of cost against adjustment factors, with interaction factors (current adjustments only)	●	◑		+		+	+	Yes	Yes
3.1.2	GLM of cost against adjustment factors, with interaction factors (additional adjustments considered)	◑	◑		+		+	+	Yes	Yes
3.1.3	Fixed 'incremental' dollar amounts for select adjustments instead of percentages	◑	●				+		Yes	Yes
3.1.4	K-means clustering to identify groups of variation in the data	○	◑		+		+	+	Yes	Yes

ID	Description	Ease of implementation	Ease of understanding	Expected impact					Alignment with purpose	Phase 1 shortlist?
				Efficiency	Equity and access	Stability	Minimising undesirable and inadvertent consequences	Consistency		
3.1 Private patient adjustments										
Current approach: Application of PPAA and PPSA adjustments to the acute and subacute cost models										
3.2.1	Bottom up review of private patient funding	◑	●		+		+	+	Yes	Yes

Appendix E Stabilisation

ID	Description	Ease of implementation	Ease of understanding	Expected impact					Alignment with purpose	Phase 1 shortlist?
				Efficiency	Equity and access	Stability	Minimising undesirable and inadvertent consequences	Consistency		
4.1 Evaluation of DRG and SNAP class comparability across classification versions for the purposes of stabilisation of acute and subacute price weights										
Current approach: For changes in classification, only those classification codes with an equivalent code in the prior classification version are stabilised										
4.1.1	Stabilisation against weighted average price weight, where no one-to-one mapping is available	●	●	+		+		+	Yes	Yes
4.1.2	Credibility theory against an expected price	○	◑			+	+	–	Yes	Yes
4.2 Purpose and application of price and adjustment stabilisation policy for all cost models										
Current approach: Stabilise price weights, inlier bounds and adjustments against the prior year's values										
4.2.1	Credibility theory	◑	◑		+		+		Yes	Yes
4.2.2	Stabilisation against non-stabilised cost weight	◑	●		+	–			Yes	Yes

Appendix F Transformation to pricing models

ID	Description	Ease of implementation	Ease of understanding	Expected impact					Alignment with purpose	Phase 1 shortlist?
				Efficiency	Equity and access	Stability	Minimising undesirable and inadvertent consequences	Consistency		
5.1 Calculation of the reference cost										
Current approach: The previous year's reference cost is indexed by the growth rate in consecutive years' cost models, where the growth rate is standardised against the latest year's activity data.										
5.1.1	Use the mean cost of the current year's acute model, instead of applying a standardised growth rate to the previous year	●	●			–		–	Yes	Yes – as a pricing signal
5.1.2	Application of current approach at a service category level	●	◑					+	Yes	Yes
5.2 Calculation of the indexation rate										
Current approach: The cost model is applied retrospectively to the five years of patient costed admitted acute activity data, with scaling factors reflecting the difference in actual cost and modelled cost calculated for each of these years. The trend of these scaling factors is used to model the indexation rate for the following three years.										
5.2.1	Regression of growth against drivers of indexation	◑	●		+				Yes	Yes
5.2.2	Compounded arithmetic or geometric average to determine the forecast	●	●			–			Yes	No
5.2.3	Exponential smoothing of growth	●	◑		+	+			Yes	Yes

ID	Description	Ease of implementation	Ease of understanding	Expected impact					Alignment with purpose	Phase 1 shortlist?
				Efficiency	Equity and access	Stability	Minimising undesirable and inadvertent consequences	Consistency		
5.2.4	ARIMA (time series) modelling of growth	◑	○		+	–			Yes	Yes
5.2.5	Use of external indices	●	●		–				Yes	Yes
5.2.6	Microsimulation to model impacts of shifts in classifications and reporting	○	◑		+	–	+		Yes	Yes
5.2.7	Analysis of historical deviation between actual and expected to adjust the indexation rate	◑	◑		+				Yes	Yes

Appendix G Back-casting

ID	Description	Ease of implementation	Ease of understanding	Expected impact					Alignment with purpose	Phase 1 shortlist?
				Efficiency	Equity and access	Stability	Minimising undesirable and inadvertent consequences	Consistency		
6.1 Review the methodology for back-casting the NEP										
Current approach: The volume multipliers are derived as the NWAUs calculated from application of the current model divided by NWAUs calculated by application of the previous year's cost model, to a consistent activity dataset. The back-cast NEP is determined by indexing the reference cost by two years, using the same annual indexation projections for the NEP.										
6.1.1	Use of a different year's data in determining volume multipliers ('VM')	○	●		+	+	+		Yes	No
6.1.2	Smoothing of volume multipliers, using multiple base years for calculation	●	◑			+	+		Yes	Yes

Appendix H Reliance and limitations

Ernst & Young ("EY") was engaged on the instructions of the Independent Hospital Pricing Authority ("Client") to undertake a fundamental review of the National Efficient Price (NEP) including a literature review, review of processes and statistical techniques used in determination of the NEP and providing alternative techniques ("Project"), in accordance with the official order dated 17 September 2018 under Deed of Standing Offer (Head Agreement for Services) 14/1213-37 dated 3 December 2017 and previously varied 27 May 2016 including the General Terms and Conditions (“the Engagement Agreement”).

The results of EY’s work, including the assumptions and qualifications made in preparing the report, are set out in EY's report dated 27 August 2019 ("Report"). You should read the Report in its entirety including any disclaimers and attachments. A reference to the Report includes any part of the Report. No further work has been undertaken by EY since the date of the Report to update it.

EY has completed this Report during the period 17 September 2018 to 27 August 2019 based on an agreed Research Plan and Project Charter with IHPA. Our Report is limited in time and scope other more detailed reviews or investigations may identify additional issues or considerations that this Report has not. The results of our work and procedures performed do not constitute an audit, a review or other form of assurance in accordance with any generally accepted auditing, review or other assurance standards, and accordingly we do not express any form of assurance.

In preparing this Report, EY has relied on information provided by the management of IHPA. EY has not conducted any audit, review or other form of verification of information provided by the management of IHPA. EY has not performed any independent verification of the accuracy or completeness of this information. EY does not accept any responsibility or liability for independently verifying any information we have obtained nor do we make any representation to the accuracy or completeness of information provided by the management of IHPA.

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Fundamental Review of the National Efficient Price

Literature Review
Final Report

Independent Hospital Pricing Authority

6 December 2018

Building a better working world

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6 December 2018

Fundamental Review of the National Efficient Price – Literature Review

Dear James,

We are pleased to present our literature review report completed as part of the first phase of the fundamental review of the National Efficient Price (NEP).

The Independent Hospital Pricing Authority (IHPA) engaged Ernst & Young (EY) to undertake a fundamental review of the National Efficient Price (NEP) including a literature review, review of processes and statistical techniques used in determination of the NEP and development of alternative techniques in accordance with the official order dated 17 September 2018 under Deed of Standing Offer (Head Agreement for Services) 14/1213-37 between IHPA and EY dated 3 December 2017 and previously varied 27 May 2016.

This report addresses the first of these three focus areas for the fundamental review summarising our approach to the literature review and the resulting key findings and alternative techniques to improve processes and/or statistical techniques used in the determination of the NEP.

We appreciate the cooperation and assistance provided to us during the course of our work. If you have any questions, please call Chris O'Hehir on (02) 9248 5435 or Tim Goodhew on (02) 9248 4894.

Yours sincerely,

C. O'Hehir

Chris O'Hehir
Partner

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Limitations and use of the report: Consistent with our official order, our report has been completed solely for the benefit of IHPA and EY has not been engaged to act, and has not acted, as advisor to any other party. Accordingly, EY makes no representations as to the appropriateness, accuracy or completeness of the report for any other party's purposes.

Our work has been limited in time and scope in accordance with our agreed research plan and in completing the literature review we have relied on information provided by IHPA, the reliance and limitations of our Report are set out in Appendix F.

1. Executive Summary

1.1 Background and scope

The National Health Reform Act 2011 (the Act) and National Health Reform Agreement (NHRA) specify the functions of the Independent Hospital Pricing Authority (IHPA) including to determine the National Efficient Price (NEP) for services provided by public hospitals where the services are funded on an activity basis. Collectively, the Act, NHRA and Pricing Guidelines outlined in the Pricing Framework for Australian Public Hospital Services comprise the policy framework that underpins the determination of the NEP.

IHPA has developed a set of National Activity Based Funding (ABF) Cost and Pricing Models that underpin the NEP determination (the Models). The Models are subject to an annual validation process to provide IHPA with quality assurance that the Models are ‘fit for purpose’.

In performing its functions IHPA is obligated to consider a range of fundamental factors specified in the Act, NHRA and Pricing Guidelines. Independent of the model validation process, to provide IHPA with an external review of these fundamental factors throughout the NEP determination process, Ernst & Young (EY) was engaged in September 2018 to undertake a fundamental review of the NEP, including a literature review, review of all current processes and statistical techniques and development of a list of recommended improvements.

1.2 Purpose

This report addresses the first of the three focus areas of the fundamental review. This includes a summary of our approach to the literature review, key findings and alternative techniques for further testing identified for each of the six NEP methodology areas: data preparation, base price weight calculation, adjustments, stabilisation, transformation to pricing models and back-casting.

For each of the NEP methodology areas our report outlines in detail the:

- Purpose of current processes / statistical techniques used in determination of the NEP;
- Challenges in the current approach in determination of the NEP;
- Alternative processes / statistical techniques identified during the literature review; and
- Short-listed alternative techniques based on a preliminary assessment against the agreed criteria (i.e. ease of implementation, ease of interpretation, expected impact with regards to key pricing guidelines, and alignment with purpose).

1.3 Findings

Table 1 on the following page summarises the number of alternative techniques short-listed through the literature review. This included review of publicly available health journals, statistical journals and EY’s previous experience reviewing the Cost Models and recommendations outlined in our prior 2014-15 ABF and Block Funding Cost Model Validation Report.

Subsequently, in Section 2 of this report for each of the 48 short-listed alternative techniques a summary is provided of the expected impacts by each of the agreed Assessment Criteria and estimated level of change to current processes. The estimated level of change for each alternative has determined based on an assessment of alignment to the current IHPA model design, structure and principles. Estimated level of change is classified as either:

- Step - an incremental change or refinement to current processes and techniques, retaining the current model design and structure; or
- Fundamental - changes which require significant alterations to the model principle, design or structure, and are expected to require a higher effort for implementation

Table 1 Number of short-listed alternative techniques by methodology area, identified through the Literature Review

Methodology area[1]	Component	Short-listed alternative techniques by estimated level of change to current process	
		Step	Fundamental
Data preparation	Commonwealth Pharmaceutical Programs data linking and removal of costs from linked episodes	0	2
	Hospital Casemix Protocol (HCP) matching methodology and inflation of costs to reflect private patient costs that are missing from the NHCDC	1	2
	Identification and treatment of outliers for all models	2	3
	Methodology to account for episodes admitted or discharged outside of the financial year	1	3
	Sample-to-population weighting of cost data	1	3
	Use of previous years' financial data in the ABF cost models	0	0
	Data cleansing	0	2
Base price weight calculation	Use of same day, short stay outlier, inlier, and long stay outlier methodology in subacute and acute cost models	2	1
	Use of L3H3 methodology and L1.5H1.5 methodology in subacute and acute cost models	2	1
	Care type per diems in the subacute cost model	1	0
	Use of multiple years and different sources of data, in the non-admitted model and block funded cost model	0	1
	Concurrent calculation of price weights for different classifications applicable to the emergency cost model	1	1
Adjustments	Adjustments for legitimate and unavoidable variation in costs, including hospital eligibility criteria, as specified in the 2018-19 NEP Determination	2	2
	Private Patient adjustments	1	0
Stabilisation	Evaluation of DRG and SNAP class comparability across classification versions for the purposes of stabilisation of acute and subacute price weights	1	1
	Purpose and application of price and adjustment stabilisation policy for all cost models	0	2
Transformation to pricing models	Calculation of the reference cost	1	1
	Calculation of the indexation rate	2	4
Back-casting	Review the methodology for back-casting the NEP	1	0
Total		19	29

[1] Appendix C outlines the current approach used by IHPA in each methodology area for determination of the NEP

Further discussion of the identified alternative techniques is included within Methodology Review Areas 1 to 6 and in the appendices to this report. For each methodology area this includes an outline of the purpose of processes and statistical techniques, challenges in the current approach and a summary of our short-listed alternative techniques, including the potential benefits of these modifications to the NEP determination.

1.4 Next steps

The literature review comprises the first phase on the fundamental review of the NEP. During this phase we consider possible alternatives to IHPA's existing process for the development of an efficient and transparent price for public hospital services.

As part of the second phase we will be prioritising a selection of these alternatives for further testing to qualitatively and quantitatively assess the extent that they may represent better practice and offer additional benefits in determination of the NEP.

The key next steps to progress the review are:

1. Prioritisation of findings for Phase 2 testing; alternative techniques within each methodology stage will be prioritised in conjunction with IHPA by considering potential cost versus benefit of implementation.
2. Quantitative assessment of prioritised ideas; quantitative analysis will be performed on select ideas against metrics and principles and also against an overall metric in test cases as we move towards a final list of alternatives to the current process.

A summary of the prioritised techniques as well as the results of the quantitative assessment will be provided in our subsequent sprint reports.

2. Summary of alternative techniques

Table 2 outlines a summary of the 48 short-listed alternative techniques identified through our Literature Review, expected impacts with respect to the agreed Assessment Criteria, and the estimated level of change to current process (i.e. step or fundamental). Green (or red) highlighting is used in relation to the Assessment Criteria to denote an expected positive (or negative) impact.

To short-list alternative techniques for further testing in Phase 2, a set of agreed Assessment Criteria have been defined that incorporate the Pricing Guidelines outlined in the Pricing Framework for Australian Public Hospital Services. Appendix B details the short-listing process of alternative techniques based on the Assessment Criteria, as well as a reconciliation of the Assessment Criteria against the Pricing Guidelines. Appendix D provides additional detail for alternative techniques and citations for sources that reference the technique.

Table 2 Summary of short-listed alternative techniques and expected impacts by the agreed Assessment Criteria

ID	Alternative technique	Assessment Criteria incorporating Pricing Guidelines (refer Appendix B)							Estimated level of change to current process
		Ease of Implementation	Ease of Understanding	Efficiency	Equity and Access	Stability	Minimising undesirable and inadvertent consequences	Consistency	
Data preparation									
Commonwealth Pharmaceutical Programs data linking and removal of costs from linked episodes									
1.1.1	Deterministic matching to enhance targeted linking of PBS claims								Fundamental
1.1.4	Imputation using K-nearest neighbour (KNN) techniques								Fundamental
Hospital Casemix Protocol (HCP) matching methodology and inflation of costs to reflect private patient costs that are missing from the NHCDC									
1.2.1	Imputation of medical and ancillary benefits based on facilities with complete reporting only								Step
1.2.2	Stratification for imputing private patient costs								Fundamental
1.2.3	Scaling of matched data using logistic regression for ancillary costs								Fundamental
Identification and treatment of outliers for all models									
1.3.1	Removal of outliers based on studentised residuals								Step
1.3.2	Removal of outliers based on an alternative distance-based approach								Step
1.3.5	Retention of outliers using studentised residuals and reduced weights								Fundamental

ID	Alternative technique	Assessment Criteria incorporating Pricing Guidelines (refer Appendix B)							Estimated level of change to current process
		Ease of Implementation	Ease of Understanding	Efficiency	Equity and Access	Stability	Minimising undesirable and inadvertent consequences	Consistency	
1.3.6	Use of multiple years data, combined with a credibility theory approach								Fundamental
1.3.10	Retention of outliers, with adjustments to be made in the calculation of the base price weight through bootstrapping								Fundamental
Methodology to account for episodes admitted or discharged outside of the financial year									
1.4.1	Weights based on Length of Stay								Step
1.4.2	Credibility theory for cost imputation, leveraging available WIP cost data								Fundamental
1.4.3	Scaling WIP data using logistic regression								Fundamental
1.4.4	Use of all WIP cost data in modelling								Fundamental
Sample-to-population weighting of cost data									
1.5.1	Weighting using matching, raking and propensity weighting techniques								Step
1.5.2	Weighting using stratification based on the PCA method								Fundamental
1.5.3	Imputation using Support Vector Machine (SVM)								Fundamental
1.5.4	Imputation using a bootstrapping method								Fundamental
Data cleansing									
1.7.1	Employment of a clear framework for undertaking data cleansing								Fundamental
1.7.2	Employment of Statistical Process Control tools to identify anomaly events in the data over the years								Fundamental
Base price weight calculation									
Use of same day, short stay outlier, inlier, and long stay outlier methodology in subacute and acute cost models									
2.1.1	Long Stay Outlier per diems as a proportion of the average inlier cost								Step
2.1.3	Use of median cost for the inlier price weight instead of the mean cost								Step

ID	Alternative technique	Assessment Criteria incorporating Pricing Guidelines (refer Appendix B)							Estimated level of change to current process
		Ease of Implementation	Ease of Understanding	Efficiency	Equity and Access	Stability	Minimising undesirable and inadvertent consequences	Consistency	
2.1.5	Stochastic Frontier Analysis to define the efficient price								Fundamental
Use of L3H3 methodology and L1.5H1.5 methodology in subacute and acute cost models									
2.2.3	Calculation of bounds using linear spline fit to LOS								Fundamental
2.2.6	Calculation of bounds using 10th and 95th percentiles								Step
2.2.7	Calculation of bounds using adjusted LOS interquartile range								Step
Care type per diems in the subacute cost model									
2.3.2	To price Paediatric Palliative care, use a fixed base plus per diem price								Step
Use of multiple years and different sources of data, in the non-admitted model and block funded cost model									
2.4.1	Credibility theory								Fundamental
Concurrent calculation of price weights for different classifications applicable to the emergency cost model									
2.5.1	Set UDG price weight to a percentile of the URG price weights								Fundamental
2.5.2	Stratify data by remoteness grouping prior to calibrating the URG average cost against UDG average cost								Step
Adjustments									
Adjustments for legitimate and unavoidable variation in costs, including hospital eligibility criteria, as specified in the 2018-19 NEP Determination									
3.1.1	GLM of cost against adjustment factors, with interaction factors (current adjustments only)								Step
3.1.2	GLM of cost against adjustment factors, with interaction factors (additional adjustments)								Fundamental
3.1.3	Fixed 'incremental' dollar amounts for select adjustments instead of percentages								Step
3.1.4	K-means clustering to identify groups of variation in the data								Fundamental
Private patient adjustments									
3.2.1	Bottom up review of private patient funding								Step

ID	Alternative technique	Assessment Criteria incorporating Pricing Guidelines (refer Appendix B)							Estimated level of change to current process
		Ease of Implementation	Ease of Understanding	Efficiency	Equity and Access	Stability	Minimising undesirable and inadvertent consequences	Consistency	
Stabilisation									
Evaluation of DRG and SNAP class comparability across classification versions for the purposes of stabilisation of acute and subacute price weights									
4.1.1	Stabilisation against weighted average price weight, where no one-to-one mapping is available								Step
4.1.2	Credibility theory against an expected block funded amount								Fundamental
Purpose and application of price and adjustment stabilisation policy for all cost models									
4.2.1	Credibility theory								Fundamental
4.2.2	Stabilisation against non-stabilised cost weight								Fundamental
Transformation to pricing models									
Calculation of the reference cost									
5.1.1	Use the mean cost of the acute model								Step
5.1.2	Application of current approach at a service category level								Fundamental
Calculation of the indexation rate									
5.2.1	Regression of growth against drivers of indexation								Fundamental
5.2.3	Exponential smoothing of growth								Step
5.2.4	ARIMA (time series) modelling of growth								Fundamental
5.2.5	Use of external indices								Fundamental
5.2.6	Microsimulation to model impacts of shifts in classifications and reporting								Fundamental
5.2.7	Analysis of historical deviation between actual and expected to adjust the indexation rate								Step
Back-casting									
Review the methodology for back-casting the NEP									
6.1.2	Smoothing of volume multipliers, using multiple base years for calculation								Step

3. Introduction

The National Health Reform Act 2011 (the Act) and National Health Reform Agreement (NHRA) specify the functions of the Independent Hospital Pricing Authority (IHPA). Clause B3 of the NHRA outlines one of the key functions of IHPA, Clause B3 reads:

> "Determining the national efficient price for services provided on an activity basis in public hospitals through empirical analysis of data on actual activity and costs in public hospitals, taking account of any time lag and the cost weights to be applied to specific types of services."

In performing its functions IHPA annually produces the NEP Determination which underpins Activity Based Funding for Australia's public hospitals. The purpose of the NEP Determination is to inform jurisdictions and key stakeholders of the Commonwealth funding for public hospital services, and to provide a price signal for the efficient cost of service delivery within public hospitals.

In developing the determination in accordance with the Act and NHRA, IHPA is obligated to consider the pricing guidelines which underpin the pricing of hospital services. These pricing guidelines comprise three subsections:

- Overarching guidelines to facilitate the provision of timely-quality care, efficiency, fairness and maintenance of agreed governmental roles
- Process guidelines to guide the modelling techniques, including transparency, administrative ease, stability and the use of evidence-based approaches
- System design guidelines to price in a way that fosters innovation, leads to price harmonisation, minimises undesirable and inadvertent consequences, utilises ABF where practicable, employs a single unit of price equivalence, bases pricing on patient characteristics and achieves public-private neutrality.

IHPA undertakes an annual external quality assurance and validation of the National Cost Models, to ensure adherence to the policy framework and the key pricing guidelines as outlined. The validation provides assurance that the cost models are accurate and fit for purpose,

As part of its key initiatives for 2018-19, IHPA has sought an additional external review of the techniques underlying the NEP determination. Ernst & Young was engaged to participate in this fundamental review in accordance with the official order dated 17 September 2018 under Deed of Standing Offer (Head Agreement for Services) 14/1213-37 between IHPA and EY dated 3 December 2017 and previously varied 27 May 2016. This fundamental review includes:

1. A literature review of modern data analysis and statistical modelling techniques applicable to activity based funding of hospital services. These are to be considered both in the context of health funding, as well as in broader literature.

2. Review of all current processes and statistical techniques used in the development of the National Efficient Price (NEP). However this exercise should not be interpreted as a validation process, with review of code and data out of scope for this review.

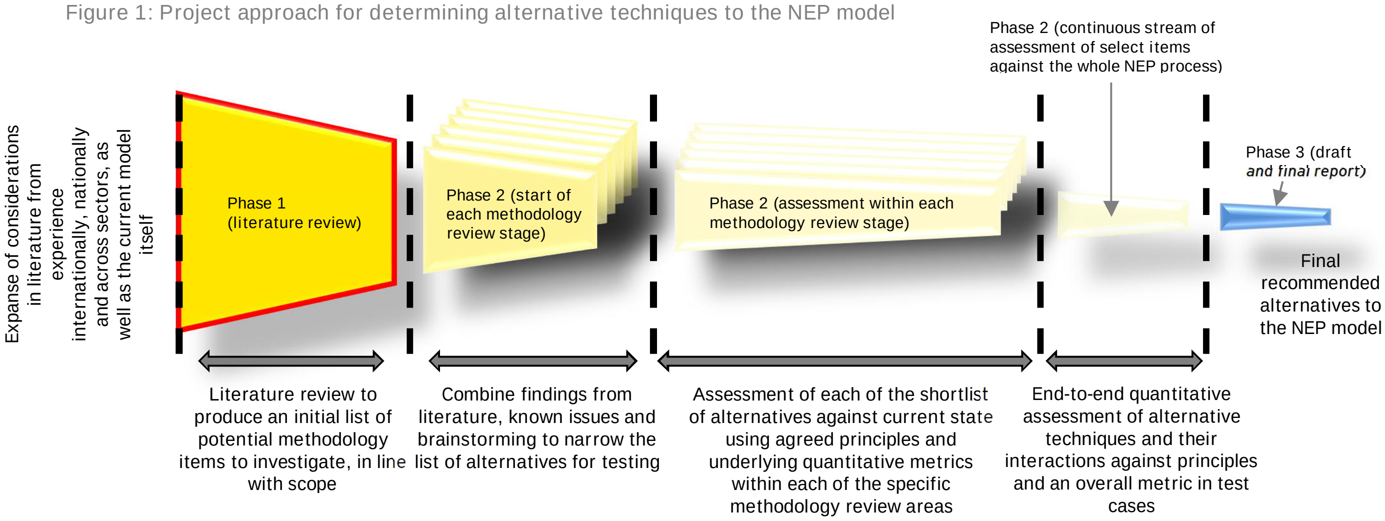
3. Development of a list of alternatives to the current process and statistical techniques used in the development of the NEP, quantified against an appropriate metric. These alternatives will build on the existing NEP framework, rather than proposing a completely new approach.

This literature review report addresses the first of these three aspects of the fundamental review and outlines our approach, key findings and alternative techniques identified from a review of publically available health journals, statistical journals and EY experience and recommendations outlined in EY's prior 2014-15 Activity Based Funding and Block Funding Cost Model Validation Report, dated 19 May 2017.

4. Approach to Literature Review

Figure 1 summarises the purpose of the literature review completed during the first phase of the fundamental review of the NEP.

Figure 1: Project approach for determining alternative techniques to the NEP model



The key steps undertaken during the Literature Review include:

1. Review of current methodology: desktop review of IHPA documentation provided to understand the purpose of current processes / techniques and identify any key challenges.
2. Develop research plan: a set of key research questions and search phrases were defined in the research plan to guide the literature review (refer to Appendix E).
3. Identification of a 'long list' of alternative techniques: a compilation of findings across the following three research streams to produce a 'long list' of alternative techniques:
   - Statistical-focused - alternative technical (statistical) techniques.
   - Sector-focused - other countries and sectors (i.e. Health and other sectors)
   - EY experience and prior review - understanding of the models, jurisdictional feedback and recommendations during EY's prior model validation review.
4. Assessment for Phase 1 short-list; the following criteria were applied to short-list alternative techniques for further consideration in Phase 2 of the review:
   - Ease of implementation – assess impacts of data availability, process modifications, model run time and on-going maintenance effort.
   - Ease of understanding – assess complexity of statistical techniques, challenges in interpretation of results and alignment to stakeholder objectives.
   - Expected impact – assess expected positive or negative impacts with respect to the agreed modelling principles (efficiency; equity and access; stability; minimising undesirable and inadvertent consequences; and consistency).
   - Alignment with purpose - assess alignment with policy objectives.
5. Identify metrics for quantitative testing; assess the feasibility and appropriateness of identified metrics relevant to each methodology stage.

The next steps post the Literature Review stage for Phase 2 are:

1. Prioritisation of findings for Phase 2 testing; In consultation with IHPA, alternatives identified in this report will be prioritised for further consideration during Phase 2.
2. Quantitative assessment of prioritised ideas; quantitative analysis against agreed metrics for prioritised alternatives to identify a final list of recommended techniques.

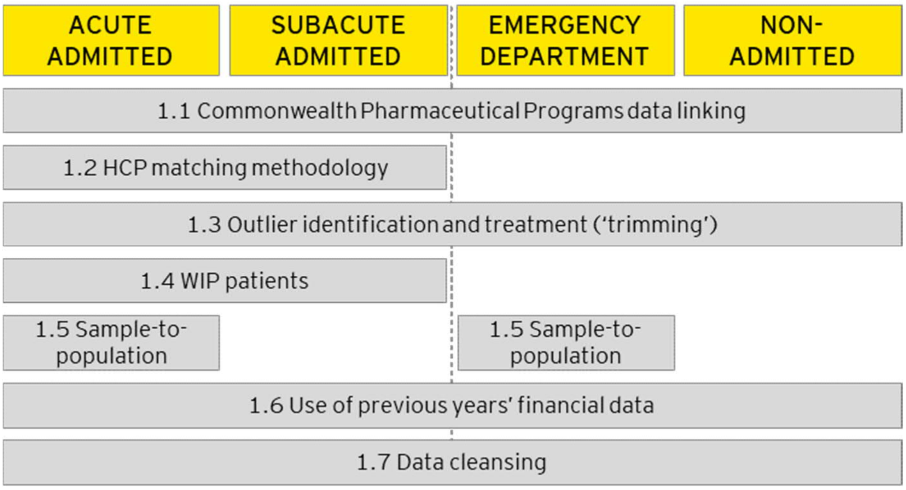
Methodology review area 1: Data preparation

The first stage of the NEP determination process involves the preparation of datasets before the creation of cost weights. This includes the linking, cleaning and weighting of appropriate datasets to enable allocation of costs. Figure 2 below provides an outline of the NEP determination stages.

Figure 2: Context of methodology step within NEP modelling process

Figure 3 summarise the seven key steps in the data preparation stage across the NEP models. Four of these steps are common across all models, however there are additional steps specific to certain service categories. This arises due to differences across service categories in the provision and volume of data, as well as in response to the specific characteristics of activity.

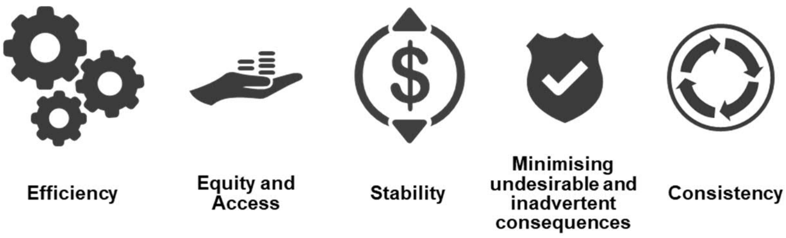
Figure 3: Summary of data preparation steps, by service category



This section summarises the purpose of each of these data preparation steps, current challenges in the approach and short listed alternatives for consideration in phase 2.

The expected impacts of the implementation of alternatives are summarised in the following sections, with respect to the 5 key criteria as defined in Appendix B. Definitions for each of the symbols utilised are provided in Figure 4, with further details on expected impacts with respect to each alternative contained in Appendix B. Where symbols are highlighted blue in the following sections, it is expected that alternatives will have an impact with respect to the relevant criteria.

Figure 4: Symbols for each of the five key criteria, used to summarise expected impacts of alternative techniques



Item 1.1 Commonwealth Pharmaceutical Programs - data linking

Purpose

Clauses A6 and A7 of the NHRA outline the circumstances where the Commonwealth will not fund patient services through the NHRA if the same service, or any part of the same service, is funded through any other Commonwealth program. In accordance with the NHRA, IHPA identifies and excludes costs that are out of scope for Commonwealth National Health Reform (NHR) funding in its determination of the NEP (clause B12). In the case of Commonwealth Pharmaceutical payments, IHPA undertakes data linking to identify and exclude costs reported in the National Hospital Cost Data Collection (NHCDC) for services that received benefits through Pharmaceutical programs.

Challenges

Jurisdictions are responsible for the data integrity within their systems and the provision of data to IHPA under the NHRA (clauses B93 and B95). IHPA links all Pharmaceutical claims to patient-level hospital activity data and calculates an adjustment factor to remove costs associated with Commonwealth Pharmaceutical Program funding. Benefits as a proportion of reported NHCDC cost are calculated for each classification code, and subsequently used to allocated unmatched benefits. This approach implicitly assumes behaviours are consistent across facilities and jurisdictions, and is not targeted. Matched costs at an aggregate classification level will be appropriate, however variation in the submission of pharmaceutical claims could result in an under or over estimation of the cost of service delivery at a facility or jurisdictional level.

A summary of IHPA's current approach to Pharmaceutical data linking is provided in Appendix C.

Findings

Aspects of the current methodology to retain:

- Apportion residual unmatched pharmaceutical benefits according to the distribution of costs associated with matched benefits to exclude all pharmaceutical costs for services in hospital.
- Offset NHCDC costs by the matched pharmaceutical benefits to exclude the proportion of reported costs that received funding through other Commonwealth programs.

Four total alternative ideas were identified for consideration from six sources. Two have been short-listed for consideration for Phase 2.

Fundamental changes to the Pharmaceutical data linking methodology to be tested:

- ID 1.1.1: Targeted deterministic matching of pharmaceutical claims, considering rulesets developed in NHFB's prior work on PBS and MBS data matching proof of concept. This will address variation in Commonwealth Pharmaceutical program benefit utilisation so that allocation of funding is fair and equitable.
- ID 1.1.4: Imputation using K-nearest neighbour (KNN) techniques. This provides an alternative statistical approach that relies on similar data points identified through a multidimensional comparison of attributes to impute missing values. This would assist to mitigate unintended impacts or consequences of underlying bias in the current approach.

Quantitative metrics to test potential impact

- Consistency in adjusted price across reform and non-reform states.
- Count of matches after applying basic filters (for example, restricting matching of non-HSD and non-EFC prescriptions to within a certain number of days of discharge).
- Sense check against the costs reported within the NHCDC in the Pharmacy Direct cost bucket.

Item 1.2 Hospital Casemix Protocol matching methodology

Purpose

The collection of private patient medical and ancillary expenses is problematic in the NHCDC. For example, some jurisdictions utilise Special Purpose Funds (SPF) to collect associated revenue and reimburse medical practitioners. These SPF do not always appear in hospital accounts used for costing in the NHCDC, leading to an underestimation of costs. While some facilities attribute these costs equally across public and private patients, others attribute across private patients only.

IHPA corrects this by inflating NHCDC costs (the 'private patient correction factor') to account for missing private patient costs using Hospital Casemix Protocol (HCP) data to identify full private charges and benefits. To inform the calculation of the private patient correction factor, IHPA seeks jurisdictional advice on private medical cost reporting status in the NHCDC (i.e. included vs. excluded) and allocation (i.e. private funding sources vs. all sources). Based on reporting status, IHPA applies an adjustment to all patients or private patients only. For excluded medical costs, IHPA assumes costs are missing in entirety. For private ancillary costs, IHPA seeks jurisdictional advice to classify facilities into three categories of hospital reporting (i.e. 0, 50 or 100 percent).

Challenges

Classification in the 50 percent group indicates private ancillary costs are partially reported in the NHCDC. Correspondingly, NHCDC costs are inflated by half the private ancillary benefits to correct for the assumed 50% level of reporting. In practice, the reporting of ancillary costs could range from 0.1% to 99.9%. Therefore this approach is likely to over or understate costs, equal to the difference between 50% and the actual reporting. Further, imputation of private ancillary benefits is based on the value of costs reported in the NHCDC. This does not account for facilities' differing levels of reporting of ancillary benefits, or impacts of differences in Private Health Insurance (PHI) coverage, for example by Australian Statistical Geography Standard (ASGS) remoteness area.

A summary of IHPA's current approach to HCP matching and inflation is provided in Appendix C.

<u>Findings</u>

Aspects of the current methodology to retain:

- Current approach to inflate NHCDC costs for underreported private medical benefits.
- Match HCP data to patient-level activity and apply weights to adjust for unmatched data.

Three total alternatives were identified for consideration from three sources. All three have been short-listed for consideration for Phase 2.

Step-changes to the HCP matching methodology to be tested:

- ID 1.2.1 Imputation of medical and ancillary benefits based on facilities with complete reporting only. This accounts for underreporting in the NHCDC in the allocation of private costs to unmatched data to enhance the estimation of total private costs for services.

Fundamental changes to the HCP matching methodology to be tested:

- ID 1.2.2: Stratification for imputing private patient costs. This accounts for differences between stratum (e.g. ASGC remoteness area to consider differences in PHI coverage).
- ID 1.2.3: Scaling of matched data using logistic regression for ancillary costs. This accounts for varying reporting levels to improve the equity of ancillary cost allocation.

Quantitative metrics to test potential impact

- Consistency in adjusted cost across private and public patients, for equivalent services.
- Consistency in adjusted cost for varying NHCDC private patient cost reporting by facility.

Item 1.3 Outlier identification and treatment (‘trimming’)

Purpose

In its development of the cost models and National Pricing Models that underpin the determination of the NEP, IHPA considers the activity-level cost data provided by jurisdictions and initially partitions this data into two groups. Activity-level cost data that is fit for use to develop DRG cost profiles and cost data that is not fit for this use, but is retained to calibrate overall cost. Additionally, IHPA trims and removes outliers prior to model development so that DRG cost profiles reflect the efficient cost of service delivery. These procedures adjust data so anomalies do not have undue influence on determination of the NEP, for example one-off trials of expensive equipment.

Challenges

The current outlier process includes reliance on specific thresholds, distance based methods and a single year of data. Thresholds have been constant since initial model development. For example, acute separations with costs less than $23 and emergency department presentations with costs less than $5 are trimmed. Due to increasing costs in health care and changes in the distribution of costs, these thresholds may require refinement to remain effective. Distance-based methods such as the log cost ratio and DFFITS to identify outliers does not give consideration to the sample size or expected error in the distribution of residuals respectively. Finally, there is likely volatility across funding years that is not considered in the current approach that utilises a single year of data.

A summary of IHPA’s current approach to treatment of outliers is provided in Appendix C.

<u>Findings</u>

Aspects of the current methodology to retain:

- An initial step at the start of outlier treatment for each service type that removes outliers based on jurisdictional advice as these are known anomalies.
- A subsequent step that removes hospital-DRG combinations with extreme high or low costs as these reflect anomalies in the ways facilities may be delivering care.

Ten total alternatives were identified for consideration from eight sources. Five have been short-listed for consideration for Phase 2.

Step-changes to the outlier treatment methodology to be tested:

- ID 1.3.1: Removal of outliers based on studentised residuals. This standardises for variation inherent in the residuals and supports consistency in outlier removal.
- ID 1.3.2: Removal of outliers based on an alternative distance-based approach. This will account for bias in the estimates and support consistency in outlier removal.

Fundamental changes to the outlier treatment methodology to be tested:

- ID 1.3.5: Retention of outliers using studentised residuals and reduced weights. This uses all available information, adjusted as necessary, and supports a consistent methodology.
- ID 1.3.6: Use of multiple years data, combined with a credibility theory approach. This accounts for volatility across the years and weights according to the reliability of data.
- ID 1.3.10: Retention of outliers, with adjustments to be made in the calculation of the base price weight through bootstrapping. This uses all available information, adjusted as necessary, and supports a consistent methodology.

Quantitative metrics to test potential impact

- Proportion of outliers detected / removed.
- Magnitude of outliers detected / removed.

Item 1.4 WIP patients

Purpose

Historically, jurisdictional NHCDC costing and coding has been inconsistent for separations where the admission date is prior to the start of the financial year and separation date during the financial year, known as work in progress (WIP) separations. NHCDC reporting has been consistent for other separations where the admission and separation date occur within the financial year (non-WIP). To account for inconsistent reporting of WIP separations, these costs are excluded from use and IHPA calculates WIP weights to scale up the consistent activity and cost data for non-WIP separations to incorporate an estimated cost profile for the WIP activity. This provides a more accurate overall cost profile based on the consistently reported non-WIP NHCDC data and allows IHPA to include all costs associated with the delivery of activity within the financial year (i.e. WIP and non-WIP).

Challenges

The current approach calculates WIP weights based on the ratio of counts of separations between the patient-level activity data and the NHCDC. The ratios are calculated in 'LOS groups' which are determined by taking length of stay percentiles within individual DRGs. This approach implicitly assumes that the profile of non-WIP separations is representative of WIP separations within these groups. However, by definition WIP separations are more likely to have a longer length of stay. Therefore, the current approach of calculating WIP weights may under-represent the costs of these services and is more likely to under-represent costs for WIP separations in higher LOS groups.

A summary of IHPA's current approach to WIP patients is provided in Appendix C.

Findings

Aspects of the current methodology to retain:

- Split data into two datasets, the first dataset contains WIP separations, while the second excludes WIP separations.
- Calculate LOS percentiles and cut points by DRG. These are subsequently used as the basis for the LOS groups.
- Classify all separations according to these LOS groups.

Four total alternatives were identified for consideration from four sources. All have been short-listed for consideration for Phase 2.

Step-changes to the WIP methodology to be tested:

- ID 1.4.1: Weights based on Length of Stay. This addresses the differing LOS profile of WIP and non-WIP activity to enhance equity of cost allocation.

Fundamental changes to the WIP methodology to be tested:

- ID 1.4.2: Credibility theory for cost imputation, leveraging available WIP cost data. This lessens reliance on the assumption that the non-WIP activity and costs reflect the WIP activity and costs.
- ID 1.4.3: Scaling WIP data using logistic regression. This addresses the differing profile of WIP and non-WIP activity, across various factors to enhance equity of cost allocation.
- ID 1.4.4: Including all WIP patients in the pricing model, in line with the approach used for non-WIP patients. This will reflect the true cost of WIP activity.

Quantitative metrics to test potential impact

- ALOS within LOS groups – to identify whether WIP and non-WIP activity is comparable.
- Proportion of WIP patients with reliable cost data for this year's portion of the stay.

Item 1.5 Sample-to-population weighting of cost data

Purpose

The NHCDC data is a sample of costed hospital activity that occurs during the financial year for all service types. To take account of the un-costed activity, the NHCDC data needs to be weighted up to the volume of activity in the activity datasets so that it represents the entire population. This is to ensure the cost data being used appropriately reflects all activity undertaken during the year.

Challenges

The current approach to apply weights to the NHCDC sample data to represent the population of all activity is inconsistent across service types. For example, weights are applied in the acute admitted and emergency department models however no sample-to-population weights are applied in the subacute model for this purpose. Sample-to-population weights are also not utilised in the Non-Admitted model, even in cases where the NHDCDC data is utilised as the basis for costing. Additionally, where weights are used, differences exist in the methodologies to define the target population. For example, the activity dataset represents the target population in the acute model. However, the emergency department model references the NHCDC as the target population in instances where more records are recorded in the NHCDC.

A summary of IHPA's current approach for weighting sample data to the population is provided in Appendix C.

Findings

Aspects of the current methodology to retain:

- Stratification of the sample data based on key variables.

Four total alternatives were identified for consideration from five sources. All four have been short-listed for consideration for Phase 2. It is intended that these weighting techniques be implemented consistently across all cost models.

Step-changes to the sample-to-population weighting methodology to be tested:

- ID 1.5.1: Weighting using matching, raking and propensity weighting techniques. This enables scaling of sample to the population based on select variables and determination of weights based on known population distributions or using statistical probabilities.

Fundamental changes to the sample-to-population weighting methodology to be tested:

- ID 1.5.2: Weighting using stratification based on the PCA method. This technique weights data based on a reduced set of statistically determined variables that represent the total information in the original dataset.
- ID 1.5.3: Imputation using Support Vector Machine (SVM). This removes the need to weight the data, instead imputing missing values based on known information.
- ID 1.5.4: Imputation using a bootstrapping method. This removes the need to weight the data, instead imputing missing values based on resampling from the existing sample.

Quantitative metrics to test potential impact

- Comparison of the distribution of services within the cost and activity datasets.

Item 1.6 Use of previous years' financial data

Purpose

Cost and activity data is required to determine the NEP. The earliest available data to support the determination of the NEP is from three years prior. This is used due to a number of factors including delays in data collection, and time required for quality assurance and validation. Earlier years' data is also necessary since the development of the pricing model happens in the financial year prior to which it applies (for example, work on the FY19/20 model is commenced in the first quarter of FY18/19, after the NHCDC Data Quality Statements have been received from all jurisdictions). The costs are indexed to the current year in order to be used as a basis for pricing.

In addition, prior years' activity and cost data is used to supplement the base year's data throughout the cost models. For example, past data is leveraged within the Acute model to address low volume DRGs; is combined with the base year's data in the Subacute model to increase the sample size; and is utilised in the Non-Admitted model to address inconsistencies in the base year's NHCDC data.

Challenges

The current approach of utilising previous years' financial data requires the application of an indexation procedure to appropriately determine price weights and an NEP for the current funding year. Additionally, this implicitly assumes that behaviours and patterns observed in cost and activity date from prior years have continued in more recent years. The indexation process is discussed in detail later within this report.

Findings

Aspects of the current methodology to retain:

The use of prior year data is deemed reasonable given the constraints of data collection and timelines for cost model development.

Item 1.7 Data cleansing

Purpose

Jurisdictions are responsible for the data integrity within their systems and the provision of data to IHPA under the NHRA (clauses B93 and B95). However, IHPA undertakes data cleansing at various stages of the NEP determination process for the purpose of segmenting data into data that is fit for development of DRG cost profiles. This includes the removal of irrelevant records and modification or transformation of variables. Data cleansing is undertaken to maximise the use of available data for the development of DRG cost profiles, cost models, pricing models and in support of the determination of the NEP. This activity is distinct to other data preparation activities including, but not limited to, renaming variables, merging datasets, filtering of data etc.

Challenges

A dedicated process for data preparation exists for each service category in the current NEP determination process. However, there are inconsistencies in the order in which data cleansing procedures are applied and no consistent framework between service categories that outlines the common procedures and purpose of these procedures. To mitigate the risk of human error, data cleansing steps could be streamlined and structured within a common documented framework to provide clarity on the rationale for procedures applied and any key assumptions.

A summary of IHPA's current approach for data cleansing is provided in Appendix C.

<u>Findings</u>

Aspects of the current methodology to retain:

- All data cleansing procedures for removing irrelevant records or making other relevant adjustments to the data.

Two alternatives were identified for consideration from two sources. Both have been short-listed for consideration for Phase 2.

Structural changes to the data cleansing methodology to be tested:

- ID 1.7.1: Employment of a clear framework for undertaking data cleansing. This will provide structure and clarity on the approach to data cleansing across the process.
- ID 1.7.2: Employment of Statistical Process Control tools to identify anomaly events in the data over the years. This graphically reflects historical trends, yielding clear and quick insights into the data that can be considered for investigation (e.g. outliers).

Quantitative metrics to test potential impact

- Number of gaps in the data cleansing process across service categories.

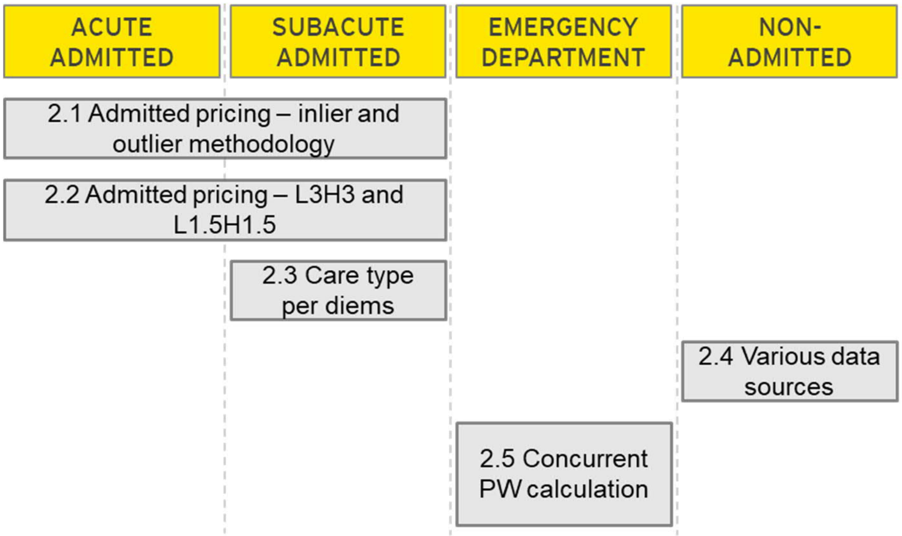
Methodology review area 2: Base price weight calculation

After the data has been prepared, cost models are developed for each of the service categories. Figure 5 outlines the first step in the development of the cost models, deriving base cost weights for the various classes within each service type.

Figure 5: Context of methodology step within NEP modelling process

Figure 6 below summarises the five key steps in the base price weight calculation process within the NEP models. Generally, the process varies by service category, however there is some overlap in process for acute and subacute models. IHPA uses the same process for admitted hospital services (i.e. acute and subacute). Other service categories include steps to address specific challenges in the volume of data and differences in reporting of data by jurisdictions within the service category.

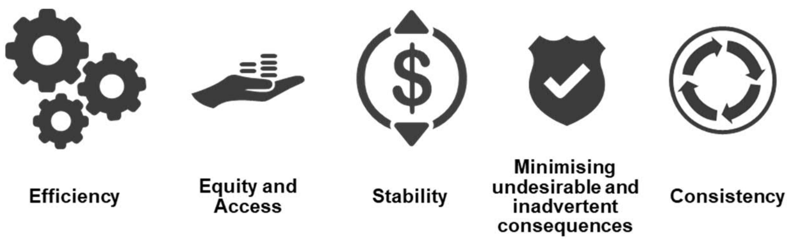
Figure 6: Summary of data preparation steps, by service category



The following sections summarise the purpose of each of these base price weight calculation steps, any known challenges with the current approach and the short listed alternatives for further consideration in phase 2.

The expected impacts of the implementation of alternatives are summarised in the following sections, with respect to the 5 key criteria as defined in Appendix B. Definitions for each of the symbols utilised are provided in Figure 7, with further details on expected impacts with respect to each alternative contained in Appendix B. Where symbols are highlighted blue in the following sections, it is expected that alternatives will have an impact with respect to the relevant criteria.

Figure 7: Symbols for each of the five key criteria, used to summarise expected impacts of alternative techniques



Item 2.1 Admitted pricing - inlier and outlier methodology

Purpose

The pricing guidelines in the IHPA Pricing Framework for Australian Public Hospital Services can be used to evaluate whether IHPA undertakes its work in accordance with policy objectives. One of the overarching guidelines is efficiency. ABF should improve the value of the public investment in hospital care and ensure a sustainable and efficient network of public hospital services.

The cost of admitted hospital services increase in relation to the length of stay (LOS) of the separation. To promote efficiency, IHPA classifies and differentially prices admitted activity using four categories defined by LOS thresholds (i.e. same day, short stay outlier, inlier or long stay outlier). The intent is to provide additional funding for shorter LOS, and reduced funding for longer LOS separations to create an incentive for facilities to innovate and drive system efficiency.

Challenges

Prices for inlier activity are set based on the mean cost without consideration of the underlying distribution. The current approach trims extreme outliers, however remaining outliers in the dataset can influence the mean potentially overestimating the efficient price. As a result of the influence of these outliers on the mean, long stay activity may be overpriced in some circumstances counter to the desired impact and policy objective.

Additionally, jurisdictions have indicated this method may be unnecessarily complex for pricing subacute services[2]. A large proportion of subacute activity is classified as outlier due to the large degree of dispersion in LOS, in this case other categories are largely underutilised.

A summary of IHPA's current approach to the inlier and outlier model is provided in Appendix C.

<u>Findings</u>

Aspects of the current methodology to retain:

- Retain the use of inlier and outlier methodology within the Acute model only, including different pricing structures for each separation category.

Six total alternatives were identified for consideration from seven sources. Three have been short-listed for consideration for Phase 2.

Step-changes to the admitted pricing methodology to be tested:

- ID 2.1.1: Long Stay Outlier per diems as a proportion of the average inlier cost. This will enhance consistency in incentivisation across classification codes.
- ID 2.1.3: Use of median cost for the inlier price weight instead of the mean cost. Median cost accounts for skew in cost distribution to enhance equity of efficient cost calculation.

Fundamental changes to the admitted pricing methodology to be tested:

- ID 2.1.5: Stochastic Frontier Analysis to define efficient price. This provides a statistical estimate efficiency in service delivery, controlling for external effects to enhance equity.

Quantitative metrics to test potential impact

- Change in cost ratios by separation category.
- Distribution of costs (i.e. comparison of mean and median).
- Volume of activity by SNAP class and care type, to assess sufficiency.

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[2] Queensland Health (2017); Consultation Paper on the Pricing Framework for Australian Public Hospital Services 2018-19 - Queensland submission to the Independent Hospital Pricing Authority.

Item 2.2 Admitted pricing – L3H3 and L1.5H1.5

Purpose

IHPA determines length of stay (LOS) thresholds or 'bounds' for each classification code to classify admitted activity as short stay outlier, inlier or long stay outlier (refer to section Item 2.1). The L3H3 method sets the lower boundary for inlier activity as one third of the average length of stay (ALOS) and sets the upper boundary as three times the ALOS. This provides a sufficient spread in the inlier bounds, activity with a LOS less than the lower boundary is a short stay outlier and activity with LOS higher than the upper boundary is a long stay outlier. For classifications with longer ALOS, the L1.5H1.5 method is used so spreads are not unreasonably large.

Challenges

The current approach to calculating bounds is largely independent of the distribution of the underlying cost data, with reference to ALOS only. This results in a varying proportion of outliers by classification code and between funding years for similar classification codes in service categories.

A summary of IHPA's current approach to defining the inlier bounds is provided in Appendix C

Findings

Aspects of the current methodology to retain:

- Calculation of the inlier bounds based on the length of stay.

Eight total alternatives were identified for consideration from eight sources. Three have been short-listed for consideration for Phase 2.

Step-changes to the inlier bound methodology to be tested:

- ID 2.2.6: Calculation of bounds using 10th and 95th percentiles. This approach considers the distribution of activity by LOS, to classify equal proportions of activity as outliers for each classification code to enhance consistency between funding years and codes.
- ID 2.2.7: Calculation of bounds using adjusted LOS interquartile range. This approach considers the distribution of activity by LOS to enhance consistency. It may be less sensitive to volatility than the previous recommendation (ID 2.2.6) as quartiles are likely to be more stable than the tail of the distribution.

Fundamental changes to the inlier bound methodology to be tested:

- ID 2.2.3: Calculation of bounds using linear spline fit to LOS and cost. This considers the underlying dynamic between cost and LOS to fit a closer representation of the relationship. Per diems can then be applied beyond the threshold where cost and LOS has a marked change.

Quantitative metrics to test potential impact

- Change in cost ratios by separation category.
- Proportion of outliers.
- Proportion of activity within each separation category.
- Inconsistencies in hierarchical ordering of DRGs.

Item 2.3 Subacute pricing – care type per diems

Purpose

Due to insufficient cost and activity data for paediatric palliative care the Australian National Subacute and Non-Acute Patient (AN-SNAP) classification cannot be used to determine the efficient price of paediatric subacute care. IHPA utilises a per diem approach to pricing paediatric palliative care. A consistent per diem is implemented for same-day and overnight activity calculated as the average cost per day.

Challenges

Use of a per diem approach does not consider fixed costs underlying the provision of care. This could result in underfunding of shorter stay activity, for which fixed costs may not be appropriately reimbursed. Additionally, the use of a per diem approach to pricing removes incentives for efficient practice with regards to minimising length of stay. These challenges are expected to be addressed as additional AN-SNAP data is provided by jurisdictions.

A summary of IHPA's current use of care type per diems is provided in Appendix C.

<u>Findings</u>

Aspects of the current methodology to retain:

- Use of an alternative approach to pricing paediatric palliative care, which does not utilise the inlier and outlier methodology.

Three total alternatives were identified for consideration from three sources. One has been short-listed for consideration for Phase 2.

Step-changes to the care type per diem methodology to be tested:

- ID 2.3.2: To price Paediatric Palliative care, use a fixed base plus per diem price. This gives consideration to fixed costs to enhance equity, which may be underestimated for short stays under the current per diem approach. In addition, this would result in a lower per diem price which reduces the incentive associated with longer stay activity to align with the overarching pricing principle of efficiency.

Quantitative metrics to test potential impact

- Significance of the intercept when fitting a regression to model the fixed and variable costs.
- Volume of short stay activity (e.g. less than ~5 days).
- Variation in average cost per day, by length of stay.

Item 2.4 Non-Admitted pricing – use of multiple data sources

Purpose

Non-admitted activity and cost data has historically been observed to have a high level of variability and low volumes of reporting. In response to this constraint, to enable stability in the non-admitted price weights and to better reflect the true cost of service delivery, IHPA leverages alternative data sources in pricing non-admitted activity. These approaches include the hierarchical use of logical links to comparable same day services in other service categories, followed by the non-admitted NHCDC data if stable, and the use of external costing studies (EY Costing Study, 2014 Costing Study and Victorian radiotherapy costs) for remaining gaps.

Challenges

For clinics without comparable same day care in other service categories, as non-admitted NHCDC data increases in volume and stability (assessed over a period of three years) the individual clinics will switch to NHCDC based pricing. Until this point, full reliance is placed on external data sources, with no consideration of NHCDC reported costs. This increases the risk of instability in price weights at the point at which the source dataset switches. The approach also makes the assumption that the indexed external costing studies are accurate and appropriate to the context.

A summary of IHPA's current use of multiple years and different sources of data in the non-admitted pricing model is provided in Appendix C.

<u>Findings</u>

Aspects of the current methodology to retain:

- Use of multiple data sources to price non-admitted activity.

One alternatives was identified for consideration from two sources. This idea has been short-listed for consideration for Phase 2.

Fundamental changes to the use of multiple data sources to be tested:

- ID 2.4.1: Credibility theory. This will enable a blended use of data sources, with a gradual movement towards NHCDC as stability and volume of the dataset increases, this will improve consistency across years and stability in price weights.

Quantitative metrics to test potential impact

- Comparison of average cost under each of the data sources.
- Variation between and within years for low volume clinics.
- Calculation of weights for use in credibility theory approach. Are these weights materially different from the current approach (i.e. materially different from 0 weighting for NHCDC where external costing studies are used currently).

Item 2.5 Emergency Department pricing – concurrent calculation

Purpose

Hospitals report Emergency Department (ED) activity to IHPA based on either the Urgency Related Group (URG) or Urgency Disposition Group (UDG) classification. One of the IHPA overarching pricing guideline is fairness, ABF payments should be fair and equitable, including being based on the same price for the same service across public, private or not-for –profit providers of public hospital services. The URG reported activity provides further detail on patient principal diagnosis, which as a measure of complexity can drive difference in cost. Recognising this difference in patient complexity due to diagnosis is not possible using the aggregated UDG classification.

To minimise undesirable and inadvertent consequences due to differing UDG/URG classification use and to promote fairness, IHPA calibrates concurrently derived price weights across both classifications. This process results in price weights by UDG code where the national weighted average price weight for activity reported at a URG level is equivalent to the UDG price weight.

Challenges

The current approach to calibration implicitly assumes complexity of patients presenting to ED at facilities reporting at a URG level is similar to patients presenting to ED at facilities reporting at a UDG level. This assumption may not be appropriate given that facilities of certain sizes or remoteness status may be more or less likely to report at a given level, leading to differences in underlying case mix of ED activity and instances of over or under estimation of the true nationally representative price weights. The current approach may also inadvertently encourage hospitals to report at a UDG level if more detailed URG reporting results in a reduction in NWAU.

A new classification for ED activity is under development, the Australian Emergency Care Classification (AECC) Version 1 that is expected to address these challenges on implementation.

A summary of IHPA's current approach to concurrent pricing within the ED pricing model is provided in Appendix C.

<u>Findings</u>

Aspects of the current methodology to retain:

- Provide prices against both URG and UDG classifications.

Two total alternatives were identified for consideration from one source. Both have been short-listed for consideration for Phase 2.

Step-changes to the Emergency Department pricing methodology to be tested:

- ID 2.5.2: Stratify data by remoteness grouping prior to calibrating the URG average cost against UDG average cost. This accounts for differences in the complexity of patients presenting, by remoteness group.

Fundamental changes to the Emergency Department pricing methodology to be tested:

- ID 2.5.1: Set UDG price weight to a percentile of the URG price weights (e.g. minimum, 25th percentile). This mitigates unintended or inadvertent consequences of facilities reporting at an aggregated UDG level by providing a financial incentive to provide more detailed URG data.

Quantitative metrics to test potential impact

- Comparison of calibration factors by remoteness group.
- Number of presentations benefiting from pricing at a UDG level.
- Differentials between URG and UDG price weights at a presentation level.

Methodology review area 3: Adjustments

Adjustments are made to the base price weights developed in each service stream where variation in costs are identified due to factors that are not in the control of the provider. This includes patient-related factors, locational factors, and quality-related aspects of care.

Figure 8: Context of methodology step within NEP modelling process

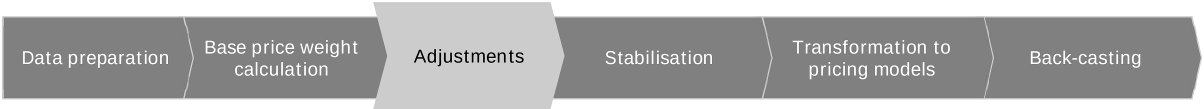
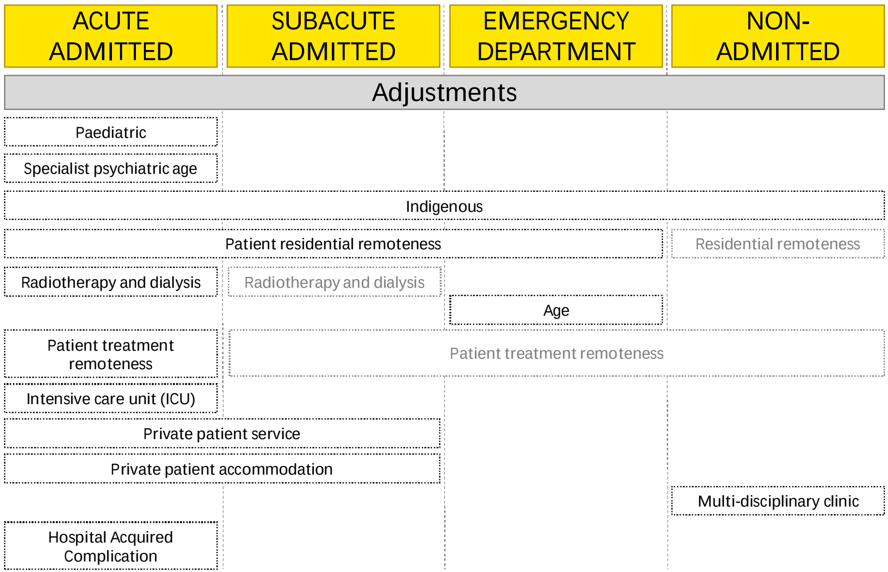


Figure 9 summarises adjustments made by IHPA in the NEP process within each of the service category models. Adjustments are generally specific to a service category, however some specific adjustments (e.g. the Indigenous adjustment) span more than one service category. IHPA in the draft 2018-19 NEP determination includes application of relevant acute adjustments across other streams where applicable (indicated in light grey below).

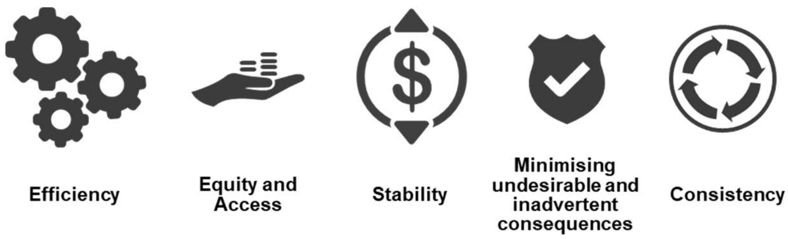
Figure 9: Summary of adjustments, by service category



The following section summarises the purpose of applying these adjustments, current challenges observed and the short listed alternatives to adjustments for further consideration in phase 2.

The expected impacts of the implementation of alternatives are summarised in the following sections, with respect to the 5 key criteria as defined in Appendix B. Definitions for each of the symbols utilised are provided in Figure 10, with further details on expected impacts with respect to each alternative contained in Appendix B. Where symbols are highlighted blue in the following sections, it is expected that alternatives will have an impact with respect to the relevant criteria.

Figure 10: Symbols for each of the five key criteria, used to summarise expected impacts of alternative techniques



Item 3.1 Adjustments for legitimate and unavoidable variation in costs

Purpose

IHPA is obligated under the National Health Reform Act 2011 to determine adjustments to the NEP to reflect legitimate and unavoidable variations in the cost of delivering health care services (Section 131(1)(d)). The NHRA specifies that IHPA must consider variations in cost due to factors such as hospital type and size; hospital location; and patient complexity (Clause B13). The purpose of these adjustments to the NEP is to provide a relevant price signal to States and Local Hospital Networks, but not duplicate existing work or grants issued by the Commonwealth Grants Commission (CGC) (NHRA Clause B14). As a result, IHPA annually reviews existing and potential price adjustments, taking jurisdictional feedback into consideration and consulting with the CGC.

Challenges

Significant feedback is provided by jurisdictions on adjustments to the NEP, including the requirement for more clarity on the impact of current adjustments and requests to consider new adjustments. IHPA as part of its ongoing program of work reviews adjustments to the NEP, however there is opportunity for the process to be automated and streamlined to promote clarity and consistency of approach. In particular, the current adjustments contain some elements which are additive, and others which are multiplicative. The current approach considers interactions between the indigenous and remoteness adjustments, however this could be extended to consider interactions between all potential sources of variation.

A summary of IHPA's current use of adjustments is provided in Appendix C.

<u>Findings</u>

Aspects of the current methodology to retain:

- GLMs on the cost ratio to estimate adjustment factors, where currently used.

Four total alternatives were identified for consideration from seven sources. Four have been short-listed for consideration for Phase 2.

Step-changes to the adjustments methodology to be tested:

- ID 3.1.1: GLM of cost against adjustment factors, with interaction factors (current adjustments only). This enables a more equitable allocation of costs and also consistency of approach, improving interpretability of the adjustment formula.
- ID 3.1.3: Fixed 'incremental' dollar amounts for select adjustments instead of percentages. This improves interpretability and clarity of the impacts of the adjustments.

Fundamental changes to the adjustments methodology to be tested:

- ID 3.1.2: GLM of cost against adjustment factors, with interaction factors (additional adjustments considered). This enables a more equitable allocation of costs, improved access, and consistency of approach, improving interpretability of the formula.
- ID 3.1.4: K-means clustering to identify groups of variation in the data. This enables a more equitable cost allocation by identifying groups with significant variation in costs.

Quantitative metrics to test potential impact

- Mean squared prediction error.
- Significance tests.
- Stability of adjustments over the years.
- Difference in pre- and post-adjustment price compared to the adjustment factor.

Item 3.2 Private patient adjustments

Purpose

In accordance with Clause A41 of the NHRA, Commonwealth ABF contributions for eligible private patients are calculated to exclude or reduce (as appropriate) the components of the service for that patient which are covered by other Commonwealth funding sources and patient charges. In pricing eligible private patient services, IHPA determines two specific adjustment factors to deduct payments made by private health insurers (i.e. accommodation, prosthetics and medical fees) and the Commonwealth through the MBS: the Private Patient Service Adjustment (PPSA) and Private Patient Accommodation Adjustment (PPAA). These adjustments are designed to prevent double payments for the same activity (i.e. through the revenue source and also the NHRA).

The PPSA is calculated from benefits reported in the HCP data, matched HCP benefits are used to develop a factor by DRG to reduce the price for private patients. However, this does not consider application of other adjustments or any potential bias in the reported vs. non-reported HCP data that may impact the estimation of the PPSA. The PPAA is calculated as a per diem rate using the prior year's average PHI default accommodation benefits by jurisdiction indexed by CPI.

Challenges

Over the period of 2008-09 to 2014-15 there was an average increase in hospital separations funded by private health insurance of 10.3% per annum[3]. This corresponds to an average increase in the proportion of public hospital separations funded by private health of 4.4% per annum. There is evidence that this high growth is driven in part by a number of the jurisdictions' funding models.

The Commonwealth indirectly contributes to eligible private patients in public hospital through the PHI premium rebate which is not currently considered in calculating the PPSA or PPAA. For calculation of the PPSA, HCP data is used to estimate benefits for private patients paid by PHI and the MBS. Variation may exist in HCP reporting and benefits paid may vary by insurer / policy. The implicit assumption that the profile of MBS and insurer payments for matched HCP data is representative of other unmatched private patient activity may not be reasonable in all circumstances and the MBS fee may be a useful reference in estimating private medical costs.

A summary of IHPA's current use of private patient adjustments is provided in Appendix C.

<u>Findings</u>

Aspects of the current methodology to retain:

- Separate application of PPAA and PPSA.
- Calculation of PPAA as average default accommodation benefit.

One alternative was identified for consideration from one source. This has been short-listed for consideration for Phase 2.

Step changes to the private patient adjustments methodology to be tested:

- ID 3.2.1 Bottom up review of private patient funding. This will provide insight into the adequacy of the current private patient adjustments to reflect the benefits provided through alternative sources.

Quantitative metrics to test potential impact

- Comparison of calculated funding under the pricing model and bottom up approach, including: by jurisdiction, by select services, by cost group (ancillary, medical, accommodation).

[3] IHPA, EY (2017); Private Patient Public Hospital Service Utilisation.

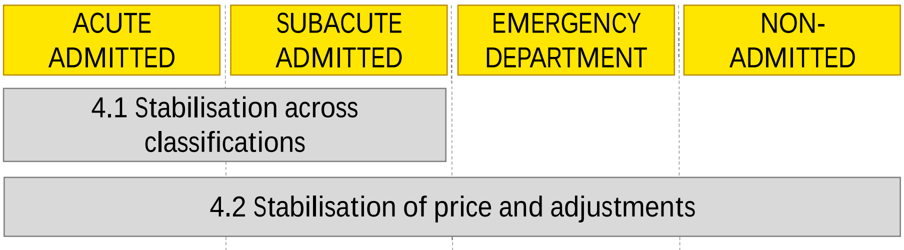
Methodology review area 4: Stabilisation

The cost weights and adjustments are subsequently stabilised to reduce the volatility in costs from the prior year that may be due changes in costs and/or activity, coding behaviours, technology changes etc. The stabilisation applied is in line with the National Pricing Model Stability Policy.

Figure 11: Context of methodology step within NEP modelling process

Stabilisation of price and adjustments occurs for all of the cost models as Figure 12 illustrates. An additional set of steps is required prior to stabilising for acute and subacute activity when classification versions change. This is to ensure comparability of classes between the years.

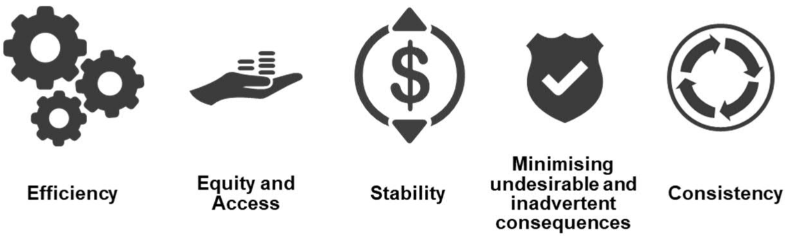
Figure 12: Summary of stabilisation steps, by service category



The following sections summarise the purpose of each of the stabilisation steps, current challenges in the approach and a short list of alternatives for further consideration in phase 2.

The expected impacts of the implementation of alternatives are summarised in the following sections, with respect to the 5 key criteria as defined in Appendix B. Definitions for each of the symbols utilised are provided in Figure 13, with further details on expected impacts with respect to each alternative contained in Appendix B. Where symbols are highlighted blue in the following sections, it is expected that alternatives will have an impact with respect to the relevant criteria.

Figure 13: Symbols for each of the five key criteria, used to summarise expected impacts of alternative techniques



Item 4.1 Stabilisation across classification versions

Purpose

Classification systems underlying the service categories provide a nationally consistent and statistically robust method for grouping activity. These classifications are periodically updated, with transformative changes which can make it difficult to compare individual classification codes across years. The stabilisation process is designed to provide jurisdictions with funding stability and predictability, by minimising the impact of statistical noise. IHPA currently stabilises the price weights for classification codes where there is a directly comparable classification code in the prior year.

Challenges

The way in which cost data and activity data is reported against classifications can change over time, most notably following introduction of revised classifications or new classifications as facilities become more familiar with the coding guidelines for new classifications. In these circumstances, activity or cost data reported in the year immediately following introduction of the revised or new classification may not be sufficiently stable or fit for purpose to form the basis of the NEP pricing models.

The current approach to stabilisation requires a directly comparable classification code to exist in the prior classification version. In this circumstance, during implementation of the revised AR-DRG v9.0 from AR-DRG v8.0 stabilisation was not applied to the majority of classification codes as no direct comparable classification code existed in AR-DRG v8.0. This can contribute to volatility in the price weights that additionally can be compounded by changed complexity in reported data that may reflect underlying changes in clinical coding practice.

A summary of IHPA's current approach to stabilising price weights across classification versions is provided in Appendix C.

Findings

Aspects of the current methodology to retain:

- Use of prior year's model output to stabilise this year's calculated values.

Two alternatives were identified for consideration from three sources. Two ideas have been short-listed for consideration for Phase 2.

Step changes to stabilisation across classification versions to be tested:

- ID 4.1.1 Stabilisation against weighted average price weight, where no one-to-one mapping is available. This approach will ensure most classification codes are stabilised when there is a change in versions, this will enhance stability in price weights during implementation of a revised or new classification.

Fundamental changes to stabilisation across classification versions to be tested:

- ID 4.1.2 Credibility theory against an expected price. This approach will ensure most classification codes are stabilised when there is a change in versions, and will reduce volatility in funding which could result if there is unexpected development in the reporting of activity. This will enhance consistency and stability across funding years and classification versions.

Quantitative metrics to test potential impact

- Number of stabilised DRGs.
- Average price based on base activity data, under each of the approaches.
- Average price based on 2018-19 activity to date, under each of the approaches.

Item 4.2 Stabilisation of prices and adjustments

Purpose

The stabilisation process is designed to provide jurisdictions with funding stability and predictability, by minimising the impact of statistical noise in the pricing model. As part of this process, IHPA imposes restrictions on the year-on-year shift in the price weights, inlier bounds and adjustment values. These restrictions are designed to ensure that the pricing model reflects changes arising from shifts in activity and cost, while limiting the variation that is observed due to the model's basis on empirical data.

Challenges

The current approach to stabilisation can result in delays in recognising a true shift in the cost of service provision. Any considerable changes in cost are currently phased in over multiple years, with effects compounded as values are stabilised against the prior year's stabilised values. For example, year-to-year movements in price weights are restricted to +/- 20% where there are less than 1,000 episodes, there are no changes to the inlier bounds, and no changes to status as per the same-day pricing and bundled ICU lists. Separate rules and eligibility criteria is applicable for stabilisation of movements in inlier bounds and adjustments, with more detail in Appendix C on this.

A summary of IHPA's current approach to stabilising prices and adjustments across all cost models is provided in Appendix C.

<u>Findings</u>

Aspects of the current methodology to retain:

- Use of prior year's model output to stabilise this year's calculated values.
- Cap on price weights changes to +/- 20% year-on-year, with minimum required volume of activity.
- Approach to stabilising bounds and adjustments.

Two alternatives were identified for consideration from two sources. Both ideas have been short-listed for consideration for Phase 2.

Fundamental changes to the stabilisation of prices and adjustments to be tested:

- ID 4.2.1: Credibility theory. This allows for true changes in price weights, adjustment and bounds to be recognised earlier, if there is sufficient volume of and low variation in the data. This will enhance consistency and stability of the NEP models.
- ID 4.2.2: Stabilisation against non-stabilised price weight. Use of the non-stabilised price weight will allow consistent trends in year-to-year prices to be recognised at a faster rate. This approach is currently under development by IHPA.

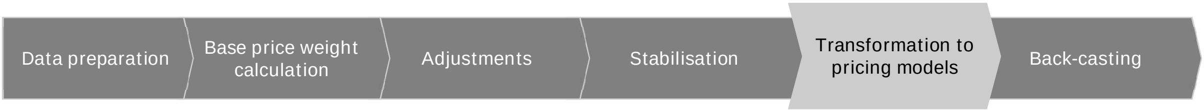
Quantitative metrics to test potential impact

- Number of stabilised variables, compared to current approach.
- Dollar impact of stabilisation, based on total allocated prices.
- Cost ratio.

Methodology review area 5: Transformation to pricing models

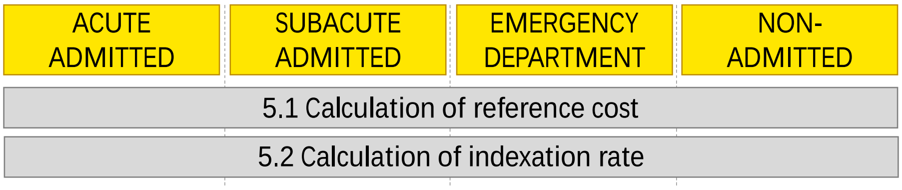
The cost model subsequently needs to be transformed to a pricing model for the purpose of calculating funding. This occurs through derivation of a reference cost (or standardised mean) to transform the costs to cost weights and an indexation rate to inflate the costs to the current year.

Figure 14: Context of methodology step within NEP modelling process



The calculation of a reference cost is based on historical admitted acute activity from three years ago and prior but used across all the service categories for the conversion of costs to cost weights. The reference cost is then indexed forward three years to be reflective of the estimated costs of delivering hospital services in the current year. The applicability of both steps to all service categories is reflected in Figure 15.

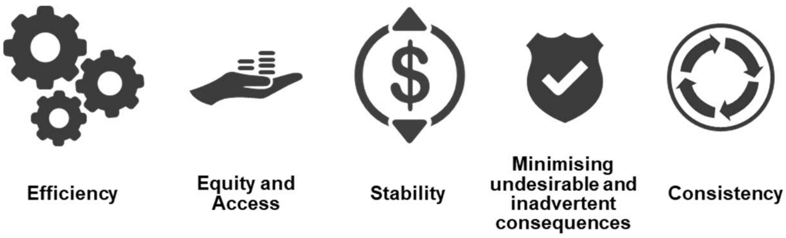
Figure 15: Summary of transformation steps, by service category



The following sections summarise the purpose of each of the steps for the transformation, current challenges and a short list of alternatives for further consideration in phase 2.

The expected impacts of the implementation of alternatives are summarised in the following sections, with respect to the 5 key criteria as defined in Appendix B. Definitions for each of the symbols utilised are provided in Figure 16, with further details on expected impacts with respect to each alternative contained in Appendix B. Where symbols are highlighted blue in the following sections, it is expected that alternatives will have an impact with respect to the relevant criteria.

Figure 16: Symbols for each of the five key criteria, used to summarise expected impacts of alternative techniques



Item 5.1 Calculation of the reference cost

Purpose

A key purpose of the NEP is to provide a price signal or benchmark for the change in efficient cost of providing public hospital services between cost models. A reference cost is derived from the cost data that reflects the mean cost of in-scope admitted acute activity, excluding any influence of case-mix changes between years. It is defined to ensure that the National Weighted Activity Unit (NWAU) maintains a consistent value across funding years. This facilitates allocative efficiency as jurisdictions can trade-off the impact of NWAU across alternative service categories in determining models of care that promote efficiency and innovative service delivery.

This is indexed forward 3 years for the purpose of calculating the NEP. The reference cost is also used to convert the costs for all service categories into cost weights, which reflect the relativities between services, and are eventually converted to price weights for funding.

Challenges

The reference cost is currently set based on costs of admitted acute activity which causes difficulties in interpretation of price weight changes in other service categories over time (i.e. movements could be either due to a change in the average price of acute services, or due to a change in the relevant service category).

Jurisdictional feedback has highlighted a need to review the purpose and calculation of the reference cost. Additionally, the Commonwealth Department of Health “supports IHPA’s decision to review alternative approaches to calculating the National Pricing Model. Options explored should attempt to strengthen the price signal provided by the National Efficient Price.”

A summary of IHPA’s current use of the reference cost is provided in Appendix C.

<u>Findings</u>

Aspects of the current methodology to retain:

- Use of the average cost of admitted acute activity to transform the cost models to cost weight models.

Two alternatives were identified for consideration from one source. Both have been short-listed for consideration for Phase 2.

Step-changes to the reference cost methodology to be tested:

- ID 5.1.1: Use the mean cost of the current year’s acute model, instead of applying a standardised growth rate to the previous year. This aids interpretation of the reference cost and simplifies the approach.

Fundamental changes to the reference cost methodology to be tested:

- ID 5.1.2: Application of current approach at a service category level. This has the potential to improve communication and price signalling in some circumstances.

Quantitative metrics to test potential impact

- Level of change in the reference cost and cost weights.

Item 5.2 Calculation of the indexation rate

Purpose

It is a key limitation that only cost and activity data from three years prior is available for setting the price due to delays in data collection and time required for quality assurance and validation. IHPA inflates the data so that it is reflective of the cost experience of the current year. The indexation rate used needs to account for changes in non-demographic drivers of cost over years.

Challenges

The current approach to indexation involves the development of scaling factors to equalise actual and modelled costs over historical years by applying the most recent activity data to the previous models. The trend of these scaling factors are used to model the indexation for the following three years, using an exponential line of best fit. The interpretation of the indexation rate is challenging as it is unclear the portion of it that relates to changes in activity versus changes in drivers of price growth. As suggested in Towards a Pricing Framework (2011), there is scope to use public indices.

Breaking the inflation rate into component parts also enables the incorporation of known changes in price (e.g. wage inflation) over the three years prior into projections.

A summary of IHPA's current use of indexation is provided in Appendix C.

<u>Findings</u>

Aspects of the current methodology to retain:

- Application of current cost model to prior years' activity data and cost ratios calculation.

Seven total alternatives were identified for consideration from eleven sources. Six have been short-listed for consideration for Phase 2.

Step-changes to the indexation methodology to be tested:

- ID 5.2.3: Exponential smoothing of growth. This is an alternate to the current method, used to place greater weight on more recent cost data.
- ID 5.2.7: Analysis of historical deviation between actual and expected to adjust the indexation rate. Understanding accuracy of historic assumptions will improve forecasts.

Fundamental changes to the indexation methodology to be tested:

- ID 5.2.1: Regression of growth against drivers of indexation. This is used in the Canadian health system; to manage volatility of material and labour in the construction industry; and predicting health expenditure in the EU based on non-demographic drivers.
- ID 5.2.4: ARIMA (time series) modelling of growth. Use of known information of recent drivers of price growth and patterns to support an informed price estimate, e.g. in the US construction industry to model prices of inputs and Finance for stock price modelling.
- ID 5.2.5: Use of external indices. Use of known information regarding recent drivers of price growth to support an informed price estimate, for example in the US where medical cost data is inflated using GDP, CPI, wages and personal consumption indices.
- ID 5.2.6: Microsimulation to model impacts of shifts in classifications and reporting. It is used in modelling household expenditure, pensions and healthcare demand. This will enhance indexation to reflect impacts of shifts in the healthcare environment over time.

Quantitative metrics to test potential impact

- Annual actual versus expected inflated price, given economic and healthcare changes.

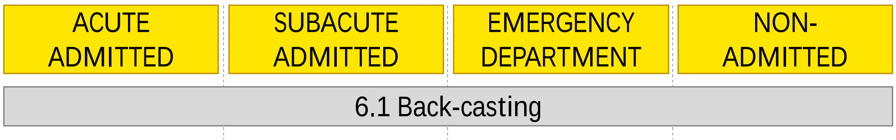
Methodology review area 6: Back-casting

The final component of the NEP determination process is back-casting. This is done to remove the effect of major changes to costing methodologies or classification systems when calculating the growth in activity and price that will be funded by the Commonwealth. The step is undertaken to feed into the funding calculations of the funding body.

Figure 17: Context of methodology step within NEP modelling process

Back-casted volume multipliers are determined for all service categories and jurisdictions. The back-casted NEP (determined by indexing the reference cost) is applied in conjunction with these multipliers to derive the base from which growth is calculated, in order to determine Commonwealth funding estimates.

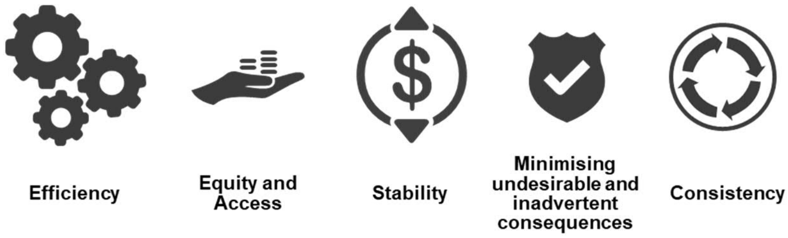
Figure 18: Summary of back-casting steps, by service category



The following section summarises the purpose of back-casting, challenges and short listed alternatives for consideration in phase 2.

The expected impacts of the implementation of alternatives are summarised in the following sections, with respect to the 5 key criteria as defined in Appendix B. Definitions for each of the symbols utilised are provided in Figure 19, with further details on expected impacts with respect to each alternative contained in Appendix B. Where symbols are highlighted blue in the following sections, it is expected that alternatives will have an impact with respect to the relevant criteria.

Figure 19: Symbols for each of the five key criteria, used to summarise expected impacts of alternative techniques



Item 6.1 Methodology for back-casting the NEP

Purpose

Clause A40 of the NHRA requires that the effect of any significant changes to the ABF classification systems or costing methodologies be back-cast to the year prior to their implementation. This is for the purpose of determining initial estimates for the efficient growth in NWAU. The estimated efficient growth in NWAU is used as an interim input in the Commonwealth Contribution Model to determine the Commonwealth ABF contributions under the NHRA. Subsequently, the Administrator of the National Health Funding Pool completes a reconciliation of Commonwealth ABF contributions once actual data is available for the year. To facilitate the initial estimates, IHPA derives volume multipliers which are applied to the prior year's NWAU to provide a comparable base for the funding year's NWAU. Similarly, a back-casted NEP is developed to reflect shifts in the mean cost of services across the year.

Challenges

The current approach to back-casting uses activity data from the most recent year in which a full year's data is available. This is generally two years prior to the year of funding, so may not be reflective of the future state.

A summary of IHPA's current use of back-casting is provided in Appendix C.

<u>Findings</u>

Aspects of the current methodology to retain:

- Approach of running historic activity data through the current and prior year's model to generate back-cast and original NEPs and volume multipliers.

Two alternatives were identified for consideration from one source. One has been short-listed for consideration for Phase 2.

Step-changes to the indexation methodology to be tested:

- ID 6.1.2: Smoothing of volume multipliers, using multiple base years for calculation. Leveraging multiple years of data will provide a more stable calculation of volume multipliers, removing the reliance on a single year of data.

Quantitative metrics to test potential impact

- Level and direction of change in the back-casted NEP and volume multipliers.

Appendix A Glossary

Term	Definition
ABF	Activity Based Funding
ALOS	Average Length of Stay
AN-SNAP	Australian National Subacute and Non-Acute Patient
APC	Admitted Patient Care
AR-DRG / DRG	Australian Refined Diagnosis Related Groups
ARIMA	Autoregressive Integrated Moving Average
Cost Models	The models comprising the ABF and Block Funded cost models
ED	Emergency Department
EY	Ernst & Young
Fundamental change	A change which requires alterations to the model principles, design or structure, and is expected to require a higher effort for implementation
GLM	Generalised Linear Model
HCP	Hospital Casemix Protocol
IHPA	Independent Hospital Pricing Authority
KNN	K Nearest Neighbours algorithm, a non-parametric algorithm used to separate data into several classes
LOS	Length of Stay
LSO	Long Stay Outlier
MBS	Medicare Benefits Scheme
National Pricing Models	Collective process to derive Commonwealth payments for in-scope hospital services. Includes data preparation, cost models, indexation and back-casting.
NEC	National Efficient Cost
NEP	National Efficient Price
NHCDC	National Hospital Cost Data Collection
NHFB	National Health Funding Body
NHRA	National Health Reform Agreement
NWAU	National Weighted Activity Units
PBS	Pharmaceutical Benefits Scheme
PPAA	Private Patient Accommodation Adjustment
PPSA	Private Patient Service Adjustment
R^2	R squared; a statistic that provides information about model goodness of fit
SMAPE	Symmetric Mean Absolute Percentage Error
SPF	Special Purpose Funds
SSO	Short Stay Outlier
Step Change	An incremental refinement to current processes and techniques, retaining the current model design and structure.
TAC	Technical Advisory Committee
TTR	Teaching, Training and Research
UDG	Urgency Disposition Group
URG	Urgency Related Group
VM	Volume Multipliers; applied to the prior year's NWAU to calculate the back-casted NWAU
WIP	Work In Progress
PCA	Principal Components Analysis

Appendix B Shortlisting of alternative techniques

The Pricing Guidelines outlined in the Pricing Framework for Australian Public Hospital Services can be used by governments and other stakeholders to evaluate whether IHPA is undertaking its work in accordance with the explicit policy objectives included in the Pricing Guidelines.

For the purpose of identifying a set of short-listed alternative techniques for further consideration during Phase 2 quantitative testing we have agreed a set of assessment criteria with IHPA. Each of the Pricing Guidelines have been considered and incorporated in the development of our assessment criteria through one of the following mechanisms:

1. The Pricing Guideline is incorporated into one of the agreed Assessment Criteria;
2. The Pricing Guideline is incorporated in our approach to the Literature Review; or
3. The Pricing Guideline is identified as related to a specific methodology area and will be applied in Phase 2 during the further testing of initiatives for the related methodology area.

Table 3 below summarises our approach to incorporating the Pricing Guidelines in development of the agreed assessment criteria.

Table 3: Mapping of IHPA's Pricing Guidelines against the agreed assessment criteria utilised in the Literature Review

Pricing Guideline	Description	Application to development of Assessment Criteria
Timely-quality care	Funding should support timely access to quality health services	This is incorporated in the 'Equity and access' criteria.
Efficiency	ABF should improve the value of the public investment in hospital care and ensure a sustainable and efficient network of public hospital services.	This is incorporated in the 'Efficiency' criteria.
Fairness	ABF payments should be fair and equitable, including being based on the same price for the same service across public, private or not-for-profit providers of public hospital services.	This is incorporated in the 'Equity and access' criteria.
Maintaining agreed roles and responsibilities of governments determined by the NHRA	Funding design should recognise the complementary responsibilities of each level of government in funding health services.	The delineation of responsibilities between jurisdictions and the legislated functions of IHPA define the scope of the Literature Review.
Transparency	All steps in the determination of ABF and block grant funding should be clear and transparent	This is incorporated in the 'Ease of understanding' criteria.
Administrative ease	Funding arrangements should not unduly increase the administrative burden on hospitals and system managers.	This is incorporated in the 'Ease of implementation' criteria.
Stability	The payment relativities for ABF are consistent over time.	This is incorporated in the 'Stability' criteria.
Evidence-based	Funding should be based on best available information	This is incorporated in our approach to the Literature Review which is based on a review of the evidence base.

Pricing Guideline	Description	Application to development of Assessment Criteria
Fostering clinical innovation	Pricing of public hospitals should respond in a timely way to introduction of evidence-based, effective new technology and innovations in the models of care that improve patient outcomes.	This is incorporated in the 'Efficiency' criteria.
Price harmonisation	Pricing should facilitate best-practice provision of appropriate site of care.	This is incorporated in the 'Equity and access' criteria.
Minimising undesirable and inadvertent consequences	Funding design should minimise susceptibility to gaming, inappropriate rewards and perverse incentives.	This is incorporated in the 'Minimising undesirable and inadvertent unintended consequences' criteria.
ABF pre-eminence	ABF should be used for funding public hospital services wherever practicable.	This is incorporated in our approach to the Literature Review, the scope of the review is the NEP process which by definition is ABF only.
Single unit of measure and price equivalence	ABF pricing should support dynamic efficiency and changes to models of care with the ready transferability of funding between different care types and service streams through a single unit of measure and relative weights.	This is specific to the Transformation to pricing models methodology area (i.e. calculation of the reference cost).
Patient-based	Adjustments to the standard price should be, as far as is practicable, based on patient-related rather than provider-related characteristics.	This is specific to the Adjustments methodology area
Public-private neutrality	ABF pricing should not disrupt current incentives for a person to elect to be treated as a private or a public patient in a public hospital.	This is specific to the Data preparation methodology area (i.e. for HCP matching) and Adjustments (i.e. PPSA and PPAA).

The following is the final set of assessment criteria agreed with IHPA for identifying short-listed alternative techniques for Phase 2 quantitative testing:

- Ease of implementation – considers availability of appropriate data for implementation, the extent of the methodology process affected, impact on model run times and level of model maintenance.
- Ease of understanding – considers the complexity of the statistical technique and possible challenges in explaining the technique and its rationale to stakeholders.
- Expected impact – considers expected positive or negative impacts of implementing the change with respect to the following principles:
    - Efficiency – the price assigned should reflect the efficient cost of service delivery.
    - Equity and access – the price should be the same for each service across all providers and fairly compensate for factors not in the control of providers.
    - Stability – prices and relativities should be consistent for services over time, except where expected given known changes.

  - Minimising undesirable and inadvertent consequences – the price paid for services should minimise gaming, inappropriate rewards and perverse incentives.
  - Consistency – a streamlined approach should be adopted for calculating the price across all service categories and services within them. Approaches should be designed such that the volume of activity at each level does not negatively impact the effectiveness of the step.
- Alignment with purpose – considers the extent to which the technique aligns with the initial purpose of undertaking the methodology

The following symbols are used to denote the assessment of each alternative against the criteria:

● Easy to implement or explain to stakeholders

◑ Some possible challenges in implementing or explaining to stakeholders

○ Challenges in implementing or explaining to stakeholders

+ Expected positive impact

- Expected negative impact

Where there is a blank ‘expected impact’, this suggests the impact is unknown at this stage.

Green (or red) highlighting is used in the following table in relation to the Assessment Criteria to denote an expected positive (or negative) impact.

Appendix B.1 Data Preparation

ID	Description	Ease of implementation	Ease of understanding	Expected impact					Alignment with purpose	Phase 1 shortlist?
				Efficiency	Equity and access	Stability	Minimising undesirable and inadvertent consequences	Consistency		
1.1 Commonwealth Pharmaceutical Programs - data linking and removal of costs from linked episodes										
Current approach: Deterministic matching of all Pharmaceutical claims, with unmatched claims distributed in line with matched claims										
1.1.1	Targeted deterministic matching of pharmaceutical claims	◑	●		+		+		Yes	Yes
1.1.2	Probabilistic matching using expectation maximization algorithm	○	◑					+	Yes	No
1.1.3	Imputation using mean of reliable data	●	●		–				Yes	No
1.1.4	Imputation using KNN method	◑	◑		+		+	+	Yes	Yes
1.2 Hospital Casemix Protocol (HCP) matching methodology and inflation of costs to reflect private patient costs that are missing from the NHCDC										
Current approach: Match HCP data at a patient level, including imputation of missing benefits based on non-missing values by classification. Offset NHCDC costs by matched/imputed benefits.										
1.2.1	Imputation of medical and ancillary benefits based on facilities with complete reporting only	●	◑		+		+	+	Yes	Yes
1.2.2	Stratification for imputing private patient costs	●	●		+			+	Yes	Yes

ID	Description	Ease of implementation	Ease of understanding	Expected impact					Alignment with purpose	Phase 1 shortlist?
				Efficiency	Equity and access	Stability	Minimising undesirable and inadvertent consequences	Consistency		
1.2.3	Scaling of matched data using logistic regression for ancillary costs	◑	◑		+		+	+	Yes	Yes
1.3 Identification and treatment of outliers for all models										
Current approach: Remove outliers using pre-defined thresholds, which are constant across classifications.										
1.3.1	Removal of outliers using studentised residuals and a defined threshold	◑	◑			+		+	Yes	Yes
1.3.2	Removal of outliers using an alternative (e.g. centroid or simple average) distance-based approach	●	◑			+		+	Yes	Yes
1.3.3	Outlier visualisation techniques such as box plots and scatter plots	○	●			–		–	Yes	No
1.3.4	Retention of outliers, without adjustment	●	●	–	+	–		+	No	No
1.3.5	Retention of outliers, using studentised residuals and reduced weights	◑	◑		+	–		+	Yes	Yes
1.3.6	Use of multiple years data, combined with a credibility theory approach	◑	●			+			Yes	Yes

ID	Description	Ease of implementation	Ease of understanding	Expected impact					Alignment with purpose	Phase 1 shortlist?
				Efficiency	Equity and access	Stability	Minimising undesirable and inadvertent consequences	Consistency		
1.3.7	Principal Component Analysis to reduce dimensions of the data	◑	○			+		+	Yes	No
1.3.8	Cluster analysis to determine groups of data points that sit at the extremes	○	◑			+		+	Yes	No
1.3.9	Robust regression to limit the influence of outliers	◑	○		+	–		+	Yes	No
1.3.10	Retention of outliers, with adjustments to be made in the calculation of the base price weight through bootstrapping	◑	◑			+		+	Yes	Yes
1.4 Methodology to account for episodes admitted or discharged outside of the financial year										
Current approach: Scale up non-WIP activity using weights based on the count of WIP activity by length of stay quartiles.										
1.4.1	Weights based on Length of Stay	●	●		+	–		+	Yes	Yes
1.4.2	Credibility theory for cost imputation, leveraging available WIP cost data	○	◑		+		+		Yes	Yes

ID	Description	Ease of implementation	Ease of understanding	Expected impact					Alignment with purpose	Phase 1 shortlist?
				Efficiency	Equity and access	Stability	Minimising undesirable and inadvertent consequences	Consistency		
1.4.3	Scaling WIP data using logistic regression	◑	◑		+			+	Yes	Yes
1.4.4	Including all WIP patients in the pricing model, in line with the approach used for non-WIP patients	●	●		+	–		+	Yes	Yes
1.5 Sample-to-population weighting of cost data										
Current approach: Scale up activity with matched NHCDC cost data, using weights based on the count of non-matched activity by state, hospital size and type.										
1.5.1	Weighting using matching, raking and propensity weighting techniques	◑	◑		+			+	Yes	Yes
1.5.2	Weighting using stratification based on the PCA method	◑	○		+			+	Yes	Yes
1.5.3	Imputation using Support Vector Machine (SVM)	◑	○			–		+	Yes	Yes
1.5.4	Imputation using a bootstrapping method	◑	◑		+			+	Yes	Yes

ID	Description	Ease of implementation	Ease of understanding	Expected impact					Alignment with purpose	Phase 1 shortlist?
				Efficiency	Equity and access	Stability	Minimising undesirable and inadvertent consequences	Consistency		
1.7 Data cleansing										
Current approach: Undertake a series of data cleansing steps including removal of irrelevant costs and application of ad-hoc adjustments specific to service categories.										
1.7.1	Data cleansing framework	●	●					+	Yes	Yes
1.7.2	Statistical Process Control tools to identify anomaly events	◑	●			+	+	+	Yes	Yes

Appendix B.2 Base price weight calculation

ID	Description	Ease of implementation	Ease of understanding	Expected impact					Alignment with purpose	Phase 1 shortlist?
				Efficiency	Equity and access	Stability	Minimising undesirable and inadvertent consequences	Consistency		
2.1 Use of same day, short stay outlier, inlier, and long stay outlier methodology in subacute and acute cost models										
Current approach: Activity is classified as one of the four separation types. Funding is then determined based on the separation category, with both fixed price and per diem approaches utilised.										
2.1.1	Long Stay Outlier per diems as a proportion of the average inlier cost	●	●	+	–		+	+	Yes	Yes
2.1.2	Per diem system for subacute activity, by care type	●	●			+	–	–	No	No
2.1.3	Use of median cost for the inlier price weight instead of the mean cost	●	●	+	–	+			Yes	Yes
2.1.4	Bootstrapping to determine the mean cost	◑	◑			+		+	Yes	Covered by 1.3.10
2.1.5	Stochastic Frontier Analysis to define the efficient price	○	◑	+		–			Yes	Yes
2.16	Innovation funding for new treatment methods, on application	○	●	–	+		+		No	No

ID	Description	Ease of implementation	Ease of understanding	Expected impact					Alignment with purpose	Phase 1 shortlist?
				Efficiency	Equity and access	Stability	Minimising undesirable and inadvertent consequences	Consistency		
2.2 Use of L3H3 methodology and L1.5H1.5 methodology in subacute and acute cost models										
Current approach: The average length of stay is currently utilised as the basis for deriving the inlier bounds, from which activity is classified into separation categories. For most activity these bounds are calculated as 1/3 of the ALOS and 3 times the ALOS. For activity with longer ALOS, these are calculated as 2/3 the ALOS and 1.5 times the ALOS.										
2.2.1	Cost based thresholds	○	●	+	+		+		Yes	No
2.2.2	Calculation of bounds using LOS interquartile range	●	●				–	–	Yes	No
2.2.3	Calculation of bounds using linear spline fit to LOS	◑	◑	+	+			–	Yes	Yes
2.2.4	Calculation of bounds using percentiles of gamma distribution	◑	◑				–		No	No
2.2.5	Use of LαHβ, fit to data	○	◑		+	–		–	Yes	No
2.2.6	Calculation of bounds using 10th and 95th percentiles	●	●	+			+		Yes	Yes
2.2.7	Calculation of bounds using adjusted LOS interquartile range	●	●			–	+	+	Yes	Yes

ID	Description	Ease of implementation	Ease of understanding	Expected impact					Alignment with purpose	Phase 1 shortlist?
				Efficiency	Equity and access	Stability	Minimising undesirable and inadvertent consequences	Consistency		
2.2.8	Removal of SSO threshold	●	◑	–			+		No	No
2.3 Care type per diems in the subacute cost model										
Current approach: Paediatric palliative care is currently funded through a purely per diem mechanism. This is required due to insufficient data to develop the inlier and outlier methodology.										
2.3.1	To price Paediatric Palliative care, supplement with last year's data	○	●			+	+	+	Yes	No
2.3.2	To price Paediatric Palliative care, use a fixed base plus per diem price	●	●				+		Yes	Yes
2.3.3	To price all Subacute activity, use a fixed base plus per diem price	●	●			+	–	–	No	Covered by 2.1.2
2.4 Use of multiple years and different sources of data, in the non-admitted model and block funded cost model										
Current approach: The non-admitted model leverages cost data across multiple sources and years, to account for low reporting and instability in the NHCDC										
2.4.1	Credibility theory	◑	◑		+	+			Yes	Yes

ID	Description	Ease of implementation	Ease of understanding	Expected impact					Alignment with purpose	Phase 1 shortlist?
				Efficiency	Equity and access	Stability	Minimising undesirable and inadvertent consequences	Consistency		
2.5 Concurrent calculation of price weights for different classifications applicable to the emergency cost model										
Current approach: URG prices are calibrated against the UDG prices, equalising the weighted average PW under the URG classifications with the PW under the mapped UDG classification										
2.5.1	Set UDG price weight to a percentile of the URG price weights (e.g. minimum, 25th percentile)	●	◑	+	−		+		Yes	Yes
2.5.2	Stratify data by remoteness grouping prior to calibrating the URG average cost against UDG average cost	●	●		+		+		Yes	Yes

Appendix B.3 Adjustments

ID	Description	Ease of implementation	Ease of understanding	Expected impact: Efficiency	Expected impact: Equity and access	Expected impact: Stability	Expected impact: Minimising undesirable and inadvertent consequences	Expected impact: Consistency	Alignment with purpose	Phase 1 shortlist?
3.1 Adjustments for legitimate and unavoidable variation in costs, including hospital eligibility criteria, as specified in the 2018-19 NEP Determination										
Current approach: Unavoidable variations in cost are currently reflected through patient level adjustments. Where appropriate, adjustments are calculated using the patient level cost ratios at the relevant step of the modelling process. This is to account for any cost variation explained by the preceding model steps										
3.1.1	GLM of cost against adjustment factors, with interaction factors (current adjustments only)	●	◑		+		+	+	Yes	Yes
3.1.2	GLM of cost against adjustment factors, with interaction factors (additional adjustments considered)	◑	◑		+		+	+	Yes	Yes
3.1.3	Fixed ‘incremental’ dollar amounts for select adjustments instead of percentages	◑	●				+		Yes	Yes
3.1.4	K-means clustering to identify groups of variation in the data	○	◑		+		+	+	Yes	Yes

ID	Description	Ease of implementation	Ease of understanding	Expected impact					Alignment with purpose	Phase 1 shortlist?
				Efficiency	Equity and access	Stability	Minimising undesirable and inadvertent consequences	Consistency		
3.1 Private patient adjustments										
Current approach: Application of PPAA and PPSA adjustments to the acute and subacute cost models										
3.2.1	Bottom up review of private patient funding	◑	●		+		+	+	Yes	Yes

Appendix B.4 Stabilisation

ID	Description	Ease of implementation	Ease of understanding	Expected impact					Alignment with purpose	Phase 1 shortlist?
				Efficiency	Equity and access	Stability	Minimising undesirable and inadvertent consequences	Consistency		
4.1 Evaluation of DRG and SNAP class comparability across classification versions for the purposes of stabilisation of acute and subacute price weights										
Current approach: For changes in classification, only those classification codes with an equivalent code in the prior classification version are stabilised										
4.1.1	Stabilisation against weighted average price weight, where no one-to-one mapping is available	●	●	+		+		+	Yes	Yes
4.1.2	Credibility theory against an expected price	○	◑			+	+	–	Yes	Yes
4.2 Purpose and application of price and adjustment stabilisation policy for all cost models										
Current approach: Stabilise price weights, inlier bounds and adjustments against the prior year's values										
4.2.1	Credibility theory	◑	◑		+		+		Yes	Yes
4.2.2	Stabilisation against non-stabilised cost weight	◑	●		+	–			Yes	Yes

Appendix B.5 Transformation to pricing models

ID	Description	Ease of implementation	Ease of understanding	Expected impact					Alignment with purpose	Phase 1 shortlist?
				Efficiency	Equity and access	Stability	Minimising undesirable and inadvertent consequences	Consistency		
5.1 Calculation of the reference cost										
Current approach: The previous year's reference cost is indexed by the growth rate in consecutive years' cost models, where the growth rate is standardised against the latest year's activity data.										
5.1.1	Use the mean cost of the current year's acute model, instead of applying a standardised growth rate to the previous year	●	●			–		–	Yes	Yes – as a pricing signal
5.1.2	Application of current approach at a service category level	●	◑					+	Yes	Yes
5.2 Calculation of the indexation rate										
Current approach: The cost model is applied retrospectively to the five years of patient costed admitted acute activity data, with scaling factors reflecting the difference in actual cost and modelled cost calculated for each of these years. The trend of these scaling factors is used to model the indexation rate for the following three years.										
5.2.1	Regression of growth against drivers of indexation	◑	●		+				Yes	Yes
5.2.2	Compounded arithmetic or geometric average to determine the forecast	●	●			–			Yes	No
5.2.3	Exponential smoothing of growth	●	◑		+	+			Yes	Yes

ID	Description	Ease of implementation	Ease of understanding	Expected impact					Alignment with purpose	Phase 1 shortlist?
				Efficiency	Equity and access	Stability	Minimising undesirable and inadvertent consequences	Consistency		
5.2.4	ARIMA (time series) modelling of growth	◑	○		+	–			Yes	Yes
5.2.5	Use of external indices	●	●		–				Yes	Yes
5.2.6	Microsimulation to model impacts of shifts in classifications and reporting	○	◑		+	–	+		Yes	Yes
5.2.7	Analysis of historical deviation between actual and expected to adjust the indexation rate	◑	◑		+				Yes	Yes

Appendix B.6 Back-casting

ID	Description	Ease of implementation	Ease of understanding	Expected impact					Alignment with purpose	Phase 1 shortlist?
				Efficiency	Equity and access	Stability	Minimising undesirable and inadvertent consequences	Consistency		
6.1 Review the methodology for back-casting the NEP										
Current approach: The volume multipliers are derived as the NWAUs calculated from application of the current model divided by NWAUs calculated by application of the previous year’s cost model, to a consistent activity dataset. The back-cast NEP is determined by indexing the reference cost by two years, using the same annual indexation projections for the NEP.										
6.1.1	Use of a different year’s data in determining volume multipliers (‘VM’)	○	●		+	+	+		Yes	No
6.1.2	Smoothing of volume multipliers, using multiple base years for calculation	●	◑			+	+		Yes	Yes

Appendix C IHPA's current methodology

Appendix C.1 Data Preparation

Methodology Area	Summary of approach
1.1 Commonwealth Pharmaceutical Programs - data linking	The following steps describe the approach to pharmaceutical costs data linking and removal: • Assign pharmaceutical benefits to individual episodes, based on an iterative matching process with specified variables. These variables include Medicare pin, facility identifier, state, gender and date of birth. • If pharmaceutical matches to multiple episodes, prioritise match to Acute and Outpatient activity over ED. For specialised drugs, specific AR-DRGs and clinics will be prioritised based on a drug mapping table. • Apportion residual unmatched pharmaceutical benefits according to the distribution of costs associated with matched benefits. • Offset NHCDC costs by the matched pharmaceutical benefits.
1.2: Hospital Casemix Protocol matching methodology	The following steps describe the approach to HCP data matching and inflation of costs: • Match HCP data to patient level records • Calculate the weight by which to scale up HCP data, as the HCP data does not contain information for all private patients within the activity data (defined based on funding source). This is the ratio of private activity in the hospital activity data to private activity in the HCP data. • Calculate Private medical benefits as the weighted sum of the MBS benefits and fund benefits in the HCP data. Take the weighted sum of the private ancillary benefits from HCP data. • Calculate total weighted medical benefits as a proportion of the total weighted reported NHCDC costs at a DRG level. Where volume of separations is low, alternatively calculate the proportion at an ADRG or MDC level. Take the same approach for total weighted ancillary benefits. • Where a private patient does not have matched benefits in the HCP data, impute these benefits based on the NHCDC costs and the proportions derived prior. • For facilities with known under-reporting of ancillary benefits in their NHCDC data, scale up the NHCDC to reflect these private benefits. This is performed based on jurisdiction advice, with scaling applied to either private patients only or across all patients. The NHCDC is scaled up by a factor of 100%, 50% or 0% of the reported ancillary benefits. • For facilities with known under-reporting of medical benefits in their NHCDC data, scale up the NHCDC to reflect these private benefits. Again, this is performed based on jurisdiction advice, with scaling applied to either private patients only or across all patients.

Methodology Area	Summary of approach
1.3: Outlier identification and treatment	The approach to identifying and removing outlier episodes across the service types broadly involves either all, or a selection of, the following steps: • Removal of episodes based on jurisdictional advice • Removal of episodes within hospital and DRG combinations with extreme high or low costs • Removal of episodes with costs that fall below a threshold specific to each service type • Removal of episodes that have extreme high or low costs within their specific DRG • Removal of episodes with extreme changes in the cost ratio between adjacent episodes
1.4: WIP patients	The approach to accounting for episodes admitted or discharged outside of the financial year is as follows: • Split data into two datasets. The first dataset contains WIP separations, while the second excludes WIP separations. • Calculate LOS percentiles and cut points by DRG. These are subsequently used as the basis for the LOS groups. • Classify all separations according to these LOS groups. • Calculate the number of separations within each group, by the defined datasets. The ratio of the count in the first dataset to the count in the second dataset (within each group) is then used to weight up costs and activity throughout the remainder of the pricing process. • IHPA additionally fixes any inconsistencies in the data, ensuring that the weights applied always increase as the LOS group increases in average length. This is applied for admitted acute and subacute activity only.
1.5: Sample-to-population weighting of cost data	The approach to weighting up the NHCDC data for volume of activity in the activity datasets is different across the service categories: • Acute admitted – Facilities are grouped into strata based on their type (paediatric, major city and other location) and NWAU (<10000, 10000-20000 and >20000). The count of separations is summarised by jurisdiction, strata type and strata size. The weight is calculated as the ratio of separations in the APC dataset to cost separations in the NHCDC dataset within the defined stratum. • Subacute – NHCDC data is currently not scaled for APC activity data. • Emergency – Population level of activity is determined as the maximum of NHCDC and activity data. Total UDG, URG and error activity from the NHCDC dataset is then scaled to this maximum. Scaling is done at a state/territory level. • Non-admitted – See methodology area 2.4 for the process for building the cost dataset for non-admitted.

Methodology Area	Summary of approach
1.6: Use of previous years' financial data	Data from three years prior is used for cost modelling e.g. FY15/16 data is used for the FY18/19 cost models. This is due to a number of factors including delays in data collection, and time required for quality assurance and validation. Earlier years' data is also necessary since the development of the pricing model occurs in the financial year prior to which it applies (for example, work on the FY19/20 model is commenced in October 2018). In addition, prior years' activity and costs data is used to supplement the current year's data, where this is limited in volume or has known data issues. Instances of this occur within the Acute, Subacute and Non-Admitted cost models.
1.7: Data cleansing	Data cleansing across the service types is undertaken to identify and remove irrelevant records and/or modify or transform the data for subsequent cost modelling. It is assumed that data validation and data preparation e.g. merging of datasets, naming of variables, creating or transforming variables etc. occurs separately to data cleansing. Examples of key data cleansing steps include: • Removal of out-of-scope costs such as blood, TTR (teaching, training and research), and capital and depreciation across all service types • Extracting sub-acute from the APC dataset • Understanding the spread of errors in the emergency department data

Appendix C.2 Base price weight calculation

<table>
<tr><th>Methodology Area</th><th>Summary of approach</th></tr>
<tr><td>2.1: Admitted pricing – inlier and outlier methodology</td><td>The current approach to admitted pricing follows an inlier and outlier model. This is implemented through the following steps:
• Separations are classified as same day, short stay outlier, inlier, or long stay outlier based on the length of stay. This is known as the separation category. Bounds for each category are defined using methodology area 2.2.
• Pricing for separations differs according the assigned separation category. All prices further differ by DRG/SNAP.
o Same day separations for specific same day DRGs/SNAPs receive a single price
o Short stay outliers receive a base fixed cost based on the Operating room, SPS and Prosthesis costs within the NHCDC data (for some DRGs and for all SNAPs this is zero), plus a variable per diem cost dependent on length of stay. The SSO per diem is calculated such that the SSO price equals the inlier price at the inlier lower bound.
o Inlier stays receive a single price, calculated as the average cost per separation
• Long stay outliers receive a base fixed cost (equal to the inlier price), plus a variable per diem cost dependent on length of stay. For classifications with sufficient volume, this per diem was calculating using regression. Otherwise, this was performed through consideration of the average daily variable costs, as determine from the NHCDC dataset.</td></tr>
<tr><td>2.2: Admitted pricing – L3H3 and L1.5H1.5</td><td>The outlier thresholds are current defined using the following steps:
• Calculate the mean length of stay for each DRG/SNAP
• Calculate the inlier lower bound:
o For subacute, mental health and 11 specified DRGs with high cost long stay outliers, this is the mean length of stay divided by 1.5
o For all other acute DRGs, this is the mean length of stay divided by 3
o The result is then rounded down to the closest integer
• Calculate the inlier upper bound:
o For subacute, mental health and 11 specified DRGs with very high cost long stay outliers, this is the mean length of stay multiplied by 1.5
o For all other acute DRGs, this is the mean length of stay multiplied by 3
o The result is then rounded up to the closest integer
95 percent confidence intervals around the calculated bounds are used to determine if the change in bounds is significant or not. Any changes must also affect at least 10 and 1% of separations.</td></tr>
</table>

Methodology Area	Summary of approach
2.3: Subacute pricing – care type per diems	Care type per diems are currently utilised within the subacute cost model due to insufficient data. Per diems are utilised for paediatric palliative care, based on the following steps: • Paediatric palliative care is flagged within the data, and excluded from the standard pricing process for subacute activity. • The average cost per day was calculated at an overall level. This is then used as the per diem value for both same day and overnight paediatric palliative care, due to insufficient data for separate same day and overnight prices.
2.4: Non-admitted pricing – use of multiple data sources	The non-admitted model currently leverages various data sources to determine clinic price weights. This is based on the following hierarchical steps: 1. If the clinic has a logical or clinical link to an acute same day service, then NHCDC acute costs are adopted. 2. Adopting the non-admitted NHCDC cost data, provided there is an adequate sample and reliable cost data 3. Adopting EY costing study or other costing studies With the improvement in the quality of reported data to the non-admitted NHCDC, pricing of clinics have been progressively transitioned from the use of costing studies to the use of NHCDC. The current non-admitted model imposed a three year time period for the evaluation of stability in the non-admitted NHCDC. The determination of stability necessitates that the yearly movement in average clinic cost within a 3 year period not exceed a 20 percent threshold.
2.5: ED pricing – concurrent calculation	Pricing for Emergency Department activity involves concurrent calculation of price weights under different classifications, based on the following steps: • Patient presentations to emergency services are classified using Urgency Disposition Groups (UDGs), whereas patient presentations to emergency departments are classified using Urgency Related Groups (URGs). • UDGs group patient presentations on the basis of the type of visit, episode end status and triage; whereas URGs group patient presentations on the basis of type of visit, episode end status, triage and diagnosis. • Data enters the cost model at one of three levels: by URG, by UDG, or aggregated to an establishment level. URG data is used to derive an initial set of average cost for URGs. The URG and UDG data is then combined to obtain an average cost for UDGs. Finally, the URG and UDG datasets were combined with the aggregate data to obtain an overall cost for the entire sample. • The URG cost parameters are scaled so that the UDG cost parameter is equal to the weighted average of the URG parameters, to prevent incentives in the level of reporting. The URG and UDG cost parameters are then calibrated against the total cost. This process ensures that the URG and UDG cost parameters are aligned and the overall model costs are equalised with actual costs.

Appendix C.3 Adjustments

<table>
<tr><th>Methodology Area</th><th>Summary of approach</th></tr>
<tr><td>3.1: Adjustments for unavoidable variations in costs</td><td>
The current approach to adjust for legitimate and unavoidable variations is to apply patient level adjustments. Where appropriate, adjustments are calculated using the patient level cost ratios at the relevant step of the modelling process. This is to account for any cost variation explained by the preceding model steps. Adjustments implemented through the following steps:
<u>Paediatric Adjustment (Acute)</u>

Episodes that occur in establishments identified as delivering specialised paediatric services; an AR-DRG which is not within Major Diagnostic Category (MDC) 15 (Newborns and other neonates); and patient age at admission of 17 years or less.
The paediatric adjustment for each AR-DRG is calculated using a linear regression on the cost ratio when compared to non-paediatric episodes, the following criteria is then applied to the adjustment:

Rounded to the nearest whole percent;
Capped and floored at 2.0 and 0.8 respectively; and
Set to 1 if the adjustment was less than 0.05 either side of 1.

<u>Specialist psychiatric age adjustment (Acute)</u>

Patients with registered psychiatric care days are identified and split into five groups, defined by age group, MDC and Paediatric hospital status.
A multivariate linear regression model on the cost ratio is used to calculate the 5 specialist psychiatric age adjustments, which are then applied to the model.

<u>Indigenous adjustment (Acute, Subacute, Emergency Care, and Non-admitted)</u>

It is recognised that the indigenous adjustment is highly correlated to the patient remoteness adjustment, therefore these adjustments are calculated together in a regression model.
A multivariate linear regression model on the cost ratio is applied to the acute data and is used to estimate the extent to which indigenous status explains the variation in the cost ratio. The acute indigenous adjustment is also applied to the subacute, non-admitted and the emergency models

<u>Patient residential remoteness adjustment (Acute, Subacute)</u>

It is recognised that the patient residential remoteness adjustment is highly correlated to the indigenous adjustment, therefore these adjustments are calculated together in a regression model.
A multivariate linear regression model on the cost ratio is applied to the acute data and is used to estimate the extent to which the three remoteness categories below explains the variation in the cost ratio.

Outer regional
Remote
Very Remote

The acute residential remoteness adjustments is also applied to the subacute model.

</td></tr>
</table>

<table>
<tr><th>Methodology Area</th><th>Summary of approach</th></tr>
<tr><td>3.1: Adjustments for unavoidable variations in costs</td><td>
<u>Patient residential remoteness adjustment (Emergency Department)</u>
▪ A multivariate linear regression model on the cost ratio is applied to the emergency data and is used to estimate the extent to which a combined remote and very remote category explains the variation in the cost ratio, while controlling for any effect caused by indigenous patients.
▪ The ED patient single remoteness adjustment is applied to the emergency department data and applied to patients assigned to remote and very remote locations.
<u>Radiotherapy and dialysis adjustment (Acute)</u>
▪ The radiotherapy and dialysis adjustment are both calculated concurrently but independently of the indigenous and patient residential remoteness adjustments. A linear regression model on the cost ratio is used to determine both adjustments independently of each other.
▪ The sum of the radiotherapy, dialysis, indigenous, and patient residential remoteness adjustments are then applied to the acute model.
<u>Age adjustment (Emergency Care)</u>
▪ Emergency care patients are split into three categories those under 65, those aged 65 to 79 years inclusive, and over 79 years
▪ A multivariate linear regression model on the cost ratio is used to estimate the extent to which patients aged 65 to 79 and those over 79 years age categories explain the variation in the cost ratio.
<u>Patient treatment remoteness adjustment (Acute)</u>
▪ After the application of the patient residential remoteness the model will then adjust for variation in the cost ratio explained by patient treatment remoteness.
▪ The adjustment is derived using a multivariate linear regression model on the cost ratio to estimate the extent to which the two hospital remoteness categories below explain the variation in the cost ratio.
▪ Remote
▪ Very Remote
▪ The patient treatment remoteness adjustment is then applied to the acute data.
<u>Intensive care unit (ICU) adjustment (Acute)</u>
▪ Episodes in eligible ICU hospitals, with reported ICU hours are analysed to calculate and average cost per ICU hour. Linear regression by state/territory was used to derive state/territory hourly ICU costs and outlier separations were excluded. The weighted mean of the hourly ICU costs taken across states is used to derive a national ICU rate.
▪ For ICU-eligible episodes, an ICU adjustment is calculated at a patient level using the national ICU rate multiplied by the reported number of whole ICU hours.
<u>Multi-disciplinary adjustment</u>
▪ A non-admitted service event where three or more health care providers (each of a different specialty) are present, as identified using the non-admitted ‘multiple health care provider indicator’.
</td></tr>
</table>

<table>
<tr><th>Methodology Area</th><th>Summary of approach</th></tr>
<tr><td>3.1: Adjustments for unavoidable variations in costs</td><td>
A 55% adjustment has been applied, calculated based on a flag for multiple health-care providers in the National minimum data set (NMDS). The adjustment was historically based on the EY National Non-admitted and Subacute admitted costing study.
<u>Hospital Acquired Complications (HAC)</u>
The funding level for admitted acute episodes will be reduced where a HAC is present. Separate adjustments have been determined for each HAC, and for three patient complexity group.
The incremental cost of a HAC, and corresponding adjustment, is determined by comparing to patients without a HAC using an AR-DRG, length of stay regression model.
The adjustments account for patient risk through the complexity groups, these are determined by a logistic regression model to predict the probability a patient will acquire a HAC, based on their patient and episode characteristics.
Where an episode contains multiple HACs, the HAC and corresponding complexity group with the largest adjustment determines the funding adjustment.
Note that HAC adjustments are out of scope for the NEP Fundamental Review.
</td></tr>
<tr><td>3.2: Private patient adjustments</td><td>
<u>Private patient service adjustment (Acute and Subacute)</u>
The private patient service adjustment is calculated at the AR-DRG level where the sample size is large enough, otherwise the adjustment is derived at a more aggregate level. The AR-DRG adjustment is calculated as the total HCP amount removed divided by the model costs for private patients.
It should be noted that the AR-DRG model costs used excludes the application of any other adjustments. That is, the private patient service adjustment is calculated in such a way that excludes any effect on the paediatric, specialist psychiatric, Indigenous, remoteness, and radiotherapy or dialysis adjustments.
<u>Private patient accommodation adjustment (Acute and Subacute)</u>
Insurers are charged for accommodation of private patients in public hospitals, the private patient accommodation adjustment is applied to account for revenue received in relation to these charges. For the purpose of deriving the adjustment associated average default benefits for private health insurers by state/territory are indexed forward one year.
The private patient accommodation adjustment is calculated at a patient level, as the episode length of stay is multiplied by the corresponding accommodation adjustment.
</td></tr>
</table>

Appendix C.4 Stabilisation

Methodology Area	Summary of approach
4.1: Stabilisation across classification versions	The following process is undertake to stabilise price weights and bounds after classification change: • Acute – when a new revision of the AR-DRG classification is released it must be determined if stabilisation between versions is appropriate. Stabilisation of a DRG occurs only if a close to one to one mapping between DRG versions can be determined, requiring at least 95% overlap in activity. • Subacute, Non-admitted and Emergency Department – no defined methodology.
4.2: Stabilisation of prices and adjustments	<u>Stabilisation of price weights</u> • The National Pricing Model Stability Policy states that inlier price weight movements between years will be capped to ±20%, with conditions required around the volume of episodes and comparability of ICU and same day status. <u>Stabilisation of acute and subacute inlier bounds</u> • Any change in AR-DRG and AN-SNAP inlier bounds are monitored to ensure they are statistically significant. Wherever an AR-DRG or AN-SNAP has not been significantly affected by a specific change in methodology through version change, then 95 percent confidence intervals are determined for each of the inlier bounds, if the previous bound is within the calculated interval, then the previous bound is retained. • Changes to the bounds are also evaluated in terms of their materiality, the change in the inlier bound is required to affect at least 1 percent of an AR-DRG/SNAP's separations and at least 10 separations. <u>Stabilisation of acute paediatric adjustments</u> • Wherever an AR-DRG has not been significantly affected by a specific change in methodology through version change, and has less than 500 episodes, movement between years is stabilised by setting the adjustment to the average value across the two NEP models • The adjustment will be set to 1.00 if volume is not sufficient or the adjustment is not considerably different from 1. <u>Stability of adjustments</u> • Stabilisation of adjustments across years to minimise volatility in year to year changes. • Adjustments are determined on a rolling average where up to three years' of historical data is used, if available, in order to maximise the stability of these adjustments.

Appendix C.5 Transformation to pricing models

Methodology Area	Summary of approach
5.1: Calculation of the reference cost	The objective of a reference cost (or standardised mean) is to transform the cost model into a cost weight model. • The previous years' reference cost is indexed by the growth rate in consecutive years cost models, where the growth rate is standardised against the latest year's activity data. • To exclude the external effects of case-mix change between years, the two cost models are applied to the latest set of acute activity. The resulting mean costs derived under each of the models are used to calculate the year on year growth. • This is referred to as the standardised change in cost models, with the associated growth referred to as the standardised growth rate.
5.2: Calculation of the indexation rate	The objective is to derive an annual indexation rate that is used to inflate the current cost model over three years to reflect the funding year's estimated costs. • To derive this rate, the cost model is applied retrospectively to the five years of patient costed admitted acute activity data. • Comparisons are made between actual and modelled costs to determine the cost ratio increase between years. The cost modelled year is set as the baseline, with the resulting cost ratios discounted from a value of 1 in the cost modelled year. • The trend of these scaling factors is used to model the indexation rate for the following three years. • Given that the inflation factor being modelled is an annual growth rate, the line of best fit is taken to have an exponential form. The exponential line of best fit is also modelled so that it passes through the current cost model's cost ratio value of 1.

Appendix C.6 Back-casting

Methodology Area	Summary of approach
6.1: Methodology for back-casting the NEP	Clause A40 of the NHRA outlines that any significant changes to the ABF classification systems or costing methodologies, the effect of such changes must be back-cast to the year prior to their implementation for the purpose of calculating Commonwealth funding estimates for each ABF service category. The volume multipliers are calculated for each jurisdiction and each service category. The formula for the volume multipliers is NWAUs delivered by current model divided by NWAUs delivered by the previous year's cost model. The volume multipliers can be applied to estimates of an NWAU count if a final reconciliation is not available. For example, consider a significant change in the model methodology causing reallocation of NWAU between states and territories. This would produce a volume multiplier above one for states and territories receiving additional NWAU and below one for those receiving a reduction in NWAU. The back-cast NEP is determined by indexing the reference cost by two years, using the same annual indexation projections for the NEP. In effect, this defines the price growth between consecutive NEPs as equal to the price indexation rate applied to calculate the latest NEP. The determination also specifies that state-specific back-casting multipliers provided will not always accurately reflect the year-on-year growth in some cases. Some classes may require application of a specific back-casting approach due to a change in their scope, counting rules or pricing approach.

Appendix D Summary of alternative techniques

Appendix D.1 Data Preparation

Methodology area 1.1: Commonwealth Pharmaceutical Programs - data linking

Pharmaceutical data linking and removal of costs from linked episodes	
Current approach: Deterministic matching of all Pharmaceutical claims, with unmatched claims distributed in line with matched claims	
1.1.1 Targeted deterministic matching of pharmaceutical claims	
Description of technique	Rather than matching all hospital PBS claims to hospital activity, instead only match on PBS claims that are compliant with regards to the requirements set out by the Federal Government. Offsetting costs by non-compliant PBS benefits will disadvantage facilities which do not make such claims. Recovery of funding for such claims should take place externally to the pricing model.
Example study/use	The Department of Health (through the NHFB) has performed matching of PBS benefits to hospital activity previously. This has involved the application of a defined ruleset to classify PBS claims as compliant. Similar matching could be utilised by IHPA in order to match on only compliant claims.
Research stream	Knowledge of the current state
Reference	1. NHFB (2013); Business rules for determining July to December 2012 hospital services eligible for Commonwealth funding – Volume 1 Proof of Concept; <https://www.publichospitalfunding.gov.au/Media/Business%20Rules%20Volume%201.pdf> 2. NHFB (2013); Business rules for determining 2012-13 hospital services eligible for Commonwealth funding – Volume 2 Extended proof of concept; <https://www.publichospitalfunding.gov.au/Media/Business%20Rules%20Volume%202.pdf>
1.1.2 Probabilistic matching using Expectation-Maximization algorithm	
Description of technique	The Expectation-Maximisation (E-M) algorithm can be used to impute missing data by making a best estimate based on other complete data points. The E-M approach reflects the underlying relationships of variables within the data. An iterative approach is undertaken in order to optimise the results of maximum likelihood procedures.
Example study/use	1. Research paper comparing the benefits and disadvantages of a number of statistical imputation techniques. 2. Research paper exploring types of missing data in healthcare research, and methods for imputation
Research stream	Statistical focused research
Reference	1. Aljuaid, T, et al (2013); Gannon University, Proper Imputation Techniques for Missing Values in Data sets; <https://www.researchgate.net/publication/312568863_Proper_imputation_techniques_for_missing_values_in_data_sets> 2. Myrah Stockdale and Kenneth Royal (2016); Missing data as a validity threat for medical and healthcare education research: Problems and solutions; <http://dx.doi.org/10.5430/ijh.v2n2p67>
1.1.3 Imputation using mean of reliable data	
Description of technique	The mean method imputes missing data by taking the mean of all complete values of that variable.
Example study/use	Research paper comparing the benefits and disadvantages of a number of statistical missing data imputation techniques.

Research stream	Statistical focused research
Reference	Peter Schmitt, Jonas Mandel and Mickael Guedj (2015); A Comparison of Six Methods for Missing Data Imputation, Journal of Biometrics & Biostatistics, <https://www.omicsonline.org/open-access/a-comparison-of-six-methods-for-missing-data-imputation-2155-6180-1000224.pdf>
1.1.4 Imputation using KNN method	
Description of technique	The K-nearest neighbour (KNN) techniques defines for each sample or individual a set of similar data points (K-nearest neighbours). Missing data is then imputed for a given variable by averaging the non-missing values of its neighbours.
Example study/use	Research paper comparing the benefits and disadvantages of a number of statistical imputation techniques.
Research stream	Statistical focused research
Reference	Aljuaid, T, et al; Gannon University, Proper Imputation Techniques for Missing Values in Data sets; <https://www.researchgate.net/publication/312568863_Proper_imputation_techniques_for_missing_values_in_data_sets>

Methodology area 1.2: Hospital Casemix Protocol matching methodology

Hospital Casemix Protocol (HCP) matching methodology and inflation of costs to reflect private patient costs that are missing from the NHCDC	
Current approach: Match HCP data at a patient level, including imputation of missing benefits based on non-missing values by classification. Offset NHCDC costs by matched/imputed benefits.	
1.2.1 Imputation of medical and ancillary benefits based on facilities with complete reporting only	
Description of technique	For private ancillary benefits, calculate the benefits proportion based only on facilities which are known to report the full cost within their NHCDC data (i.e. facilities with complete data). Alternatively, scale up the NHCDC costs for facilities which do not report full ancillary benefits, prior to calculating the proportion.
Example study/use	Research on the imputation of missing data in health research. Specifically discusses use of Bayesian techniques to appropriately leverage partially observed variables.
Research stream	Knowledge of the current state
Reference	Sterne, et al; Multiple imputation for missing data in epidemiological and clinical research: potential and pitfalls; <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2714692/>
1.2.2 Stratification for imputing private patient costs	
Description of technique	Scale up private patient costs based on a stratification of data. Define the strata based using factors found to be influential in driving the level of private benefits. For example, consider stratification by regional area or jurisdiction.
Example study/use	Stratification used elsewhere within the pricing models – for example in the sample to population scaling process.
Research stream	Knowledge of the current state
Reference	IHPA (2018); National Pricing Model Technical Specifications; <https://www.ihpa.gov.au/sites/g/files/net636/f/publications/national_pricing_model_technical_specifications_2018-19.docx>
1.2.3 Scaling of matched data using logistic regression for ancillary costs	
Description of technique	Fit a logistic regression to the available data to derive the probability that the NHCDC cost data contains the ancillary benefits in full, for those facilities which have stated they partially report benefits. This regression will be fit based on the activity for which it is known that the NHCDC cost data either fully contains the ancillary benefits, or does not contain any ancillary benefits. The inverse of the probability can then be used to scale up the NHCDC costs for activity where partial data is reported.
Example study/use	Examination of the application of non-response adjustments obtained by modelling response propensity. The approach is described as: dependent variable is defined as 0 (non-response) or 1 (response), a logistic model is run, and the non-response adjustment factor is the inverse of the predicted response propensity using the estimates from the logistic regression.
Research stream	Knowledge of the current state
Reference	Stas Kolenikov (2016); Post-stratification or non-response adjustment; <https://www.surveypractice.org/article/2809-post-stratification-or-non-response-adjustment>

Methodology area 1.3: Outlier identification and treatment

Identification and treatment of outliers for all models	
Current approach: Remove outliers using pre-defined thresholds, which are constant across classifications within service categories.	
1.3.1 Removal of outliers using studentised residuals and a defined threshold	
Description of technique	The studentised deleted residual statistic is widely used in regression modelling for outlier identification. It involves deleting observations one at a time, each time refitting the regression model on the remaining observations. The formula for the deleted residual is: $t_i = \frac{d_i}{s(d_i)}$, where d_i is the value of the deleted residual and $s(d_i)$ is its estimated standard deviation.
Example study/use	Study that looks at the use of a regression method in SAS to identify outliers in Korean monthly labour statistics data.
Research stream	Statistical focused research
Reference	Jinyoung Kim, Key-Il Shin; Multiple imputation reducing outlier effect by weight adjustment method; <https://www.statistics.gov.hk/wsc/CPS106-P6-S.pdf>
1.3.2 Removal of outliers using an alternative (e.g. centroid or simple average) distance-based approach	
Description of technique	The LR-Firth method is a logistic regression where the estimator is bias-corrected. A trimmed mean can be used when identifying outliers by comparing data points to a form of the average.
Example study/use	Study that looks at the use of logistic regression to identify outliers in hospital mortality data.
Research stream	Sector focused research
Reference	Kristoffersen DT, Helgeland J, Clench-Aas J, Laake P, Veierød MB (2018); Observed to expected or logistic regression to identify hospitals with high or low 30-day mortality?; <https://doi.org/10.1371/journal.pone.0195248>
1.3.3 Outlier visualisation techniques such as box plots and scatter plots	
Description of technique	Informal outlier visualisation techniques include interquartile range techniques (box plots), scatterplots, probability plots etc.
Example study/use	Study that looks at use of the techniques in medical datasets.
Research stream	Statistical focused research
Reference	Jorma Laurikkala, Martti Juhola and Erna Kentala; Informal identification of outliers in medical data; <http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.36.7407&rep=rep1&type=pdf>
1.3.4 Retention of outliers, without adjustment	
Description of technique	Unless it is known that points are erroneous, retain all values rather than deleting them.
Example study/use	Study on the effect of outliers within interval estimation, in the context of health data.
Research stream	Knowledge of the current state
Reference	Horn, P S, et al (2001); Effect of Outliers and Nonhealthy Individuals on Reference Interval Estimation; <http://clinchem.aaccjnls.org/content/47/12/2137>

1.3.5 Retention of outliers, using studentised residuals and reduced weights	
Description of technique	See 1.3.1 above for notes on using studentised residuals for outlier identification. An example weight adjustment method for weighting outliers versus non-outliers: $w^f = \begin{cases} w^f = 0 & for\ outliers \\ w\left(\frac{n}{n-k}\right) = w\left(1+\frac{k}{n-k}\right) & for\ non-outliers \end{cases}$, where w is the design weight assigned to values and f is an outlier weight adjustment factor.
Example study/use	See 1.3.1. The study also notes that the weight adjustment method chosen does not depend on the underlying population types and outlier detection methods.
Research stream	Statistical focused research
Reference	See 1.3.1.
1.3.6 Use of multiple years data, combined with a credibility theory approach	
Description of technique	Credibility theory blends the content of various data sources, and a weighted average of the data is calculated, with the weights developed according to the reliability of the data (in terms of inherent variation in the data points, volume of data, how recent it is, known anomalies etc.).
Example study/use	Actuarial standard of practice in the use of credibility procedures
Research stream	Knowledge of current state
Reference	Actuarial Standards board (2013); Credibility procedures; <http://www.actuarialstandardsboard.org/wp-content/uploads/2014/02/asop025_174.pdf>
1.3.7 Principal Component Analysis to reduce dimensions of the data	
Description of technique	Principle Components Analysis (PCA) is a dimension-reduction tool that can be used to reduce a large set of variables to a small set that still contains most of the information in the large set. The first component extracted accounts for the largest amount of total variation in the data. Subsequent components have less variation and data in these can be considered outliers.
Example study/use	Paper that discusses use of PCA in high dimensional data for outlier detection. It mainly considers its use for spatiotemporal data.
Research stream	Statistical focused research
Reference	Alka Bhushan, Monir H. Sharker, Hassan A. Karimi (2015); Incremental principal component analysis based outlier detection methods for spatiotemporal data streams; <https://www.isprs-ann-photogramm-remote-sens-spatial-inf-sci.net/II-4-W2/67/2015/isprsannals-II-4-W2-67-2015.pdf>
1.3.8 Cluster analysis to determine groups of data points that sit at the extremes	
Description of technique	This technique classifies data to different clusters and data points which are not members of any of known clusters are considered outliers. Examples of clustering techniques K-means and PAM (Partitioning Around Medoids). The latter uses the most centrally located object in a cluster (medoid) instead of the cluster mean.
Example study/use	The study compares K-means and PAM and finds that the former is sensitive to outliers and the latter produces better class separation. However, PAM is computationally intensive as it is iterative.
Research stream	Statistical focused research
Reference	Vijay Kumar, Sunil Kumar, Ajay Kumar Singh (2013); Outlier Detection: A Clustering-Based Approach; <https://pdfs.semanticscholar.org/c2f9/bbb699269779aff0259ba2e03e2aaac0d1aa.pdf>

1.3.9 Robust regression to limit the influence of outliers	
Description of technique	A key purpose of robust regression is to provide stable results in the presence of outliers by limiting their influence. The methods most commonly used today for outlier detection within robust regression are Humber M estimation, high breakdown value estimation and combinations of these methods.
Example study/use	The study uses the ROBUSTREG procedure in SAS to analyse an example dataset of the national growth of several countries.
Research stream	Statistical focused research
Reference	Colin Chen, SAS Institute Inc.; Robust Regression and Outlier Detection with the ROBUSTREG Procedure; <https://pdfs.semanticscholar.org/ccb3/3dfc93f60ddb9f488533b8d85081c550a7d8.pdf>
1.3.10 Retention of outliers, with adjustments to be made in the calculation of the base price weight through bootstrapping	
Description of technique	Bootstrapping resamples from sample data to create an approximation or best estimate of the population i.e. it approximates the sampling distribution of the sample statistics. Confidence limits need to be set.
Example study/use	1. Study that looks at the effect of outliers within interval estimation, in the context of health data. 2. Study that looks at the application of bootstrapping for determining statistics such as the mean and median of various example dataset of modest sample size.
Research stream	Knowledge of the current state
Reference	1. Horn, P S, et al (2001); Effect of Outliers and Nonhealthy Individuals on Reference Interval Estimation; <http://clinchem.aaccjnls.org/content/47/12/2137> 2. Kesar Singh and Ming Xie (2010); Bootstrap: A Statistical Method; <http://www.stat.rutgers.edu/home/mxie/rcpapers/bootstrap.pdf>

Methodology area 1.4: WIP patients

Methodology to account for episodes admitted or discharged outside of the financial year	
Current approach: Scale up non-WIP activity using weights based on the count of WIP activity by length of stay quartiles.	
1.4.1 Weights based on Length of Stay	
Description of technique	Within LOS groups, weight non-WIP activity up to account for missing cost data for WIP activity. The weights will be calculated as the ratio of the total length of stay within the full activity to the total length of stay within the non-WIP activity, by LOS group.
Example study/use	Review of the IHPA cost models. Found that within the highest LOS group, the ALOS was higher across all high volume DRGs if WIP patients were included in the calculation. Various other
Research stream	Knowledge of the current state
Reference	EY (2017); Validation of the 2014-15 ABF and Block Funded Cost Models; provided to IHPA previously
1.4.2 Credibility theory for cost imputation, leveraging available WIP cost data	
Description of technique	Most jurisdictions provide cost data associated with costs incurred in this financial year, for activity with an admission date prior to the beginning of the financial year. This technique makes use of this data, in combination with the available non-WIP cost data for similar activity. The credibility weighting will be proportional to the proportion of the overall stay which occurred within this financial year.
Example study/use	1. Report summarising findings of an independent review of the NHCDC cost data. Specific detail is available around the comprehensiveness of the WIP activity cost data. Similar reports are available for other cost rounds. 2. Standards documentation covering the use of credibility procedures
Research stream	Knowledge of the current state
Reference	1. KPMG (2017); Round 19 Independent Financial Review of the National Hospital Cost Data Collection; <https://www.ihpa.gov.au/sites/g/files/net636/f/publications/d17-1839_ihpa_nhcdc_ifr_round19_final_report_february_2017.pdf> 2. Actuarial Standards Board (2013); Credibility Procedures; <http://www.actuarialstandardsboard.org/wp-content/uploads/2014/02/asop025_174.pdf>
1.4.3 Scaling WIP data using logistic regression	
Description of technique	Fit a logistic regression to the available data of WIP and non-WIP activity to derive the probability that the separation is a non-WIP stay. The regression will be used to determine the significant factors for determining this probability. The inverse of the probability can then be used to scale the existing non-WIP activity and costs for WIP separations.
Example study/use	Examination of the application of non-response adjustments obtained by modelling response propensity. The approach is described as: dependent variable is defined as 0 (non-response) or 1 (response), a logistic model is run, and the non-response adjustment factor is the inverse of the predicted response propensity using the estimates from the logistic regression.
Research stream	Knowledge of the current state
Reference	Stas Kolenikov (2016); Post-stratification or non-response adjustment; <https://www.surveypractice.org/article/2809-post-stratification-or-non-response-adjustment>

1.4.4 Including all WIP patients in the pricing model, in line with the approach used for non-WIP patients	
Description of technique	Reporting of costs for WIP patients has improved over time, with the NHCDC data becoming more complete and improvements in consistency in reporting between jurisdictions. Full use of the WIP NHCDC data in the pricing model will better reflect the true costs of these patients, and incentivise jurisdictions to report WIP costs in their entirety in the future.
Example study/use	Report summarising findings of an independent review of the NHCDC cost data. Specific detail is available around the comprehensiveness of the WIP activity cost data. Similar reports are available for other cost rounds.
Research stream	Knowledge of the current state
Reference	KPMG (2017); Round 19 Independent Financial Review of the National Hospital Cost Data Collection; <https://www.ihpa.gov.au/sites/g/files/net636/f/publications/d17-1839_ihpa_nhcdc_ifr_round19_final_report_february_2017.pdf>

Methodology area 1.5: Sample-to-population weighting of cost data

Sample-to-population weighting of cost data	
Current approach: Scale up activity with matched NHCDC cost data, using weights based on the count of non-matched activity by state, hospital size and type.	
1.5.1 Weighting using matching, raking and propensity weighting techniques	
Description of technique	Raking is a weighting procedure in which a set of variables in a population dataset (that relates to the sample dataset) is chosen where the population distribution is known. The method iteratively adjusts the weights for each record until the sample distribution aligns with the population for the chosen variables. Matching adjusts samples by creating a target sample dataset that is representative of the population and has all of the variables to be used in adjustment. Matching is performed by fitting a statistical model (e.g. random forest) to determine the level of similarity between the 'target' sample and the sample itself. The final matched dataset contains the cases in which a match is determined. Propensity weighting involves the calculation of probabilities that cases come from the population or the sample. Techniques such as random forests or even logistic regression can be used to calculate these probabilities. The weight is equal to the estimated probability it comes from the population divided by the probability it comes from the sample. Cases underrepresented relative to their share of the population receive large weights; cases overrepresented receive lower weights. All three techniques can be used for generating weights, however raking alone may be sufficient when the sample size is large.
Example study/use	Research studies comparing the effectiveness of various statistical techniques for choosing variables and calculating sample weights so that the sample resembles the population.
Research stream	Statistical focused research
Reference	1. Leyla Mohadjer, John Burke, James Green, and Joseph Waksbera; Weighting and population estimates; <https://nces.ed.gov/pubs2001/2001457_3.pdf> 2. Pew Research Center (2018); For Weighting Online Opt-In Samples, What Matters Most?; <http://www.pewresearch.org/2018/01/26/for-weighting-online-opt-in-samples-what-matters-most/>
1.5.2 Weighting using stratification based on the PCA method	
Description of technique	Principle component analysis can be applied to remove redundant and irrelevant variables in data so that the dataset can be reduced to a smaller number of variables that preserve as much of the information as possible. This can be used as a way of stratifying sample data appropriately.
Example study/use	Research study that examines various ways of performing dimension reduction on high-dimensional microarray data.
Research stream	Statistical focused research
Reference	Pritam Sahaa, Nabanita Roya, Deotima Mukherjeea, Ashoke Kumar Sarkarb,(2016); Application of Principal Component Analysis for Outlier Detection in Heterogeneous Traffic Data; <https://core.ac.uk/download/pdf/82714554.pdf>
1.5.3 Imputation using Support Vector Machine (SVM)	
Description of technique	Support Vector Machine is a machine learning algorithm that can be used for missing value imputation. It enables classification of data and subsequent imputation within these classifications.

Example study/use	The aim of this paper is to examine whether a combination of instance selection from the observed medical data and missing value imputation offers better performance than performing missing value imputation alone.
Research stream	Sector focused research
Reference	Min-Wei Huang, Wei-Chao Lin, and Chih-Fong Tsai (2018); Outlier Removal in Model-Based Missing Value Imputation for Medical Datasets; <https://doi.org/10.1155/2018/1817479>
1.5.4 Imputation using a bootstrapping method	
Description of technique	Bootstrapping resamples from sample data to create an approximation or best estimate of the population i.e. it approximates the sampling distribution of the sample statistics such as mean and variance. Confidence limits need to be set.
Example study/use	The study looks at the application of bootstrapping for determining statistics such as the mean and median of various example dataset of modest sample size.
Research stream	Sector focused research
Reference	Kesar Singh and Ming Xie (2010); Bootstrap: A Statistical Method; <http://www.stat.rutgers.edu/home/mxie/rcpapers/bootstrap.pdf>

Methodology area 1.6: Use of previous years' financial data

Current approach: Use of prior years' data for sample size boosting.

No alternative techniques were identified.

Methodology area 1.7: Data cleansing

Data cleansing	
Current approach: Undertake a series of data cleansing steps including removal of irrelevant costs and application of ad-hoc adjustments specific to service categories.	
1.7.1 Data cleansing framework	
Description of technique	Application of a data cleansing framework will identify gaps in the current process while highlighting best practice techniques. It would provide structure to the code, and clarity around the process.
Example study/use	Describes data cleaning as the “entirety of operations performed on existing data to remove anomalies and receive a data collection being an accurate and unique representation of the mini-world”. References work of other academics where the major steps within data cleaning are described as: 1. Defining and determining error types 2. Searching and identifying error instances 3. Correcting the uncovered errors 4. Post-processing and controlling
Research stream	Knowledge of the current state
Reference	Li, Lin (2012); Data Quality and Data Cleaning in Database Applications; https://pdfs.semanticscholar.org/f551/918d57f83f4092e291378f567b25bc614e29.pdf
1.7.2 Statistical Process Control	
Description of technique	Statistical Process Control (SPC) can help monitor process behavior. An example of an SPC tool is the control chart which helps record data and identify unusual or anomaly events by distinguishing between two types of variation (common cause and special cause).
Example study/use	SPC and the control chart can provide researchers and practitioners with a method of understanding and communicating data from healthcare efforts. It combines time series analysis methods with graphical representation of data, yielding quick and understandable insights into the data for decision-making.
Research stream	Knowledge of the current state
Reference	J C Benneyan, R C Lloyd, P E Plsek; Statistical process control as a tool for research and healthcare improvement; <https://qualitysafety.bmj.com/content/12/6/458>

Appendix D.2 Base price weight calculation

Methodology area 2.1: Admitted pricing – inlier and outlier methodology

Use of same day, short stay outlier, inlier, and long stay outlier methodology in subacute and acute cost models	
Current approach: Activity is classified as one of the four separation types. Funding is then determined based on the separation category, with both fixed price and per diem approaches utilised.	
2.1.1 Long Stay Outlier per diems as a proportion of the average inlier cost	
Description of technique	Calculation of long stay outlier payments as a percentage of the average daily price for an inlier. Various percentages have been implemented, including 75% (France), 80% (Victoria – Medical patients) and 70% (Victoria - Surgical patients)
Example study/use	1. Plan for Belgian hospital funding, including summary of the outlier bound definition and per diem definitions in European health systems. 2. Victoria funding for acute hospital activity
Research stream	1. Sector focused research 2. Knowledge of the current state
Reference	1. Stephani V, et al (2018); Payment methods for hospital stays with a large variability in the care process; <https://kce.fgov.be/sites/default/files/atoms/files/KCE_302_Payment_methods_hospital_stays_Report_0.pdf> 2. Victoria DHHS (2011); Victorian Health Policy and Funding Guidelines - Part 3: Technical guidelines; < https://www2.health.vic.gov.au/about/publications/policiesandguidelines/Victorian-Health-Policy-and-Funding-Guidelines---Part-3-Technical-guidelines>
2.1.2 Per diem system for subacute activity, by care type	
Description of technique	Use of simple per diem system for subacute activity, by care type. This could be calculated as the average per diem cost for subacute activity of that care type.
Example study/use	Feedback from jurisdictions on the complexity of the subacute pricing model – "The AN-SNAP classification is vastly more complicated than needed, and adds little explanatory power when compared with the simpler combination of care type and per diem payment system."
Research stream	Knowledge of the current state
Reference	Queensland Health (2017); Consultation Paper on the Pricing Framework for Australian Public Hospital Services 2018-19 - Queensland submission to the Independent Hospital Pricing Authority; <https://www.ihpa.gov.au/sites/g/files/net4186/f/department_of_health_queensland_submission.pdf>
2.1.3 Use of median cost for the inlier price weight instead of the mean cost	
Description of technique	Calculation of inlier price as a percentile of the prices for activity of that classification type, rather than the mean. Examples include median or lower quartile.
Example study/use	1. Canadian Institute for Health Information (CIHI) summarises the recommended application of ABF within Canada (note that this is implemented at a province level, so not nationwide). Part of this recommends benchmark pricing based on a trim point or a ranking (e.g. lowest quartile) to incentivise efficiency. References example of ABF in Victoria in early 90s which utilised a below-average cost pricing system. 2. NHS investigation of national tariff for specific services. Recommend use of weighted median cost to derive national price, rather than weighted mean. This lessens the impact of high cost outliers, which skew the mean.
Research stream	1. Sector focused research 2. Sector focused research

Reference	1. Canadian Institute for Health Information (2013); The Why, the What and the How of Activity-Based Funding in Canada: A Resource for Health System Funders and Hospital Manager, <https://secure.cihi.ca/free_products/ActivityBasedFundingManualEN-web_Nov2013.pdf> 2. FTI Consulting (2015); Establishing a relationship between provider costs and national prices Final Report; <https://improvement.nhs.uk/documents/495/Establishing_a_relationship_between_provider_costs_and_national_prices.pdf>
2.1.4 Bootstrapping to determine the mean cost	
Description of technique	See 1.3.10
Example study/use	
Research stream	
Reference	
2.1.5 Stochastic Frontier Analysis to define the efficient price	
Description of technique	Stochastic Frontier Analysis (SFA) involves the parametric estimation of a production function across all public hospitals. This makes consideration of various inputs and outputs into the delivery of hospital services, providing an estimation of the technical and allocative efficiency of the system. These analysis outputs can be used to derive an understanding of the truly efficient cost of service delivery, with the assumption that some facilities in the system are operating at or close to full efficiency. This analysis can further make consideration of contextual factors which may influence the inputs required for service delivery – for example, the remoteness status of the facility or proportion of indigenous patients.
Example study/use	Paper exploring the measurement of productivity within public hospitals in Australia.
Research stream	Knowledge of the current state
Reference	Productivity Commission (2008); Assessing productivity in the delivery of public hospital services in Australia: Some experimental estimates; <https://www.pc.gov.au/research/supporting/public-hospital-productivity/public-hospital-productivity.pdf>
2.1.6 Innovation funding for new treatment methods, on application	
Description of technique	Discretionary provision of additional funding to hospitals to fund new and innovative treatment methods in public hospitals.
Example study/use	Presentation summarising the hospital payment methods utilised within Germany.
Research stream	Knowledge of the current state.
Reference	Mannheim Institute of Public Health; Understanding the German Healthcare System; <http://miph.umm.uni-heidelberg.de/miph/upload/pdf/GHCS_Kap._6.pdf>

Methodology area 2.2: Admitted pricing – L3H3 and L1.5H1.5

Use of L3H3 methodology and L1.5H1.5 methodology in subacute and acute cost models	
Current approach: The average length of stay is currently utilised as the basis for deriving the inlier bounds, from which activity is classified into separation categories. For most activity these bounds are calculated as 1/3 of the ALOS and 3 times the ALOS. For activity with longer ALOS, these are calculated as 2/3 the ALOS and 1.5 times the ALOS.	
2.2.1: Cost based thresholds	
Description of technique	Quantification of long stay outlier threshold in terms of cost rather than length of stay. Funding is then determined as 90% of the difference between the actual cost and the threshold cost. This requires the cost data to be collected and known prior to the provision of funding. Note that this is not possible in the Australian context given the delay in provision of cost data.
Example study/use	Reimbursement for Ohio inpatient hospital activity
Research stream	Sector focused research
Reference	Ohio Hospitals Association (2018); Medicaid Hospital Reimbursement 101 & Franchise Fee Update Webinar; <https://www.ohiohospitals.org/getmedia/64d16c86-aaac-4880-85e5-3f3399c58e22/HEP-Webinar-Presentation-4-10-18.aspx>
2.2.2 Calculation of bounds using LOS interquartile range	
Description of technique	Within the UK and Denmark, the inlier upper bound is calculated as: Q75 + (Q75 – Q25)*1.5
Example study/use	Plan for Belgian hospital funding, including summary of the outlier bound definition and per diem definitions in European health systems.
Research stream	Sector focused research
Reference	Stephani V, et al (2018); Payment methods for hospital stays with a large variability in the care process; <https://kce.fgov.be/sites/default/files/atoms/files/KCE_302_Payment_methods_hospital_stays_Report_0.pdf>
2.2.3 Calculation of bounds using linear spline fit to LOS	
Description of technique	Fit linear spline (with two knots) to the data with LOS as predictor and cost as response. Use these knots as the trim points for SSO and LSO, beyond which there is a different relationship observed between LOS and cost.
Example study/use	An actuarial focused study of the methods utilised within general insurance pricing.
Research stream	Knowledge of the current state
Reference	Anderson, et al (2007); GRIP - General Insurance Premium Rating Issues Working Party; <https://www.actuaries.org.uk/documents/general-insurance-premium-rating-issues-working-party-grip-report-final-version>
2.2.4 Calculation of bounds using percentiles of gamma distribution	
Description of technique	This technique fits a gamma distribution to the length of stay. Bounds are then derived based on the mean and 98th percentile of the distribution. Note that this did not result in the desired spread in bounds.
Example study/use	Investigation of ways to calculate trim points for acute admitted care, using Swiss APDRG classifications.
Research stream	Sector focused research
Reference	Schenker, L, et al (2003); Cost-weights version 4.1, APDRG Suisse; <http://www.apdrgsuisse.ch/public/fr/o_rapport_cw_v41_e.pdf>

2.2.5 Use of $L\alpha H\beta$, fit to data	
Description of technique	This technique flexes the values of α and β to create the desired spread in activity across the separation categories. Analysis required restrictions on the proportion of outliers detected, as well as knowledge of the hierarchy of DRGs. This enabled investigation of output for reasonableness, with higher complexity DRGs expected to receive higher inlier cost weights.
Example study/use	Investigation of ways to calculate trim points for acute admitted care, using Swiss APDRG classifications.
Research stream	Sector focused research
Reference	Schenker, L, et al (2003); Cost-weights version 4.1, APDRG Suisse; <http://www.apdrgsuisse.ch/public/fr/o_rapport_cw_v41_e.pdf>
2.2.6 Calculation of bounds using 10th and 95th percentiles	
Description of technique	The low trim point for inliers is calculated as the 10^{th} percentile of the empirical distribution. The high trim point for inliers is calculated as the 95^{th} percentile. Implementation of this alternative technique will involve investigation into the appropriateness of these percentiles, as well as potential alternative thresholds.
Example study/use	Iranian report exploring alternative methodologies for defining the trim points, for funding in an admitted setting. Explores the potential use of L3H3, IQR and 10th-95th percentiles.
Research stream	Sector focused research
Reference	Ghaffari, S; et al (2010); Trialling diagnosis-related groups classification in the Iranian health system: A case study examining the feasibility of introducing casemix; <https://www.ncbi.nlm.nih.gov/pubmed/20799543>
2.2.7 Calculation of bounds using adjusted LOS interquartile range	
Description of technique	The inlier upper bound is defined as: $$Q3 + multiplier * (Q3 – Q1)$$ Whereby the multiplier is determined such that 4.5% of cases are classified as long stay outliers.
Example study/use	Canadian Institute for Health Information (CIHI) summarises the recommended application of ABF within Canada (note that this is implemented at a province level, so not nationwide).
Research stream	Sector focused research
Reference	Canadian Institute for Health Information (2013); The Why, the What and the How of Activity-Based Funding in Canada: A Resource for Health System Funders and Hospital Manager, <https://secure.cihi.ca/free_products/ActivityBasedFundingManualEN-web_Nov2013.pdf>
2.2.8 Removal of SSO threshold	
Description of technique	Within the UK and Denmark, there is no inlier lower bound (i.e. no short stay outliers). In many countries lower limits have been removed over time to encourage same day care.
Example study/use	Plan for Belgian hospital funding, including summary of the outlier bound definition and per diem definitions in European health systems.
Research stream	Sector focused research
Reference	Stephani V, et al (2018); Payment methods for hospital stays with a large variability in the care process; <https://kce.fgov.be/sites/default/files/atoms/files/KCE_302_Payment_methods_hospital_stays_Report_0.pdf>

Methodology area 2.3: Subacute pricing – care type per diems

Care type per diems in the subacute cost model	
Current approach: Paediatric palliative care is currently funded through a purely per diem mechanism. This is required due to insufficient data to develop the inlier and outlier methodology.	
2.3.1 To price Paediatric Palliative care, supplement with last year's data	
Description of technique	Scale up prior year costs (i.e. 4 years ago) using indexation assumptions, and leverage within this year's development of price. This increases the sample size to enable use of a pricing approach consistent with other Subacute care types.
Example study/use	Prior data is used elsewhere within the pricing models – for example in the acute admitted pricing model, to increase the size of the sample for low volume DRGs.
Research stream	Knowledge of the current state
Reference	IHPA, Acute Model Expert Guide - 20140305, <provided by IHPA>
2.3.2 To price Paediatric Palliative care, use a fixed base plus per diem price	
Description of technique	Apply a fixed baseline plus per diem approach to funding. This makes consideration of fixed costs, which may not be adequately for short stays under a strictly per diem approach. The fixed cost and per diem amounts can be derived through a regression. This can be accompanied by analysis of the operating room, SPS and Prosthesis costs as reported in the NHCDC (underlying fixed costs).
Example study/use	A fixed base cost plus per diem approach is currently utilised to fund short stay outliers within the admitted activity models.
Research stream	Knowledge of the current state
Reference	IHPA (2018); National Pricing Model Technical Specifications; <https://www.ihpa.gov.au/sites/g/files/net636/f/publications/national_pricing_model_technical_specifications_2018-19.docx>
2.3.3 To price all Subacute activity, use a fixed base plus per diem price	
Description of technique	See 2.1.2
Example study/use	
Research stream	
Reference	

Methodology area 2.4: Non-admitted pricing – use of multiple data sources

Use of multiple years and different sources of data, in the non-admitted model	
Current approach: The non-admitted model leverages cost data across multiple sources and years, to account for low reporting and instability in the NHCDC	
2.4.1 Credibility theory	
Description of technique	Credibility theory blends the content of various data sources, in this case to derive an assumption on cost. A weighted average of data is calculated, with weights developed according to the variation in the data points as well as the volume of data. The intention is to gradually move to using the NHCDC cost data over time, once there is sufficient volume and stability in the data source. Until this point, the weighted average will place lower weighting on the NHCDC data and greater weighting on the alternative data sources.
Example study/use	1. Actuarial standard of practice in the use of credibility procedures 2. Use of credibility theory to price within group medical insurance
Research stream	1. Knowledge of current state 2. Statistical focused research
Reference	1. Actuarial Standards board (2013); Credibility procedures; <http://www.actuarialstandardsboard.org/wp-content/uploads/2014/02/asop025_174.pdf> 2. Fuhrer, C (2015); A Practical Approach to Assigning Credibility for Group Medical Insurance Pricing; <https://www.soa.org/research-reports/2015/2015-practical-approach-credibility-group-medical-insurance/>

Methodology area 2.5: Emergency Department pricing – concurrent calculation

Concurrent calculation of price weights for different classifications applicable to the emergency cost model	
Current approach: URG prices are calibrated against the UDG prices, equalising the weighted average PW under the URG classifications with the PW under the mapped UDG classification	
2.5.1 Set UDG price weight to a percentile of the URG price weights (e.g. minimum, 25th percentile)	
Description of technique	Calculate the URG price weights in line with the current approach. Assign the UDG price weight as either: - The minimum of the URG price weights, for the URGs that map to the given UDG - The 25th percentile of the URG price weights, for the activity which maps to the given UDG This will provide an incentive for facilities to report activity at a URG level. Additionally it will remove the perverse incentive to report at a UDG level if the activity is of lower complexity, which would lead to the allocation of a lower price weight if reported at a URG level.
Example study/use	N/A
Research stream	Knowledge of the current state
Reference	N/A
2.5.2 Stratify data by remoteness grouping prior to calibrating the URG average cost against UDG average cost	
Description of technique	Group data based on the remoteness grouping of the facility, prior to calibrating the URG average cost against the UDG average cost. This requires a separate scaling factor to be calculated for each remoteness grouping and UDG combination. This will account for differences in case mix between facilities of differing levels of remoteness. The current approach implicitly assumes that – at a national level – the case mix of activity reported at a URG level is the same as the case mix of activity reported at a UDG level. This may not be the case if particular facility types are more likely to report at certain levels.
Example study/use	Stratification used elsewhere within the pricing models – for example in the sample to population scaling process.
Research stream	Knowledge of the current state
Reference	IHPA (2018); National Pricing Model Technical Specifications; <https://www.ihpa.gov.au/sites/g/files/net636/f/publications/national_pricing_model_technical_specifications_2018-19.docx>

Appendix D.3 Adjustments

Methodology area 3.1: Adjustments for unavoidable variations in costs

Adjustments for legitimate and unavoidable variation in costs, including hospital eligibility criteria, as specified in the 2018-19 NEP Determination	
Current approach: Unavoidable variations in cost are currently reflected through patient level adjustments. Where appropriate, adjustments are calculated using the patient level cost ratios at the relevant step of the modelling process. This is to account for any cost variation explained by the preceding model steps	
3.1.1 GLM of cost against adjustment factors, with interaction factors (current adjustments only)	
Description of technique	Regression on the current adjustment factors using a log link transformation with a gamma error distribution, with the allowance for interactions between the factors. Although the gamma distribution with a log link is commonly used in healthcare to address the skewness of the data, other models can also be considered.
Example study/use	1. Study comparing GLMs and ordinary least squares regression (OLS) in predicting individual patient costs in intensive care units. 2. UK Institute of Actuaries of paper reviewing premium rating issues from an actuarial involvement perspective, including the role of GLMs fit to claims experience for determining relative premium rates by rating factors.
Research stream	Knowledge of the current state
Reference	1. Moran et al (2006); New models for old questions: generalized linear models for cost prediction; <http://www.maths.adelaide.edu.au/patty.solomon/Online_early.pdf> 2. Anderson et al (2007); General Insurance Premium Rating Issues Working Party; <http://www.actuaries.org.uk/documents/general-insurance-premium-rating-issues-working-party-grip-report-final-version>
3.1.2 GLM of cost against adjustment factors, with interaction factors (additional adjustments considered)	
Description of technique	Investigation of alternative statistically significant drivers of unavoidable variation in cost – for example through one way tables, correlations, statistical significance of variables in simple OLS regressions. These factors can then be incorporated with the existing adjustment factors in a regression using a log link transformation with a gamma error distribution (or other model), with the allowance for interactions between the factors.
Example study/use	See 3.1.1. Additionally, various stakeholder consultation papers (2018-19 and 2019-20) with feedback and recommendations of additional adjustments to consider.
Research stream	Knowledge of the current state
Reference	See 3.1.1. Various submission papers to IHPA during the annual consultation process on the Pricing Framework. In particular, see the following links: 1. https://www.ihpa.gov.au/consultation/past-consultations/pricing-framework-australian-public-hospital-services-2018-19 2. https://www.ihpa.gov.au/consultation/past-consultations/pricing-framework-australian-public-hospital-services-2019-20
3.1.3 Fixed 'incremental' dollar amounts for select adjustments instead of percentages	
Description of technique	Consideration of fixed dollar amounts to adjust for remoteness, Indigenous status etc. in a similar way that this is done for ICU and HACs. This should be utilised where the additional cost of service delivery for the specific cohorts will be close to constant, irrespective of the underlying service performed
Example study/use	1. IHPA consultation papers that seek a better understanding of the impact of current adjustments

	2. Paper that discusses quantification of variation of Australian acute-care costs (those that are legitimate and unavoidable) as a means of controlling cost of healthcare, given data availability and within the context of growing budgetary pressures for Government.
Research stream	Knowledge of the current state
Reference	1. Consultation papers 2018-19 and 2019-20 (IHPA) 2. Weidmann, B, et al. (2014); Quantifying variation in Australian acute-care costs; <https://grattan.edu.au/wp-content/uploads/2014/03/807-costly-care-technical-supplement.pdf>
3.1.4 K-means clustering to identify groups of variation in the data	
Description of technique	K-means clustering (or a potential variation of this technique, G-means clustering) for creating clusters in the data based on the level of similarities between data points. These groups aim to capture as much variation in the data as possible.
Example study/use	Study that looks at clustering / classification techniques for discovering patterns in healthcare data. The study experiments with an example survey dataset for illustration of the G-means algorithm that minimizes the computation effort required in clustering when dealing with large datasets.
Research stream	Knowledge of the current state
Reference	R Haraty et al (2015); An Enhanced K-means Clustering Algorithm for Pattern Discovery in Healthcare Data; <https://journals.sagepub.com/doi/full/10.1155/2015/615740>

Methodology area 3.2: Private Patient Adjustments

Adjustments for legitimate and unavoidable variation in costs, including hospital eligibility criteria, as specified in the 2018-19 NEP Determination – Private Patients only	
Current approach: Application of PPAA and PPSA adjustments to the acute and subacute cost models	
3.2.1 Bottom up review of private patient funding	
Description of technique	Information around the MBS fees (75% paid by Commonwealth and 25% paid by insurer) and insurer accommodation charges is available in external data sources. The Commonwealth also indirectly contributes to private patients in public hospitals through a means tested Private Health Insurance premium rebate. A bottom up approach to pricing of eligible private patient services can be undertaken to investigate the completeness of current private patient adjustments in the National Cost and Pricing Models (i.e. are all Commonwealth and insurer payments captured), alternative approaches to estimating the PPSA and PPAA could be considered and the HCP data could be tested against other sources to understand the impact of any potential non-reporting bias that may be incorporated within the data.
Example study/use	Stakeholder consultation papers (2018-19 and 2019-20) with recommendations to investigate adequacy of current private patient adjustments.
Research stream	Knowledge of the current state
Reference	https://www.ihpa.gov.au/sites/default/files/submission_re_pricing_framework_for_australian_public_hospital_services_2018-19_-_catholic_health_australia.pdf

Appendix D.4 Stabilisation

Methodology area 4.1: Stabilisation across classification versions

Evaluation of DRG and SNAP class comparability across classification versions for the purposes of stabilisation of acute and subacute price weights	
Current approach: For changes in classification, only those classification codes with an equivalent code in the prior classification version are stabilised	
4.1.1 Stabilisation against weighted average price weight, where no one-to-one mapping is available	
Description of technique	A change in classification can be transformative, with no one to one mapping available between classification versions. This was evident in the shift from DRG v8.0 to DRG v9.0, with roughly 100 of the 800 DRGs able to be directly mapped. In order to stabilise those without a one-to-one mapping, a weighted average approach should be employed. This should make consideration of the distribution of matches across various codes - with the weighted average based on this distribution.
Example study/use	Use of weighted average of comparable items across years, to determine estimate for CPI.
Research stream	Knowledge of the current state
Reference	Reserve Bank of Australia; Inflation and its Measurement; <https://www.rba.gov.au/education/resources/explainers/inflation-and-its-measurement.html>
4.1.2 Credibility theory against an expected price	
Description of technique	Credibility theory blends the content of various data sources, in this case to stabilise the actual price against an expected price (for example, based on the indexed application of the previous year's model). A weighted average of data is calculated, with weights developed according to the variation in the experience. The intention is to gradually move to use of the new classification over time (e.g. with a one year lag to full implementation), once there is greater stability in the coding and a better understanding of volume of activity under the new classification. Until this point, the weighted average will place greater weighting on the prior models, with lower weighting on the emerging NHCDC data until it stabilises.
Example study/use	1. Actuarial standard of practice in the use of credibility procedures 2. Use of credibility theory to price within group medical insurance
Research stream	1. Knowledge of current state 2. Statistical focused research
Reference	1. Actuarial Standards board (2013); Credibility procedures; <http://www.actuarialstandardsboard.org/wp-content/uploads/2014/02/asop025_174.pdf> 2. Fuhrer, C (2015); A Practical Approach to Assigning Credibility for Group Medical Insurance Pricing; <https://www.soa.org/research-reports/2015/2015-practical-approach-credibility-group-medical-insurance/>

Methodology area 4.2: Stabilisation of prices and adjustments

Purpose and application of price and adjustment stabilisation policy for all cost models.	
Current approach: Stabilise price weights, inlier bounds and adjustments against the prior year's values	
4.2.1 Credibility theory	
Description of technique	Credibility theory blends the content of various data sources, in this case to stabilise values against the prior year. A weighted average of the two years is calculated, with weights developed according to the variation in each year's data. The intention is to gradually recognise experience as it emerges, with full weight once there is stability and volume in the calculated values. If variation is high, the weighted average will place greater weighting on the prior values with lower weighting on the emerging data until it stabilises.
Example study/use	1. Actuarial standard of practice in the use of credibility procedures 2. Use of credibility theory to price within group medical insurance
Research stream	1. Knowledge of current state 2. Statistical focused research
Reference	1. Actuarial Standards board (2013); Credibility procedures; <http://www.actuarialstandardsboard.org/wp-content/uploads/2014/02/asop025_174.pdf> 2. Fuhrer, C (2015); A Practical Approach to Assigning Credibility for Group Medical Insurance Pricing; <https://www.soa.org/research-reports/2015/2015-practical-approach-credibility-group-medical-insurance/>
4.2.2 Stabilisation against non-stabilised cost weight	
Description of technique	The effects of stabilisation currently compound year on year, with stabilised prices forming the basis for stabilisation in the next year. While this provides increase conformity across years, it can lead to a considerable delay in the recognition of true shifts in the cost of delivery. To overcome this, the stabilisation process should be applied through comparison of the newly calculated value against the prior year's unstabilised value. This will remove the impact of the prior year's stabilisation and allow for consistent trends in cost to be appropriately recognised at a faster rate.
Example study/use	N/A
Research stream	Knowledge of the current state
Reference	N/A

Appendix D.5 Transformation to pricing models

Methodology area 5.1: Calculation of the reference cost

Calculation of the reference cost	
Current approach: The previous year's reference cost is indexed by the growth rate in consecutive years' cost models, where the growth rate is standardised against the latest year's activity data.	
5.1.1 Use the mean cost of the current year's acute model, instead of applying a standardised growth rate to the previous year	
Description of technique	Use of the average cost of acute services instead of a standardised growth rate applied to the previous year's reference cost. This will aid ease of interpretation of the current year's reference cost as representing the average cost of service delivery. While this will be distorted by activity changes, it still acts as a price signal as it represents the average price of activity in the system. However, this approach will not take into account differences in the National Cost and Pricing Models between years and will likely provide a poor signal of the growth in average cost between years as the denominator (i.e. NWAU) will not be consistent across years.
Example study/use	N/A
Research stream	Knowledge of the current state
Reference	N/A
5.1.2 Application of current approach at a service category level	
Description of technique	Introduction of pseudo-reference costs for each service category, for which the magnitude is calculated in line with the current approach. This would improve ease of communication, providing more consistent comparability of service category price weights across years. The use of the single reference cost from the acute model for the purpose of calculating base cost weights could still be retained, with relativity factors provided in order to derive the service category specific reference costs and weights.
Example study/use	Victorian government reference prices for each health services category, which are also split by public and private patients.
Research stream	Knowledge of the current state
Reference	Department of Health and Human Services (2018); Department of Health and Human Services policy and funding guidelines 2018; https://dhhs.vic.gov.au/sites/default/files/documents/201808/Policy%20and%20Funding%20Guidelines%202018%20Volume%202%20Chapter%203%20Health%20Operations.pdf

Methodology area 5.2: Calculation of the indexation rate

Calculation of the indexation rate	
Current approach: The cost model is applied retrospectively to the five years of patient costed admitted acute activity data, with scaling factors reflecting the difference in actual cost and modelled cost calculated for each of these years. The trend of these scaling factors is used to model the indexation rate for the following three years.	
5.2.1 Regression of growth against drivers of indexation	
Description of technique	Break down of the indexation rate into key drivers e.g. award rates, consumable inflation etc. Each component part can be indexed separately.
Example study/use	1. Manual covering the basic principles of ABF with respect to the Canadian public health system that suggests indexing the base average cost by estimating individual cost effects and blending these e.g. more up-to-date economy-wide measures such as consumer price or labour price indices. 2. Paper analysing the use of regression against relevant independent variables to predict future trends in costs in the construction industry e.g. the GARCH approach. This is to address the problem of price volatility of material and labour. 3. Paper breaking down public health expenditure in EU countries by key non-demographic drivers and using regression techniques to estimate the impact of these on future health costs. The paper uses macroeconomic health data from the OECD and Eurostat, also supplemented by other national data.
Research stream	Sector focused research
Reference	1. Canadian Institute for Health Information (CIHI) (2013); The Why, the What and the How of Activity-Based Funding in Canada: A Resource for Health System Funders and Hospital Manager; <https://secure.cihi.ca/free_products/ActivityBasedFundingManualEN-web_Nov2013.pdf> 2. Joukar, Alireza (2016); Analysis and Management of the Price Volatility in the Construction Industry; <https://digitalcommons.lsu.edu/gradschool_dissertations/182> 3. João Medeiros et al (2013); Estimating the drivers and projecting long-term public health expenditure in the European Union: Baumol's «cost disease» revisited; <http://ec.europa.eu/economy_finance/publications/economic_paper/2013/pdf/ecp507_en.pdf>
5.2.2 Compounded arithmetic or geometric average to determine the forecast	
Description of technique	It is suggested that using a compounding rate that sits in between the arithmetic and geometric historical returns. This will reduce bias in the forecast, which is inherent when either average is utilised in isolation.
Example study/use	Paper discussing the use of arithmetic and geometric averages of historical investment returns for forecasting the terminal value of a portfolio.
Research stream	Statistical focused research
Reference	Eric Jacquier et al.; Geometric or Arithmetic Mean: A Reconsideration; < https://www.jstor.org/stable/4480527?seq=1#page_scan_tab_contents >
5.2.3 Exponential smoothing of growth	
Description of technique	Exponential smoothing methods give larger weights to more recent observations, and the weights decrease exponentially as the observations become more distant. An example method is the Holt-Winters method that accounts for both trend and seasonal patterns.
Example study/use	Lecture slides describing the approach to various exponential smoothing methods i.e. simple exponential smoothing, Holt's Trend Corrected Exponential Smoothing, and Holt-Winters methods.

Research stream	Statistical focused research
Reference	Alan Wan (2018); Exponential Smoothing Methods; <http://personal.cb.cityu.edu.hk/msawan/teaching/ms6215/Exponential%20Smoothing%20Methods.pdf>
5.2.4 ARIMA (time series) modelling of growth	
Description of technique	The ARIMA model predicts a value in a response time series as a linear combination of its own past values, past errors, and current and past values of other time series. There are three key stages of analysis when using PROC ARIMA in SAS: identification (to specify the response series and identify candidate models); estimation and diagnostic checking (specify the ARIMA model to fit to variable identified and estimate parameters and their significance); and forecasting (to forecast the time series and generate confidence intervals for the estimates).
Example study/use	1. Technical chapter providing examples for the use of the ARIMA procedure. 2. Paper analysing the use of regression against relevant independent variables to predict future trends in costs in the construction industry e.g. the GARCH approach. This is to address the problem of price volatility of material and labour. 3. Paper looking at the build of stock price predictive models using the ARIMA model.
Research stream	Statistical focused research
Reference	1. SAS OnlineDoc: Version 8; The ARIMA Procedure (Chapter 7); <https://dms.umontreal.ca/~duchesne/chap7.pdf> 2. Joukar, Alireza (2016); Analysis and Management of the Price Volatility in the Construction Industry; <https://digitalcommons.lsu.edu/gradschool_dissertations/182> 3. Adebiyi et al. (2014); Stock Price Prediction Using the ARIMA Model; <http://ijssst.info/Vol-15/No-4/data/4923a105.pdf>
5.2.5 Use of external indices	
Description of technique	Use of price indices for adjusting health expenditures or costs for inflation. This includes consideration of consumer price indices, consumption indices (e.g. GDP), wage price indices etc.
Example study/use	1. Application of indices to historical medical cost data in the US to inflate to the current period i.e. the GDP implicit price deflator, CPI and the Personal Consumption Expenditures (PCE) index. 2. Use of drivers of US medical care price growth to understand and break down medical inflation including general inflation, labour intensity (relative cost of labour for the sector), wage inflation, and labour-productivity changes.
Research stream	Sector focused research
Reference	1. Abe Dunn et al. (2016); Adjusting Health Expenditures for Inflation: A Review of Measures for Health Services Research in the United States; <https://onlinelibrary.wiley.com/doi/pdf/10.1111/1475-6773.12612> 2. John R. Virts and George W. Wilson; Inflation and Healthcare prices; <https://www.healthaffairs.org/doi/pdf/10.1377/hlthaff.3.1.88>
5.2.6 Microsimulation to model impacts of shifts in classifications and reporting	
Description of technique	Microsimulation enables modelling of patterns and decision-making at a cohort or individual level to determine system-wide impacts of these.
Example study/use	A microsimulation of household expenditure to illustrate the effect of socio-economic factors on household spending patterns. The paper also suggests the application of microsimulation methods in policy formation, pension forecasting, anticipating care demand for healthcare, and effects of demographic change on demand for pensions and healthcare.

Research stream	Knowledge of the current state
Reference	Tony Lawson (2014); Methods and Tools for the Microsimulation of Household Expenditure; <https://www.researchgate.net/publication/297904387_Methods_and_Tools_for_the_Microsimulation_of_Household_Expenditure>
5.2.7 Analysis of historical deviation between actual and expected to adjust the indexation rate	
Description of technique	Use of historical accuracy of the models to predict potential deviation from actual in future estimates.
Example study/use	N/A
Research stream	Knowledge of the current state
Reference	N/A

Appendix D.6 Back-casting

Methodology area 6.1: Methodology for back-casting the NEP

Methodology for back-casting the NEP	
Current approach: The volume multipliers are derived as the NWAUs calculated from application of the current model divided by NWAUs calculated by application of the previous year's cost model, to a consistent activity dataset. The back-cast NEP is determined by indexing the reference cost by two years, using the same annual indexation projections for the NEP.	
6.1.1 Use of a different year's data in determining volume multipliers ('VM')	
Description of technique	Use of more recent data when calculating the growth in NWAUs delivered e.g. in the 2018-19 determination, using the data in the first half of 2017-18, instead of 2016-17 data.
Example study/use	N/A
Research stream	Knowledge of the current state
Reference	N/A
Reference	N/A
6.1.2 Smoothing of volume multipliers, using multiple base years for calculation	
Description of technique	Currently volume multipliers are calculated using the most recent full year of data as a basis, with full reliance on this single year as being representative of the future state. Alternatively, IHPA could calculate the volume multipliers which would result utilising the most recent three years of data (i.e. resulting in three different sets of multipliers). A simple average, or exponential smoothing of these multipliers can then be implemented to spread reliance across multiple years of activity.
Example study/use	Lecture slides describing the approach to various exponential smoothing methods i.e. simple exponential smoothing, Holt's Trend Corrected Exponential Smoothing, and Holt-Winters methods.
Research stream	Statistical focused research
Reference	Alan Wan (2018); Exponential Smoothing Methods; <http://personal.cb.cityu.edu.hk/msawan/teaching/ms6215/Exponential%20Smoothing%20Methods.pdf>

Appendix E Research plan

Research aims

The objective for this research is to undertake a literature review of modern data analysis and statistical techniques, with particular focus on the suitability and applicability to the pricing of activity based funding of Australian public hospitals.

Methodology

1. Formulation of the search strategy (including research questions, search phrases etc.)
2. Execution of the search based on the search strategy
3. Assessment of search results against predetermined criteria
4. Additional review of the short-listed research, if required
5. Consolidation of findings into a list of alternative techniques
6. Reporting of the list of alternative techniques and initial assessment of these

Search strategy

Research questions
During the research period we will attempt to address the following high level research questions:

1. What alternative statistical techniques can be used in the pricing of activity based funding in Australia to arrive at the National Efficient Price?
2. Do these alternative statistical techniques have benefits that have been observed in healthcare in other jurisdictions or in other sectors? Do they have known limitations?
3. What performance measurement techniques can be applied to test whether the techniques identified will result in an improvement against the current method?

Type of academic articles to search
We will scan academic articles in the following order of preference:

1. Australian journal articles or publically available information
2. Western journal articles or publically available information (Canada, UK, Scandinavia, relevant states in the US)
3. Other available international journal articles or publically available information.

Key phrases to search
The literature review will be guided by an agreed set of key phrases with IHPA. Key search phrases will include:

Review 1: Data preparation methodology
Key words: matching; imputation; segmentation; outlier costs; outlier removal; outlier weighting; sample weighting

- Data preparation processes and techniques relevant to activity based funding
- Techniques for linking / matching datasets in healthcare and other sectors
- Techniques for imputing unknown amounts in healthcare and other sectors
- Techniques or process for identifying outlier hospitals, services, and costs in healthcare or more generally, identifying outliers in data across sectors

- Techniques for segmentation of costs in healthcare and other sectors
- Techniques for sample-to-population weighting of data across sectors

Review 2: Calculation of base price weights

Key words: L3H3; trim points; per diem; short-stay outliers; long-stay outliers; inpatient; URG and UDG linkage; ED pricing

- Alternative/similar approaches to the "L3H3" method in healthcare
- Alternative approaches for trimming outliers (e.g. by length of stay and other factors in healthcare) across sectors in the allocation of funding
- Alternative approaches for pricing same-day, short-stay and long-stay episodes of acute and/or subacute care in the public healthcare sector
- Linking different classification levels
- Approaches to pricing emergency department care

Review 3: Adjustments application methodology

Key words: adjustments; Indigenous; regional; ICU; paediatric; public versus private; cost variation; interaction factors

- Techniques for identifying significant factors in the data that enable differentiation of costs across healthcare and other sectors
- Techniques for accounting for interactions between factors identified in the data
- Examples of adjustments made for legitimate and unavoidable variation in costs in healthcare and other sectors across jurisdictions and how these are applied

Review 4: Approach to applying stabilisation

Key words: stabilisation; comparability of price; consistency

- Techniques for controlling for volatility in prices in healthcare and other sectors (e.g. across years, when there are small sample sizes)
- Stabilisation policies in healthcare and other sectors
- Techniques to ensure comparability of classification versions over time in healthcare and other sectors

Review 5: Transformation of cost model to pricing model

Key words: medical cost indexation rate; medical cost projection rate; cost weights

- Example use of reference costs in healthcare and other sectors i.e. techniques to determine change in costs excluding effects of changes in case-mix, for example
- Converting dollar amounts weights
- Methods for projecting and indexing costs in healthcare and other sectors

Review 6: Method for back-casting NEP

Key words: back-casting; back-test

- Methods for measuring the effect of model changes or methodologies over time

For all review areas

- Advantages and disadvantages of the techniques identified
- Application of the techniques in the health sector
- Application of the techniques in other non-Health sectors
- Techniques to measure the performance of each of the techniques identified

Appendix F Reliance and limitations

Ernst & Young ("EY") was engaged on the instructions of the Independent Hospital Pricing Authority ("Client") to undertake a fundamental review of the National Efficient Price (NEP) including a literature review, review of processes and statistical techniques used in determination of the NEP and providing alternative techniques ("Project"), in accordance with the official order dated 17 September 2018 under Deed of Standing Offer (Head Agreement for Services) 14/1213-37 dated 3 December 2017 and previously varied 27 May 2016 including the General Terms and Conditions ("the Engagement Agreement").

The results of EY's work, including the assumptions and qualifications made in preparing the report, are set out in EY's report dated 21 November 2018 ("Report"). You should read the Report in its entirety including any disclaimers and attachments. A reference to the Report includes any part of the Report. No further work has been undertaken by EY since the date of the Report to update it.

EY has completed this Report during the period 17 September 2018 to 21 November 2018 based on an agreed Research Plan with IHPA. Our Report is limited in time and scope other more detailed reviews or investigations may identify additional issues or considerations that this Report has not. The results of our work and procedures performed do not constitute an audit, a review or other form of assurance in accordance with any generally accepted auditing, review or other assurance standards, and accordingly we do not express any form of assurance.

In preparing this Report, EY has relied on information provided by the management of IHPA. EY has not conducted any audit, review or other form of verification of information provided by the management of IHPA. EY has not performed any independent verification of the accuracy or completeness of this information. EY does not accept any responsibility or liability for independently verifying any information we have obtained nor do we make any representation to the accuracy or completeness of information provided by the management of IHPA.

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Our Report may be relied upon by the Independent Hospital Pricing Authority (IHPA) pursuant to the terms of official order dated 17 September 2018 under Deed of Standing Offer (Head Agreement for Services) 14/1213-37 between IHPA and EY dated 3 December 2017 and previously varied 27 May 2016. We disclaim all responsibility to any party for any loss or liability that any party may suffer or incur arising from or relating to or in any way connected with the contents of our report, the provision of our report to any party or the reliance upon our report by any party.