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Continuous Mortality Investigation

Income Protection Committee

WORKING PAPER 59

Reporting Sickness Experience for the CMI Individual Income Protection Investigation:

Summary statement of revised methodology;

Description of updated format of results tables; and

Analysis of change in methodology and comparison basis

February 2012

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CONTENTS

1 INTRODUCTION

The CMI Income Protection (IP) Committee's main focus over recent years has been on producing a new set of Sickness graduations, now known as IPM 1991-98. An overview of the work on these graduations, completed in 2010, is provided by CMI Working Paper 48.

The development work took very much longer than we would have liked, due in large part to the complexity of IP risks and the limitations of the available data. In tackling these problems, a large number of refinements were introduced to the methodology, and the corresponding changes have now been implemented in the CMI's IP experience analysis tools. The Committee has also taken the opportunity afforded by this redevelopment to make the results more easily accessible by releasing them in Microsoft Office Excel workbooks.

Using these new tools, the Committee is pleased to present, for the first time, Individual IP business experience using the new graduations as the basis of comparison.

CMI Working Paper 60 provides a report on the experience of the quadrennium 2003-06. It also provides a high-level analysis of the trends in experience over 1991-2006. More detailed results for each of the four quadrennia 1991-94, 1995-98, 1999-2002 and 2003-06, using IPM 1991-98 as the basis for expected Claim events, are provided alongside the Paper in the new spreadsheet (MS Office Excel workbook) format.

This Paper acts as a technical reference document for CMI Working Paper 60 and for subsequent reports using this updated methodology and reporting format.

These two Papers together mark an important step for the CMI IP investigation. They bring the new graduations fully into use, incorporate a number of methodology refinements into the investigation and introduce a new reporting format for the results.

The structure of this reference paper is as follows:

- An overview of the CMI Individual IP dataset is set out in Section 2.
- A short statement of the (revised) experience analysis methodology is set out in Section 3. This Section also includes a brief note of the key features of IPM 1991-98 and its predecessor SM1975-78. The note is supported by more detailed tables in the Appendix and is intended to help practitioners interpret the analysis results.
- Section 4 provides a description of the format adopted for the results tables in Excel.
- Section 5 provides an overview of the statistical tests reported with the results. It is intended primarily as a guide to help practitioners interpret those test results.
- Last, Section 6 presents a high-level analysis of the change in reported results, for 1991-2006, arising from the methodology improvements and the change in comparison basis. This Section includes a brief summary of the material refinements to the methodology.

This Paper complies with the material requirements of the principles in the Board for Actuarial Standard's generic TASs. In particular, TAS D and TAS M have been met insofar as their principles are applicable.

The CMI welcomes feedback on its work. Comments and suggestions from IP practitioners for further improvements to the new spreadsheet-format reporting would be particularly helpful. Please send any comments via e-mail to ip@cmib.org.uk or in writing to: CMI, Cheapside House, 138 Cheapside, London, EC2V 6BW.

2 DATA

2.1 *Description of the data*

The data is collected on a calendar year basis and contains records for each policy In force at the beginning of the year and each policy In force at the end of the year, together with records for each Claim in payment at any point during the year.

All records contain fields describing the attributes of each policy. The following fields are critical for the current standard investigation and reports:

- Record Type (In force or Claim)
- Office Number
- Record Year
- Policy Identifier (sometimes differs between In force and Claims data)
- Sex
- Date of Birth
- Deferred Period
- Policy Expiry Date
- Occupation Code.

Additional fields are used in selecting records and determining eligibility for the investigation (see Section 2.2):

- Territory (UK, Ireland, Isle of Man, Channel Islands)
- Benefit Type (level benefit, escalating benefit, waiver, lump sum, etc)
- Medical Rating or Exclusion.

Sickness Claims records contain extra fields relating to the duration and other features of the Claim:

- Date of falling Sick
- Date benefit payment commenced
- Mode of commencement (new Claim, revival, continuation from previous year, etc)
- Date benefit payment ceased
- Mode of cessation (Recovery, Death, expiry, continuation into following year, etc).

We refer to the cessation of Claims, through the Recovery or Death of the Claimant, collectively as Claim Terminations.

Note that throughout this Paper we use the term 'Sick' to mean being unable to work as a result of illness or injury, as defined for the underlying IP policies. However the definition of disability or incapacity may vary between policies. The IP Committee expects that the great majority of policies and Claims are subject to an "Own Occupation" definition, but also expects that some are subject to a tighter definition. Such definitions may bring a broader range of occupations into the disability assessment, or rely on basic functional assessments such as "Activities of Daily Working" or "Activities of Daily Living".

The full dataset contains further fields, including Policy Commencement Date and Benefit Amount, which are not used in the current standard analyses but which have been, or could be, used for supplementary investigations. For further details of the data specification refer to the CMI IP Investigation Coding Guide.

The dataset is somewhat limited in its form and this complicates some elements of the analysis. Particular constraints are that in general:

- there are no unique life or policy identifiers in the data;
- only partial details, such as month and year but not day, are recorded for dates of birth;
- the data relates to each calendar year separately, often with discontinuities between years as offices enter or leave the investigation;
- it is not always possible to match Claim records to In force policy records.

Changes to the Coding Guide for CMI IP data have been agreed so that many of the issues will be removed for new data once contributors are able to adopt the latest version of the Guide (v3.0, published July 2009). However, given the many competing demands on the resources of contributing offices, the IP Committee recognises that this migration to a stronger data definition may take several years to complete. In the meantime, the Committee continues to operate a pragmatic approach, working flexibly with offices to assist them in making a full or partial data submission in a mutually agreed format.

2.2 *The Aggregate data and the Standard* subset*

The total data is referred to as the ***Aggregate*** data. However, for the main analyses, non-UK policies, policies with special benefit types (such as lump sums or waiver), and policies with identifiable underwriting (medical) ratings or exclusions are all omitted to restrict the analysis to a subset of the Aggregate data referred to as the ***Standard**** data.

The label *Standard** is used to distinguish this data subset from that previously defined as ***Standard*** data. Prior to the introduction of CMI Occupation Class to the data for investigation years 1991 onwards, the data used for standard analyses was further restricted by excluding policies known to have an occupational rating. This smaller data subset was referred to as the *Standard* data and broadly (but not exactly) corresponds to Class 1 *Standard** business in the current analysis.

For investigation years 1991 onwards, the Claim Inceptions and Terminations experience is analysed for the *Standard** data subset by Sex, Deferred Period, Occupation Class, Age and duration Sick.

In addition to restricting the analysis to the *Standard** data, some records have to be rejected because the data is invalid or internally inconsistent. Ideally such records are corrected with the assistance of the contributing office, but where this is not possible the records are excluded. The algorithm applied to identify and exclude unacceptable Claim records is set out in CMI Working Paper 46 (Part A: *Note on Exclusions and some other features of the Claims data*).

2.3 *Deferred Periods (DP)*

The standard analyses and reports cover experience for Deferred Periods 1, 4, 13, 26 and 52 weeks only. Policies with a Deferred Period of 1 month are included in the 4 weeks category; similarly 3, 6 and 12 month Deferred Periods are mapped to 13, 26 and 52 weeks.

The *Standard** data also includes smaller, but non-trivial, data volumes for Deferred Periods 0, 2 and 8 weeks. This data is excluded from the current standard analyses and reports but the Committee does intend to conduct a separate investigation of these experiences.

A very small proportion of the records have 'odd' Deferred Periods, not equal to any of the categories noted above. Such records are assumed to be data errors and are excluded from the analysis.

Policies with Deferred Period 1 week strictly have a six-day Deferred Period, not a seven-day one. That is, if the insured is Sick for exactly seven days, he or she may claim for all seven; but if the insured is Sick for only six days he or she may not claim at all. This interpretation was developed through consultation with the contributing offices and has been found to be consistent with the observed Claimant Recovery rates for these durations of Sickness.

2.4 *CMI Occupation Class (OC)*

Since 1991, the CMI has been collecting IP data sub-divided by Occupation Class. Offices submit data using their own internal occupation class coding. These are then converted by the CMI to the most appropriate of the four CMI standard Occupation Classes for analysis purposes. A broad description of the classes is as follows:

Class 1	Professional, managerial, executive, administrative and clerical classes not engaged in manual labour.
Class 2	Master craftsmen and tradesmen engaged in management and supervision; skilled operatives engaged in light manual work in non-hazardous occupations.
Class 3	Skilled operatives engaged in manual work in non-hazardous occupations.
Class 4	Skilled and semi-skilled operatives engaged in heavy manual work or subject to special hazard.

The CMI does not collect data by individual occupation and it is not possible to drill down into the data to analyse the experience of specific groups such as teachers or doctors. Furthermore, it is entirely possible that a particular occupation insured by different offices could end up in different CMI standard classes. The IP Committee does believe, though, that despite this possible classification ambiguity, there should be a reasonable degree of consistency across the Investigation.

Not all offices, however, can provide a complete breakdown of all their data by Occupation Class. This arises for a number of reasons such as:
- None of the office's data can be coded by Occupation Class
- Coding by Occupation Class is not possible for all investigation years
- Only part of the office's portfolio can be coded by Occupation Class
- Claims data can be coded by Occupation Class but In force data cannot.

This requires a fifth subset of the *Standard** data, "Class Unknown", to be analysed. This presents no special problems with the analysis of Claim Terminations experience. However, the analysis of Claim Inceptions requires consistent coding by Occupation Class for three sets of data: In force at both the beginning and end of a year and Claims during the year.

Where there are clear inconsistencies (for example: Claims and year-end In force data is coded by Occupation Class and start-of-year In force data is not) all the office's Claim

Inceptions experience for that year is analysed under "Class Unknown". This approach has also been adopted where there appears to be some inconsistency, for example: where the proportion of an office's business coded as having unknown Occupation Class differs markedly between the beginning and end-of-year In force or between the In force and Claims records.

Some offices can code only Claims data by Occupation Class but not In force data so the proportion of "Class Unknown" business is significantly lower for the Terminations analysis than for the Inceptions analysis.

2.5 *Duplicate Records*

It is important to identify Duplicate records within the data, where possible, and to remove them, or make other suitable allowances, as their inclusion would otherwise undermine the statistical model and analysis. Duplicate records typically occur when a policyholder buys additional cover of the same 'type', so that the dataset contains a number of separate records with sufficiently similar conditions for it to be better to treat them as one policy / Claim rather than as several.

We can identify Duplicates within the Claims records with reasonable confidence. The algorithm applied to identify Duplicate Claim records requires a complete match on all of the following data items:

- Year of Investigation
- Sex
- Occupation Class (as coded for the Inceptions analysis)
- Occupation Class (as coded for the Terminations analysis)
- "Standard Status" (whether in 1, 2 or all 3 of *Standard*, *Standard** and *Aggregate*)
- Age Definition (how age is stored for the record)
- Year and Month of Birth (exact date of birth is generally not available in the data)
- Deferred Period (exact weeks)
- Date of start of Sickness (day, month and year)
- Date (day, month and year) and Mode of Commencement of Claim
- Date (day, month and year) and Mode of Cessation of Claim Cause of Sickness.

Further details, and a discussion of de-duplication issues, are set out in CMI Working Paper 46 (Part B: *The Identification of Duplicates*).

Note that Claim records identified as Duplicates often relate to policies taken out at different times, for example through the insured adding to their level of cover. The treatment of Duplicates would therefore need further careful consideration if experience were to be investigated by policy duration.

For the Claims data for the years 1991-2002 combined, there were 38 Duplicate records for every 100 'original' Claims records. Further investigation has shown that:

(a) There were no statistically significant differences in the Claim Terminations experience of various categories of 'original' and Duplicate records. The analysis is set out in CMI Working Paper 46 (Part C: *The Experience of Singletons and Duplicates*).
(b) The prevalence of Duplicates varies significantly by Occupation Class (highest for Class 1), Deferred Period (highest at DP1), Age (rising with Age) and Sex (higher for

males), all factors for which we would naturally subdivide the data anyway, but not for any other factors available in the data (after aggregation across offices). Further information is also given in CMI Working Paper 46 (Part D: *An Analysis of the Distribution of Duplicates*).

Identifying Duplicate Claim records using the above algorithm is sufficient to enable the Claim Terminations experience analysis to be run on a de-duplicated file. It also allows us to consider Claim Inceptions both including and excluding Duplicates.

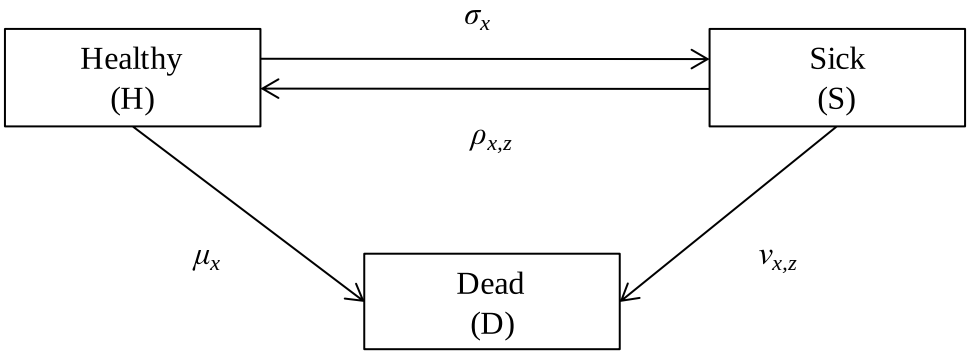
To calculate the exposed-to-risk for the Claim Inceptions experience analysis we require both the Claim records and the In force files. As we cannot identify Duplicates in the In force data – there are insufficient data fields capable of differentiating between different policies – we calculate exposure using the files including Duplicates, and then scale the result down by the ratio (smoothed across neighbouring cells by Age) of the Claim Inceptions count excluding Duplicates to the Claim Inceptions count including Duplicates. See Section 3.4 for further details.

3 METHODOLOGY

3.1 *The underlying statistical model*

The multiple-state model described below provides the necessary strong foundation for the statistical analysis of the IP experience. This model was introduced in CMIR 12 (1991) and is illustrated in Figure 1.

Figure 1: A diagrammatic representation of the model for Sickness.



Lives are assumed to enter the risk pool in state *H* ('Healthy') and are then subject to the risks of falling 'Sick' (transferring to state *S*) or dying (transferring to state *D*). The transition intensities (or 'forces of decrement') for these two transitions are denoted σ_x and μ_x and are assumed to depend only on attained age *x*. In particular, it is assumed that they do not depend on policy duration.

Lives may leave state *S* by recovering (transferring back to state *H*) or dying (transferring to state *D*). The transition intensities for these changes of state are denoted $\rho_{x,z}$ and $\nu_{x,z}$ respectively and are assumed to depend only on the attained age, *x*, and the duration, *z*, of the current Sickness at the point of transition. It is also assumed that those who recover from Sickness and re-enter the Healthy state have the same future rates of Sickness and mortality as those that have never been Sick.

In applying the model, it is convenient to work throughout by defining Age by reference to the start of Sickness, rather than to age attained. We therefore re-express the transition intensities from state *S* as $\rho_{y+z,z}$ and $\nu_{y+z,z}$ where *y* is the Age at which the life fell Sick and *z* is the duration of the current Sickness, so that y+z is the attained age.

Although strictly speaking the model deals with transition intensities we often use the shorter term "rates" in the remainder of this Paper and in experience investigation reports.

3.2 *Applying the model to the CMI IP business dataset*

The data held by insurers relates to IP Claims rather than directly to Sickness. An IP Claim can only arise once the insured life has been Sick throughout the Deferred Period. The CMI dataset therefore does not allow observation of transitions during the Deferred Period between states *H* and *S*, in either direction, nor from state *S* to *D*. Furthermore, transitions from state *H* to *D* cannot be observed at all in the CMI data.

However, the state of 'Claiming' is simply a subset of state S and matches it once the duration of Sickness, z, is beyond the end of the Deferred Period (and beyond any relevant "run-in" period, as explained below). Given this, the available data is sufficient to support estimation of all the required transition rates, except for the 'healthy life' mortality, μ_x. It is then possible to produce a set of graduated transition rates to represent the experience of a selected subset of the data, and to use those graduated rates more generally as the basis of an 'Actual over Expected' Claim events analysis of experience.

The CMI IP Committee has so far only performed its investigations on a lives basis. Although data is collected on benefit amounts, such data has not yet been used in the graduations or experience analysis work.

The main steps in the graduation process are summarised below. This is provided as important background to understanding the following Sections:

- Section 3.3 (and the Appendix) which outlines the features of the two sets of graduations commonly used as the comparison basis in CMI IP experience analyses; and
- Sections 3.4 and 3.5 which set out in greater detail the methodology for the 'Actual over Expected' experience analysis for Claim Inceptions and Claim Terminations respectively.

For graduations work, the CMI usually selects a dataset combining the data for all contributing offices and across a number of consecutive Investigation Years.

To apply the model, the Claim Terminations experience is examined first, counting the number of events (Claimant Recoveries and Deaths) and the central exposure (life years in Claim). Sickness Termination rates are then calculated, separately for Recoveries and Deaths from Sick, for durations, z, greater than the Deferred Period. For these calculations the data is sub-divided to produce two-dimensional arrays by Age at start of Sickness and duration Sick (in very short time intervals at least for the early durations of Sickness) for each combination of Sex, Occupation Class and Deferred Period.

An important feature of the experience is that Claim Recovery rates (at least for DPs 4 and 13) during the weeks immediately following the end of the Deferred Period appear to be unreasonably low compared to the general trend by Sickness duration. It is thought the most likely explanation is that many insured lives, whose Sickness extends only a short way beyond the Deferred Period, do not make a Claim, and so their imminent Recoveries are not observed in the experience. We refer to such effects as "run-in" period adjustments.

The graduated Claim Termination rates provide a basis for filling in one of the gaps in observations: estimating the transition rates from 'Sick but not (yet) Claiming'. Observations on the shorter Deferred Period business are used to infer the pattern of Termination rates for pre-Claim Sickness for longer Deferred Period business, and a complete set of estimated Sickness Termination rates for all durations Sick is then obtained by extrapolating the graduation formulae back to Sickness duration zero (the date of falling Sick).

Next the Claim Inceptions experience is examined, counting the number of Claim Inceptions, I, and calculating the central exposure period (life years) from the In force. For these calculations the data is sub-divided by Age, Sex, Occupation Class and Deferred Period.

The expected number of Sickness Inceptions is given by $EtR.\sigma$ where EtR is the exposed-to-risk and σ is the Sickness Inception rate to be estimated (ignoring age subscripts). Sicknesses are not observed unless and until a Claim starts, so the probability of a Sickness continuing to the end of the Deferred Period, π, and (noting the run-in effect) the probability that a Claim is then made, η, must be allowed for. Combining these, the expected number of Claim Inceptions is given by $EtR.\sigma.\pi.\eta$, and so σ can be estimated from the data as $I/(EtR.\pi.\eta)$.

To perform the calculations, the factors π and η are calculated from the graduated Sickness Termination rates, and those rates are also used for some of the required adjustments to the crude exposed-to-risk to calculate EtR (see Section 3.4). Then σ is calculated and graduated, and Claim Inception rates are finally derived as $i = \sigma.\pi.\eta$. Although estimation uncertainty in π and η will directly affect the estimate of σ, those factors are 'reversed out' of the equation in moving from Sickness to Claim Inception rates, so that there is much less uncertainty in the graduated Claim Inception rates and they correspond well to the observed crude Claim Inception rates, I/EtR.

In graduating the experience, it is usual to 'borrow strength' across the Deferred Periods where it is reasonable, and not inconsistent with the data, to assume some commonality of patterns and features. The Tables in the Appendix set out the extent to which this approach has been taken for the two sets of graduations commonly used as the comparison basis in CMI IP experience analyses.

For completeness, note that μ_x, which cannot be derived from the CMI dataset, is generally not a critical assumption for the pricing or valuation of IP business provided (as is typically the case) no additional benefits are payable on death; see CMIR 12, pages 97-98 for further discussion, including approaches for estimating μ_x.

3.3 *Features of comparison tables: SM1975-78 and IPM 1991-98*

When reviewing experience analysis results presented in an 'Actual over Expected' format, it is necessary to understand the features of the basis used for calculating the expected Claim events. The required information includes the nature of the dataset underlying the basis, and whether, and if so how, the rates in the basis vary with the data attributes used to subdivide the analysis. For the current CMI IP investigation the relevant attributes are: Age, Sex, Deferred Period and CMI Occupation Class, plus Age at falling Sick and duration of Sickness for the Claim Terminations analysis.

The graduations commonly used as the comparison basis in CMI IP experience analyses are:

- **SM1975-78** – underlying dataset: *Standard* data, Males, 1975-78.
- **IPM 1991-98** – underlying dataset: *Standard** data, Males, CMI Occ Class 1, 1991-98.

Both of these graduations reflect the experience of CMI Individual IP business for males, of (at least broadly) CMI Occupation Class 1, only. Furthermore, in using these graduations as the basis for calculating expected Claim Inceptions and Terminations, no adjustments are made for females or other Occupation Classes, and therefore differences in $100 \times A/E$ by Sex and Occupation Class directly represent differences in the observed Claim event rates.

The major features observed in the experience of the underlying datasets, and built into these graduated rates, are summarised in Tables A1 (SM1975-78) and A2 (IPM 1991-98) in the Appendix. See also Figures 2 (Claim Inceptions), 3 (Claimant Recoveries) and 4 (Claimant Deaths) in Section 6 for a comparison of the two sets of graduations and an illustration of the patterns of the graduated rates. For further information, see also CMI Working Paper 48.

3.4 *Claim Inceptions Experience Analysis*

The experience analysis compares the actual number of Claim Inceptions, I, with the expected number calculated as $EtR.\sigma.\pi.\eta$ (using the notation set out in Sections 3.1 and 3.2).

For both SM1975-78 and IPM 1991-98, σ, π and η are all functions of Age, x, and also of the Deferred Period, d. In practice we also expect the experience to vary over time and by Sex and Occupation Class. The data are therefore accumulated and sub-divided into small cells for the bulk of the calculations with each cell representing a unique combination of:

- Age last birthday
- Investigation Year
- Sex: Male or Female
- Deferred Period: DP 1, 4, 13, 26 or 52 weeks
- CMI Occupation Class: Class 1, 2, 3, 4 or Unknown.

In particular, single-year age intervals are used so that we can assume that σ, π and η are nearly constant over the age interval for each cell.

Age is defined as age last birthday at the start of Sickness for Claim Inceptions. For the calculation of the exposed to risk, the In force policies census data, at the beginning and end of each Year, is classified by Age last birthday at those dates. The data, for both Claims and In force records, are generally sufficient for an exact calculation of Age given the grouping to whole years, but where this is not the case a best, and unbiased, estimate is derived from the available data.

The calculation of central exposed-to-risk, EtR, is rather more complex than for a typical mortality investigation and, in particular, makes greater use of the Claim records. For the insured to count as being exposed to the risk of falling Sick in a particular period (say a short interval such as a day), he or she must be healthy at the outset of that period: that is, the exposed-to-risk equates to only the time spent in state H during the investigation period.

There are a number of steps to the calculation:

(i) First, note the need to adjust for the timing of observed Claim Inceptions relative to the underlying Sickness Inceptions: a Claim Inception observed at time T relates to Sickness which started at time $T - d$, where d is the Deferred Period (as a fraction of a year). Therefore data relating to calendar year Y has to be used to estimate the exposure (to falling Sick) for year '$Y - d$' for each Deferred Period.

(ii) Initially, policy-years of (central) exposure are calculated using a modified census method. Given the known In force at the start and end of each year, Y, the exposure for the year '$Y - d$' is estimated using interpolation (and extrapolation backwards) assuming exponential, rather than linear, change over time in the In force.

(iii) Next, the first step is made in adjusting from an 'all lives' to a 'healthy lives' basis by deducting the total time spent Claiming during the investigation period. This is calculated for each year Y directly from the Claim records, and then the timing adjustment noted in (i) is made, to obtain figures for year '$Y - d$', by using 'growth factors' consistent with those calculated for the In force in step (ii).

(iv) To complete the restriction to 'healthy lives', the total time spent Sick but not Claiming during the investigation period must be estimated and deducted. This is calculated in three parts:

- for known Claims, the Deferred Period;

- for policies where Sickness has not lasted the duration of the Deferred Period, an estimate of the time spent Sick;
- for policies where Sickness lasted beyond the duration of the Deferred Period but for which no Claim was made, the Deferred Period *plus* an estimate of the time spent Sick during the run-in period.

(v) A further estimated adjustment is made to remove exposure less than a Deferred Period prior to policy expiry as no Claims could arise from Sickness starting that late in the policy term.

(vi) Restrictions are built into steps (iii), (iv) and (v) to ensure that the deductions do not exceed the 'raw' exposure. That is the final exposure may be zero but never negative.

As noted in Section 2.5, Duplicates cannot be identified directly in the In force data, and so the calculations set out above are necessarily performed using the files including Duplicates. Thus the calculated exposed-to-risk at this stage is on a policies basis rather than a lives basis.

The next stage is to count the Claim Inceptions in each cell (classifying Age by age last birthday at date of falling Sick). As Duplicate records can be identified in the Claims File, this count is performed twice, first including Duplicates (cumD) and then excluding Duplicates (exD).

A check is made to ensure that Claims only arise in cells for which there is positive exposure. Any Claims recorded for cells where the exposed-to-risk is zero are deemed to be data errors and are omitted from the analysis. Note that:

- This restriction may result in the count of 'valid' Claims being dependent, to a small degree, on the basis used for the calculation of exposure and expected Claims (as the basis affects step (iv) above so that a change of basis could change cells from zero to positive exposed-to-risk or vice versa).
- It is possible for a quite correct Claim record to be deemed invalid under this rule: imagine that there is no In force at the start of a year at Age x, but there is one policy at Age x–1; the policyholder passes his x^{th} birthday, falls Sick, claims, and then dies before the end of the year, so that the In force at Age x at the end of the year is zero; this scenario would result in one Claim Inception but zero exposure. This is a defect of any annual census method of exposure calculation.

For the statistical analysis of the experience it is appropriate to exclude Duplicate Records. The final step, therefore, in the calculation of the exposed-to-risk is to estimate life-years exposure from the policy-years exposure value calculated thus far.

The principle adopted is to use information on the prevalence of Duplicates in the Claims file to infer a similar prevalence of Duplicates in the exposed-to-risk. These inferences are made at a fairly granular level by performing the calculations separately, and independently, for each combination of Year, Sex, Deferred Period and Occupation Class.

The life-years (exD) exposed-to-risk for each cell is estimated by scaling down the policy-years (cumD) value for the cell by the ratio, smoothed across neighbouring cells by Age, of the Claim Inceptions count exD to the Claim Inceptions count cumD.

The Claim counts are calculated as running averages across Age using the following rules:

(a) *Minimum number of cells = 9*. That is, the scaling factor for Age x is calculated from the counts of Claim Inceptions exD and cumD over the Age range x–4 to x+4.

(b) *Minimum number of exD Claims = 15*. That is, the range of cells used is expanded (above and below Age x) until the count of Claim Inceptions exD over the range is at least 15 (or ultimately until the range includes the cells for all Ages for the relevant Year, Sex, Deferred Period and Occupation Class).

Note that:

- In using the prevalence of Duplicates in the Claims data as the best estimate of the prevalence of Duplicates in the exposed-to-risk, it is implicitly assumed that the experience of policyholders with multiple policies is the same as that of policyholders with singleton policies; however, the dataset provides no information on which any other assumption could be based.
- This methodology is a development on the approach described in CMI Working Paper 47 (and used in producing the IPM 1991-98 graduations). At that stage, the scaling factor for each cell simply used the counts of Claim Inceptions exD and cumD for that cell, without any smoothing by Age. However, subsequent analysis revealed a subtle flaw in that methodology resulting in a small but systematic understatement, by around 2% on average, of the all-age A/E exD ratios.
- The smoothing algorithm and parameters represent a practical, ad hoc, solution. The Committee's main criteria in setting them was to seek a degree of smoothing such that the resulting scaling factors were reasonably smooth by Age whilst still reflecting the widely observed pattern of increasing prevalence of Duplicates with Age, and the significant variations in the prevalence of Duplicates by Occupation Class, Deferred Period and Sex.
- The Committee regards this revised approach as satisfactory but not necessarily as the best possible approach. Alternative ways of allowing for the presence of Duplicates in the In force data may be investigated, although the Committee's preferred approach – assuming the support of contributing offices – would be to tackle the problem directly by enhancing the data collected so that all Duplicate In force policies could be identified.

Finally, the expected Claim Inceptions, E, are calculated for each cell and compared with the count of actual Claims, A:

$$A_{x,d} = I_{x,d}\ (\text{exD})$$

$$E_{x,d} = EtR_{x,d}\ (\text{exD}) \times \sigma_{x+½,d} \times \pi_{x+½,d} \times \eta_{x+½,d}$$

where:

- x and d represent Age (last birthday) and Deferred Period respectively; subscripts for Year, Sex and Occupation Class have been omitted
- $I_{x,d}$ (exD) is the count of Claims Inceptions, excluding Duplicates, for Age x last birthday at start of Sickness and Deferred Period d
- $EtR_{x,d}$ (exD) is the Healthy lives exposed-to-risk at Age x last birthday, scaled down to an exD basis, for business with Deferred Period d
- $\sigma_{x+½,d}$ is the Sickness transition intensity at age x+½ for Deferred Period d
- $\pi_{x+½,d}$ is the probability that a life falling Sick at age x+½ will remain Sick until the end of the Deferred Period – that is, until age x+½+d
- $\eta_{x+½,d}$ is the probability that a life who fell Sick at age x+½, and who has remained Sick until the end of the Deferred Period, at age x+½+d, will then make a Claim.

Categorising the data by age last birthday gives age intervals from exact age x to exact age $x + 1$, and allows use of $\sigma_{x+½,d}$, $\pi_{x+½,d}$ and $\eta_{x+½,d}$ as reasonable approximations to the constant values assumed to be applicable to each cell for these functions.

The values of $\sigma_{x+½,d}$ are calculated directly from the graduation formulae for Sickness inception intensities. The values of $\pi_{x+½,d}$ and $\eta_{x+½,d}$ are calculated directly from the graduation formulae for Sickness recovery and mortality intensities. In particular, estimates of the early duration Termination rates, during the Deferred Period and any run-in period, are required, and these rates are also used for the second and third elements of stage (iv) of the exposure calculation. An outline of the derivation of transition rates from 'Sick but not (yet) Claiming' is given is Section 3.2. Full details of calculation methods for π, η and the exposure calculation steps are set out in CMI Working Paper 47, Sections 5 and 6 (subject to the modification noted above to the factors used to scale down the cumD exposed-to-risk to provide an estimate of the exD value).

The comparison of Claim Inceptions experience is imperfect as the calculation of expected Claims requires assumptions on Termination rates (for example, as noted above, for π, η and some of the adjustments to the exposure). Strictly Termination rates applicable to the relevant Sex and Occupation Class should be used, but both SM1975-78 and IPM 1991-98 only have graduated rates for Males in CMI Occupation Class 1. However, the distortion of results is small compared with the observed differences in Claim Inceptions experience.

3.5 *Claim Terminations Experience Analysis*

The experience analysis compares the actual numbers of Claim Terminations, treating Recoveries and Deaths separately, with the expected numbers of each of these events. Only the Claims data file is required and the calculations are performed after all Duplicate Claim records have been removed – that is, the calculations are on a lives basis, not a policy basis.

As set out in Section 3.1, the transition intensities for Claimant Recovery and Death, denoted $\rho_{y+z,z}$ and $\nu_{y+z,z}$ respectively, are assumed to depend on the Age, y, at which the life fell Sick and the duration, z, of the current Sickness, so that $y+z$ is the attained age at the point of exposure / transition. ρ also depends on the Deferred Period, d, for both SM1975-78 and IPM 1991-98, as does ν for IPM 1991-98. In addition, the analysis is structured so that variations in experience over time, and by Sex and Occupation Class, can also be examined. The following data attributes are therefore maintained throughout the calculations so that the results can be accumulated into cells each representing a unique combination of:

- Age last birthday at start of Sickness (in years, grouped)
- Duration of Sickness (in days or weeks, grouped)
- Investigation Year
- Sex: Male or Female
- Deferred Period: DP 1, 4, 13, 26 or 52 weeks
- CMI Occupation Class: Class 1, 2, 3, 4 or Unknown.

In all CMI Investigations so far, the procedure has been first to work through the dataset calculating exposure sub-divided into small cells, and then to multiply the accumulated exposure in each cell by the appropriate mortality or transition rate in order to calculate an expected number of events for the cell. The cells are defined such that the mortality or transition rates may be assumed to be nearly constant over the cell. For example, age intervals from exact age x to exact age $x + 1$ have often been used so that the rate at age $x+½$ could be used as a reasonable approximation to the constant value (in respect of age) assumed to be applicable to each cell.

For the IP Claims Terminations a quite different process is now used. A framework of cells is defined, as above, for reporting, but the analysis proceeds by working through each Claim record individually, calculating at a more granular level its own contribution to the exposed-to-risk and expected number of events (Claimant Recoveries or Deaths) in each cell.

The Age at start of Sickness, for each Claim record, is calculated twice: first to give an integral age last birthday in years, to determine the reporting cell into which the results for this Claim are to be added; and then to the nearer month, so that the Age at start of Sickness, y, for the subsequent calculations takes the form $n+{}^{m}/_{12}$ years where n and m are integers.

Next, noting that each Claim record relates to a single Investigation Year, the duration of Sickness, z, at the first day of Claim for that record in that Investigation Year is calculated, in days, minus ½ a day to give the result as at the mid-point of that day. The contributions to the numbers of expected Claimant Recoveries and Deaths for that day are then calculated as ${}^{1}/_{365}$ times the (annual) values of $\rho_{y+z,z}$ and $\nu_{y+z,z}$. These contributions are added in to the relevant reporting cell. Each day of Claim for the record is processed in this way, working through the Investigation Year, with one day (${}^{1}/_{365}$ of a year) being added to the duration, z, for each day processed; note that Age, y, is defined only in relation to the date of falling Sick and so does not change as the duration of Sickness increases.

Thus the amounts of expected Claimant Recoveries and Deaths in any reporting cell are accumulations of small amounts of exposure, processed a day at a time, each multiplied by its own values of ρ and ν for the mid-point of its 'micro-cell'. The days in Claim are also accumulated in the relevant cells and converted to years exposed-to-risk, for information, but not for further calculation.

Finally, the expected numbers of Claim Terminations for the chosen reporting cells, by Age at falling Sick and by duration of Sickness, are compared with the corresponding counts of actual Claimant Recoveries and Deaths within the cells.

The Sickness duration intervals adopted for the current analysis and reporting are: 7–14 days; 2–3 weeks; 3–4 weeks; 4–8 weeks; 8–13 weeks; 13–17 weeks; 17–26 weeks; 26–30 weeks; 30–39 weeks; 39–52 weeks; 52 weeks–2 years; 2–5 years; 5–11 years; and over 11 years. The intervals do not overlap; weeks consist of 7 days so that "2–3 weeks" means "15–21 days"; and for this purpose a year is always 365 days exactly, so that "52 weeks–2 years" means "365 to 730 days". These duration groupings are suitable for all Deferred Periods, when started at the correct point, and also neatly accommodate the run-in periods assumed for Recovery rates in SM1975-78 and IPM 1991-98.

Age last birthday at falling Sick is grouped into 5-year age bands: up to 19; 20−24; 25−29; 30−34; 35−39; 40−44 45−49; 50−54; 55−59, 60−64; 65−59; and 70 and over (although we expect there to be no observations in the last group, and very few in either the first or the second last). As was noted for Claim Inceptions, the data are generally sufficient for an exact calculation of Age last birthday, given the grouping to whole years, but where this is not the case a best, and unbiased, estimate is derived from the available data.

For completeness, note that:

- Sickness is assumed to start at 00:01 on the Date of falling Sick and end at 23:59 on the Date of Cessation of the Claim, so the days of Commencement and Cessation of Claim are each counted as a full day's exposure, and if the Claim ends by Recovery or Death, that event is assumed to occur on the last day of the Claim.
- Each required value of $\rho_{y+z,z}$ and $\nu_{y+z,z}$ for each day for each Claim record is calculated directly from the graduation formulae for Sickness recovery and mortality intensities. Any lower Recovery rates built in to the graduation formulae for a run-in period, after the end of the Deferred Period, are incorporated into these calculations.
- If, for any reporting cell, the accumulated expected Recoveries and Deaths were divided by the accumulated exposed-to-risk, the result would be weighted average of values of ρ or ν within the cell, but these would normally not equal the value of ρ or ν for the mid-point of the cell (by Age and duration Sick).

This methodology has a number of advantages over the 'traditional' approach used for other CMI Investigations as outlined above. In particular, performing these calculations using single-day intervals of duration Sick, and Age at falling Sick to the nearest month, maximises the accuracy of the calculations given the available data. In addition, it ensures that the expected numbers of events do not depend on the way the durations of Sickness, or Age, are subsequently grouped for reporting.

This increased accuracy is particularly appropriate for the analysis of IP Claimant Recoveries as the Recovery rates change very rapidly by duration Sick in the first few weeks of Sickness. A more exact Age at falling Sick could be calculated if the day of birth were available, rather than just the month and year, but the variation of rates by Age is much less critical than that by duration Sick.

The same level of accuracy could in principle be obtained with the traditional method by defining the framework of cells with much smaller divisions – micro-cells by day of duration Sick and nearest month of Age at falling Sick. The exposed-to-risk could be accumulated in each micro-cell and the totals then multiplied by the values of ρ and ν for the mid-point of that micro-cell to obtain values for the expected numbers of Recoveries and Deaths. However, the number of micro-cells would be impractically large, so the way the calculations are now done is computationally much more efficient.

4 FORMAT OF RESULTS TABLES

4.1 *General structure of results tables*

In the past, the outputs from CMI Income Protection experience investigations have been presented as a set of tables in text form, for example as Word documents or PDF files. The Committee has been concerned for some time that the text format poses an unnecessary hurdle for any user of the reports who wishes to extract the numerical values for further use. The Committee has therefore taken the opportunity, afforded by the current systems redevelopment, to make the information in the results tables more easily accessible by releasing them in spreadsheet format.

The output of each experience analysis will now be presented as a set of tables in a Microsoft Office Excel workbook.

The same format will be used whether the analysis covers a single office or a group of offices, and whatever the investigation period (typically a calendar year or quadrennium).

The output contains summary data items, such as a measure of the exposed-to-risk and a count of the actual Claim events (A), and calculated items, such as the number of expected Claim events (E), $100 \times A / E$ as the main measure of experience, and the results of a range of statistical tests.

Two sets of results are shown for the statistical tests. The tests are performed first on the basis of the expected Claim events, E, testing whether the observed experience can reasonably be said to conform to the expected basis. Then the tests are repeated on the rescaled basis $E^* = E \times [\sum A / \sum E]$, testing to see whether a simple rescaling of the expected basis, such that the overall $100 \times A/E^*$ is equal to 100, would provide an acceptable (and better) fit to the observed experience.

This information is presented separately for males and females, and for each of the main types of Claim event: Claim Inceptions and Claim Terminations (which are subdivided into Claimant Recoveries and Claimant Deaths). The output is further subdivided by CMI Occupation Class and by Deferred Period, and then within each resulting subset by Age at falling Sick and by duration Sick.

To achieve this, each results workbook contains 10 worksheets:

- Contents
- Notes
- Claim Inceptions – Male – Summary
- Claim Inceptions – Male – Detail
- Claim Inceptions – Female – Summary
- Claim Inceptions – Female – Detail
- Claimant Recoveries – Male – Summary
- Claimant Recoveries – Female – Summary
- Claimant Deaths – Male – Summary
- Claimant Deaths – Female – Summary

Within each worksheet, the subdivision by CMI Occupation Class is presented through six separate tables covering: CMI Occupation Classes 1, 2, 3 and 4; Class Unknown; and All Classes Combined.

The experience is generally analysed separately for the five common Deferred Periods: 1, 4, 13, 26 and 52 weeks. For the Summary level worksheets, the results by Deferred Period are presented as separate columns within each Occupation Class table. For the Detail level worksheets, the information for each combination of Occupation Class and Deferred Period is presented as a separate table.

The format of the tables draws considerably from that used previously (as described in CMIRs 15 and 18) giving a high degree of continuity and comparability of the reports. Enhancements include the addition of Summary tables for Claim Inceptions experience, the reporting of extra data items and statistical test results, and the resolution of a number of inconsistencies, particularly between the reporting of Claim Inceptions and Terminations.

At present the result tables presented in Excel format broadly match the level of information previously provided in public CMI reports such as in CMIRs 18, 20 and 22. The next stage of development will extend the coverage to the level of information previously provided in reports to CMI member offices. In particular, this will include a further layer of detail in relation to Claim Terminations. The Committee is also minded to provide additional information where practical, such as providing the detail results in more granular form using individual ages rather than rigid age groups.

4.2 *Claim Inceptions Experience*

The results of the Claim Inceptions experience analysis are presented in 4 worksheets. The format of the 'Claim Inceptions – <Sex> – Summary' worksheets is described in Table 1. The format of the 'Claim Inceptions – <Sex> – Detail' worksheets is described in Table 2.

The age groups adopted are: 17–19; 20–24; 25–29; 30–34; 35–39; 40–44; 45–49; 50–54; 55–59; and 60–64. Exposure and Claim events outside the age range 17–64 are not analysed.

As the $100 \times A/E$ results in the Summary worksheets are shown for each age group without the corresponding A or E, some additional formatting is applied to prevent undue emphasis being placed on cell results based on low volumes of data. For age groups where the expected number of Claim Inceptions, E, is less than 5, the data have been aggregated into neighbouring cells, as indicated by the direction of the arrows (↑ or ↓), for the calculation of $100 \times A/E$. For age groups where the actual number of Claim Inceptions, A, is less than 30, the $100 \times A/E$ result is shown in italics. Additional information on the data for each age group cell is presented, without grouping, in the tables in the Detail worksheets.

The results of an array of statistical tests are shown in the Summary worksheets for each combination of Sex, Occupation Class and Deferred Period. This statistical analysis tests whether the observed experience is consistent with the basis used for calculating the number of expected Claim Inceptions, E, or with a simple rescaling of it, E^*. Results which indicate that the experience is significantly different from the basis for E (or E^*), as determined by a probability value of less than 5%, are highlighted. Further information on the statistical tests, including guidance on interpreting their results, is given in Section 5.

Table 1: Claim Inceptions Experience Summary Tables		
Number of Tables	12 Summary Tables [6 per worksheet]	{M, F} × {6 OCs} OC = {1, 2, 3, 4, Unknown, All}
Reporting Level	Rows: Age Group All age total Columns: DP = {1, 4, 13, 26, 52}	5-year age-groups; showing further grouping where used
Data and Results	Exposure, cumD Actual Inceptions, cumD Actual Inceptions, exD, *A* Expected Inceptions, *E* 100 × *A/E*	All-age total only; including Duplicates All-age total only; including Duplicates All-age total only; excluding Duplicates All-age total only; excluding Duplicates Shown for each age group and all-age total
Statistical Tests	Pearson $X^2 = \Sigma z^2$ Degrees of freedom $p(\chi^2)$ Total Poisson Deviance Degrees of freedom $p(\text{Deviance } \chi^2)$ #(+/–), *p*(+/–) #(Runs), *p*(Runs) *p*(K-S)	Pearson chi-squared test; $z = (A - E)/\sqrt{E}$ calculated on individual age cells; cells grouped if $E < \mathbf{5}$; continuity adjustments applied. Poisson Deviance chi-squared test; deviance calculated on individual age cells without grouping. Signs test Runs test Kolmogorov-Smirnov test All test results shown for both *E* and $E^* = E \times [\Sigma A/\Sigma E]$
Use of highlights	100 × *A/E* is shown as *italic* if the actual number of Claim Inceptions is < 30 All probability values are shown to 4 decimal places if < 0.10 and as **bold** if < 0.05	

Table 2: Claim Inceptions Experience Detail Tables		
Number of Tables	60 Detailed Results Tables [30 per worksheet]	{M, F} × {5 DPs} × {6 OCs} DP = {1, 4, 13, 26, 52} OC = {1, 2, 3, 4, Unknown, All}
Reporting Level	Rows: Age Group All-age total	5-year age-groups, without any further grouping
Data and Results	Exposure, cumD Actual Inceptions, cumD Actual Inceptions, exD, *A* Expected Inceptions, *E* 100 × *A/E* $E^* = E \times [\Sigma A/\Sigma E]$ 100 × *A/E**	Include Duplicates Include Duplicates Excluding Duplicates Excluding Duplicates
Statistical Tests	None	Tests omitted here but shown in summary tables
Use of highlights	None	

4.3 *Claim Terminations Experience*

The results of the Claim Terminations experience analysis are presented in 4 worksheets at 'Summary' level. The format of these worksheets is described in Table 3.

The age groups adopted are very similar to those used for the Claim Inceptions analysis: up to 19; 20–24; 25–29; 30–34; 35–39; 40–44; 45–49; 50–54; 55–59; 60–64; 65–69; and 70 and over. Exposure and Claim events are analysed without applying any 'working age' limits; in practice, the 1991-2006 Claims dataset spans ages 17 to 67 inclusive.

The Sickness duration intervals adopted are: 7–14 days; 2–3 weeks; 3–4 weeks; 4–8 weeks; 8–13 weeks; 13–17 weeks; 17–26 weeks; 26–30 weeks; 30–39 weeks; 39–52 weeks; 52 weeks–2 years; 2–5 years; 5–11 years; and over 11 years.

As the $100 \times A/E$ results in the Summary worksheets are shown for each age group and duration interval (separately) without the corresponding A or E, some additional formatting is applied to prevent undue emphasis being placed on cell results based on low volumes of data. For data cells (each combination of age group and duration interval) where the expected number of Claimant Recoveries (or Deaths), E, is less than 8, the data have been aggregated into neighbouring cells, as indicated by the direction of the arrows (↑ or ↓), for the calculation of $100 \times A/E$. The grouping process works across both dimensions, age and duration, and is detailed in Section 5. For data cells where the actual number of Claimant Recoveries (or Deaths), A, is less than 30, the $100 \times A/E$ result is shown in italics.

The results of an array of statistical tests are shown for each combination of Sex, Occupation Class and Deferred Period. This statistical analysis tests whether the observed experience is consistent with the basis used for calculating the number of expected Claimant Recoveries (or Deaths), E, or with a simple rescaling of it, E^*. Results which indicate that the experience is significantly different from the basis for E (or E^*), as determined by a probability value of less than 5%, are highlighted. Further information on the statistical tests, including guidance on interpreting their results, is given in Section 5.

At present the results tables for Claim Terminations do not extend to the equivalent level of the 'Inceptions Detail' worksheets. However, the next stage of development of the spreadsheet-based reporting will provide the equivalent level of additional information on the data for each age-group / duration-interval cell.

4.4 *Results table naming convention*

The following naming and referencing convention has been adopted for the results tables:

Each table is given a reference of the form: 'Table X.y.n.mm'
where:

- X = I for Inceptions; R for Recoveries; D for Deaths
- y = m for males; f for females
- n = CMI Occupation Class = 1, 2, 3 or 4, plus 5 for 'Unknown' and 6 for 'All'
- mm = Deferred Period = 01, 04, 13, 26 or 52
- The 'mm' term is omitted for the summary tables of experience by Deferred Period.

Table 3: Claim Terminations Experience Summary Tables		
Number of Tables	24 [6 per worksheet]	{M, F} × {Recoveries, Deaths} × {6 OCs} OC = {1, 2, 3, 4, Unknown, All}
Reporting Level	Rows: Age Group Duration of Sickness All-age and duration total Columns: DP = {1, 4, 13, 26, 52, 4-52, All}	 5-year age-groups; showing further grouping where used Varying intervals - see Section 4.3 Note inclusion of columns for DPs 4-52 combined, and All DPs combined
Data and Results	Actual Terminations, *A* Expected Terminations, *E* 100 × *A/E*	Total only; Claim Terminations exclude Duplicates (exD) Total only Shown for each age group and (separately) each duration
Statistical Tests	Pearson $X^2 = \Sigma z^2$ Degrees of freedom $p(\chi^2)$ Total Poisson Deviance Degrees of freedom p(Deviance χ^2) #(+/–), p(+/–) $p(B)$ p(TW-KS)	Pearson chi-squared test; $z = (A - E)/\sqrt{E}$ calculated on age group / duration cells; cells merged if $E < 8$ (a complex two-dimensional process); continuity adjustments applied. Poisson Deviance chi-squared test; deviance calculated on age group / duration cells without grouping. Signs test Two way runs test A two-way extension of the Kolmogorov-Smirnov test All test results shown for both E and $E^* = E \times [\Sigma A/\Sigma E]$
Use of highlights	100 × *A/E* is shown as *italic* if the actual number of Recoveries or Deaths is < 30 All probabilities (bar $p(B)$) are shown to 4 decimal places if < 0.10 and as **bold** if < 0.05 $p(B)$ is always shown to 3 decimal places and as **bold** if < 0.050	

5 STATISTICAL ANALYSIS

5.1 *Overview of statistical tests*

As set out in Section 4, the experience analysis results are presented separately for each combination ('table') of investigation period, Sex, Deferred Period and Occupation Class. The 'headline' result for each table is the 100 × *A*/*E* across all cells – that is, for all Ages combined and, for Claim Terminations, all durations Sick combined as well. This is supported by 100 × *A*/*E* values for Age groups and intervals of duration Sick, and by summary totals for the numbers of actual and expected Claim events.

Whilst this summary information presents a high-level picture of the experience for each table, it is not sufficient on its own to enable the results-users to assess the significance of apparent features in the picture. To overcome this problem, the results of an array of statistical tests are also shown for each table to help users interpret the reported experience.

As a first step, the user is likely to need to assess the overall 'level' of the Claims experience. This could be approached in two ways, either:

(a) Testing to see whether the level of the experience could reasonably be described as being consistent with the basis used for calculating the number of expected Claim events; or
(b) Estimating the level of the experience relative to the expected basis.

In both cases, there is an implicit assumption that the 'shape' of the experience, by Age and duration Sick (if appropriate), conforms to the expected basis. Therefore the second step is to test whether the observed experience fits sufficiently closely with either:

(a) The basis used for calculating the number of expected Claim events, *E*; or with
(b) A simple rescaling of the basis, $E^* = E \times [\sum A / \sum E]$ – that is, a simple multiplicative adjustment to the expected basis so that $\sum A = \sum E^*$ for the table overall.

The statistical tests provided to support the user in making these judgements are described in the following Sections.

First, some preliminaries, to establish the statistical framework, are covered in Section 5.2.

The estimation of a 'confidence interval' for the observed 100 × *A*/*E* is discussed in Section 5.3. Different formulae (and nomenclature) are appropriate for the two approaches, (a) and (b), for assessing the overall level of the observed experience.

A number of statistical tests are used to assess the fit between the observed experience and the expected basis: Chi-squared test; Signs test; Runs test; and the Kolmogorov-Smirnov test. These are described in Sections 5.4 to 5.8, and the interpretation of the overall results from this battery of tests is discussed in Section 5.9. These tests are performed first on the basis of the expected Claim events, *E*, testing whether the observed experience can reasonably be said to conform to the expected basis. Then the tests are repeated on the rescaled basis *E**, testing to see whether a simple rescaling of the expected basis, such that the overall 100 × *A*/*E** is equal to 100, would provide an acceptable (and better) fit to the observed experience.

Individual test results which might indicate that the experience is significantly different from the basis for E (or *E**), as determined by a probability value of less than 5%, are highlighted in the summary tables.

5.2 *Preliminaries: Poisson model; Duplicates; grouping of data*

5.2.1 Poisson Model

For each part of the investigation, Claim Inceptions, Claimant Recoveries and Claimant Deaths, the relevant number of Claim events are counted and compared with the corresponding central exposed-to-risk. These data items are subdivided into cells small enough so that the continuous transition intensity, or 'Claim rate', can be assumed to be reasonably constant within each cell. The numbers of Claim events are reasonably small compared with the exposure – that is, the Claim rates are much less than 1.00 per unit of exposure.

With these conditions, the number of Claim events observed in each cell is approximately Poisson distributed, with a Poisson parameter that corresponds with the "expected" number of events, E. Therefore the distribution has both its mean and variance equal to E.

It follows that, when cells are added together, the total number of events is also Poisson distributed with a parameter that corresponds with the sum of the expected numbers. If the expected number of events in any cell, or in any group of cells, or in all cells combined, is reasonably large, we can assume that the number is approximately normally distributed

5.2.2 Duplicates

The Poisson model, as described in Section 5.2.1, assumes that each individual at risk is independent of the others. This would not be true if Duplicate policy records and Claims records were included as they would, for example, give rise to two or more simultaneous apparent events from the same underlying event. Therefore it is important to identify and remove Duplicate records as far as possible.

We can identify Duplicate Claim records with reasonable confidence. The counts of Claim events for the experience analysis are therefore derived from the exD Claims files, that is: with Duplicates removed. Similarly, the exposed-to-risk for the Claim Terminations analysis is calculated from the exD Claims file.

As we cannot identify Duplicates in the In force data, exposure for the Inceptions analysis is calculated using the files including Duplicates, and then the results are scaled down by the ratio (smoothed across neighbouring cells by Age) of the Claim Inceptions count excluding Duplicates to the Claim Inceptions count including Duplicates. See Section 3.4 for further details. The Committee regards this approach as making a more accurate allowance for Duplicate records than the "variance ratio" approach previously applied (see CMIR 15).

Although all identified Duplicates have been eliminated from the counts of the Claim events, it is possible that some Duplicate Claims remain undetected. In addition, the adjustment for Duplicates in the exposed-to-risk for the Claim Inceptions analysis is only an approximation. These issues, arising from weaknesses in the dataset, may lead to over-dispersion in the experience or, more generally, to some distortion of the test statistics – see, for example, the comments on the chi-squared test in Section 5.4.

5.2.3 Grouping of cells

Some of the tests rely on the assumption that the numbers of Claim events in each cell are approximately normally distributed. Given the underlying Poisson model for Claim events, this is a reasonable assumption only if the expected numbers of Claim events in each cell are sufficiently large. For these tests it is therefore useful to group neighbouring cells so that the sum of the expected Claim events in the group is large enough to ensure the validity of the statistical test.

For some purposes, where a close approximation to the normal distribution is essential, a minimum of say 30 events in each cell might be appropriate. However, in context of a battery of tests being applied to support the interpretation of the experience analysis results, a greater degree of approximation is acceptable. The Committee consider that the applied minima of 5 for the Claim Inceptions analysis and 8 for the Claim Terminations analysis, although somewhat arbitrary, are suitable for this purpose.

For the Claim Inceptions experience analysis, the tests are applied to the 'column' of cells, by single year of Age, for the selected investigation period, Sex, Deferred Period and Occupation Class. In almost all investigations the numbers at each Age may be less than 5 at the extreme ages under consideration, and in some tables the data may be scanty at more than just the extreme ages.

The grouping algorithm used for the Claim Inceptions experience analysis is:

- Starting at the lowest Age in the column of data, cells for consecutive Ages are grouped until the sum of the expected Claim Inceptions in the group is 5 or more; a group is completed at that point.
- The next group is then started, working up through the Ages completing each group as soon as the sum of the expected Claim Inceptions in the group is 5 or more.
- A group may (and often does) consist of a single Age.
- At the end of the column, if the last (incomplete) group has fewer than 5 expected Claim Inceptions, it is added to the last completed group.

In summary, the column is traversed first from top to bottom, combining a cell with its next neighbour until the group of cells reaches the required minimum size. Any incomplete group at the end of the column is then added back to the last completed group.

For the Claim Terminations experience analysis, the tests are applied to the rectangular array of cells, by Age (columns) and by duration Sick (rows), for the selected event (Recovery or Death), investigation period, Sex, Deferred Period and Occupation Class. Here, as well as the problem of low data volumes at some Ages, the data are also spread across the second dimension – duration Sick.

As a preliminary step, the data are accumulated into a manageable number of cells in the array using the Age groups and duration Sick intervals noted in Section 4.3. Then the grouping algorithm used for the Claim Terminations experience analysis involves three separate processes similar to that used for Claim Inceptions:

- First, the columns (Ages) are traversed from left (lowest Age) to right, adding any column with fewer than 15 expected Claim events to its next neighbour, and reversing the sweep to pick up any incomplete groups at high Ages.

- Second, the rows (durations Sick) are traversed from bottom (highest duration) to top, adding any row with fewer than 15 expected Claim events to its next neighbour, and reversing the sweep to pick up any incomplete groups at short durations Sick.
- Finally, within each row, each cell is looked at, traversing from left to right adding any cell with fewer than 8 expected Claim events to its next neighbour, and reversing the sweep to pick up any incomplete groups at high Ages.

The values used for the minimum number of expected Claim events in each group are higher for the Terminations analysis than the Inceptions analysis. This is driven by practical considerations, noting that the data are much sparser in the two-way tables of Terminations than in the one-way tables on Inceptions. The values used are unchanged from those set out in CMIR 15 and used in the previous experience reporting framework.

If individual discretion were applied in the grouping of cells, or use were made of alternative algorithms, slightly different results might be produced. However, the Committee is satisfied that the current method is reasonable.

5.3 *Confidence interval for observed 100 × A/E*

In the experience analysis summary results tables for each part of the investigation, Claim Inceptions, Claimant Recoveries and Claimant Deaths, results are presented separately for each combination ('table') of investigation period, Sex, Deferred Period and Occupation Class. In particular, the statistic $R = 100 \times A/E$ is shown as a total for the table and also for each Age group, and, for the Claim Terminations analyses, for each reporting interval for duration Sick too.

5.3.1 Testing the hypothesis that the experience conforms to the expected basis

Under the hypothesis that the observed number of Claim events conforms to the expected basis, it is assumed that the number of events is Poisson distributed with parameter E, and therefore with mean E and variance E, and so standard deviation $\sqrt{E}$. Provided E is sufficiently large, say at least 5 but preferably 30 or more, a normal approximation can be assumed, so that an approximate 95% probability interval for the observed number of events is: $E \pm 1.96\sqrt{E}$.

Then the expected value of R is 100 and the standard deviation is $100\sqrt{E}/E$, so:

An approximate 95% probability interval for R is: $100\,(E \pm 1.96\sqrt{E})\,/\,E$

If the observed ratio R, for the table as a whole, lies inside this range, then there is reasonable evidence that at least the overall level of the number of Claims events is consistent with the chosen basis. Further tests can then be used to show whether the observed numbers in individual cells are also consistent with the chosen basis.

Equivalently:

if 100 lies within the range: $100\,(A \pm 1.96\sqrt{E})\,/\,E$

then the observations are consistent with the chosen basis.

Note that we use the term 'probability interval' here rather than 'confidence interval'. In common with some statisticians, we restrict use of the term 'confidence interval' to the estimate of the value of a parameter (for example see Section 5.3.2). Some statisticians would refer to the given interval as an 'acceptance interval' for the hypothesis being tested.

As an alternative way of performing the test, the tail probability could be calculated (again assuming normality)*:

If $A < E$, calculate $p(A)$ = P[Number of Claim events $< A$]

If $A > E$ calculate $p(A)$ = P[Number of Claim events $> A$]

If $p(A)$ is less than 0.025 then A (or equivalently R) would lie outside of the corresponding 95% probability interval, leading to the rejection of the hypothesis at the 5% level.

[* Because A is necessarily integral, a "continuity adjustment" could be applied – see Section 5.4 for an example.]

5.3.2 Estimating the level of the experience relative to the expected basis

It is often the case with an experience analysis that one does not expect the experience to conform to the expected basis – for example because it relates to a different subset of business, or to a different time period, or to a different dataset altogether. However, it is possible that a simple multiplicative adjustment to the expected basis may provide a satisfactory fit.

To estimate the level of the experience relative to the expected basis, assume that in each cell the expected number of events is a constant r times those expected under the chosen reference basis. The number of Claim events expected in total is therefore $r.E$, and it can be assumed that the observed number of events is Poisson distributed with parameter $r.E$, and therefore with mean $r.E$, variance $r.E$ and standard deviation $\sqrt{rE}$.

It can be shown that the maximum likelihood estimate of r is A/E with variance A / E^2. The standard error of the estimate of r is therefore $\sqrt{A}/E$. It can also be shown that the estimate is approximately normally distributed. Therefore:

An approximate 95% confidence interval for r is: $\left(A \pm 1.96\sqrt{A}\right) / E$

Equivalently, multiplying by 100:

An approximate 95% confidence interval for 100 r is: $100\ (A \pm 1.96\sqrt{A})\ /\ E$

Further tests can then be used to show whether the observed numbers in individual cells are also consistent with the adjusted expected basis – that is, that applying a constant multiplier to the reference basis provides a satisfactory fit across the experience. This is indeed the objective of the statistical tests applied using the E^* basis for expected Claim events.

5.4 *Pearson X^2 and chi-squared test*

The chi-squared test provides an overall measure of the 'goodness of fit' of the observed experience to the expected basis.

Given the actual number of Claim events in any cell, A, and the expected number of events, E, it is natural to calculate the difference, or deviation, $A - E$, and also the relative or standardised deviation, z, allowing for the variance of the number of events in each cell (according to the assumed underlying model). Using the Poisson model, and testing against a given basis for expected Claims, the variance is equal to the expected number of events, E, so:

$$\text{Standardised deviation, } z \quad = \quad (A - E) / \sqrt{E}$$

Provided the individual z's are (at least approximately) normally distributed, the "chi-squared statistic", $X^2 = \Sigma z^2$, the sum of the squares of the standardised deviations, is distributed as χ^2 with the number of degrees of freedom equal to the number of cells in the summation, reduced by one for each constraint that may be imposed.

For the Pearson X^2, two refinements are made. First, grouped data cells are used to ensure satisfactory event counts in each cell to respect the requirement for approximate normal distributions. Second, continuity adjustments are applied in the calculation of the z's. That is, in calculating the difference between the actual number of events, A, and the expected number, E, an allowance is made for the fact that the actual number is necessarily an integer, whereas the assumed normal distribution is continuous, by moving the difference nearer to zero by 0.5.

So, in full:

Let Standardised deviation, $z \quad = \quad D / \sqrt{E}$

where
if $A - E > 0.5$ then $D = A - E - 0.5$
if $-0.5 \leq A - E \leq 0.5$ then $D = 0$
if $A - E < -0.5$ then $D = A - E + 0.5$

Then Pearson χ^2statistic, $X^2 \quad = \quad \Sigma z^2$

The chi-squared test is applied, by calculating the probability of a value of X^2 greater than that observed, to test whether the observed value is more extreme than might be expected.

Calculate $p(\chi^2) \quad = \quad \mathrm{P}[\ \chi_{\mathrm{df}}^2 \geq X^2\ ]$

where χ_{df}^2 has a χ^2 distribution with *df* degrees of freedom

When the test is performed using the expected Claim events, E, *df* is equal to the number, N, of grouped data cells used in the summation over all Ages (and all durations Sick for the Terminations analysis). Note that the grouping is determined using only the numbers of expected Claim events, E, and is not dependent on the numbers of observed events, A.

When the test is performed using the scaled expected Claim events, E^*, *df* is equal to the number, N^*, of grouped data cells used, reduced by one to allow for the constraint that the total scaled expected, ΣE^*, is made equal to the total actual, ΣA. Note that N^* may differ from N as the grouping of cells is dependent on the number of expected Claim events, E^* and E respectively, in each cell.

The values of X^2, *df* and $p(\chi^2)$ are shown in the experience analysis summary results tables.

The chi-squared test is the most comprehensive test applied in the analysis and provides an overall measure of the 'goodness of fit' of the observed experience to the expected basis. If the value of X^2 is high, so that the value of $p(\chi^2)$ is less than say 0.05, it may well indicate a poor fit, particularly if supported by low probability values in the other tests.

However, low values of $p(\chi^2)$ may arise even where the results of other tests are satisfactory and the fit does not appear to be unreasonable. Inspection of the individual values of z's may show that there is a quite small number of unusually high values; these may indicate errors or 'rogue' results in those data cells. Low values of $p(\chi^2)$ may also arise through unusually high values of X^2 with considerable irregularity in the values of z's, some being high and others low. This shows 'over-dispersion' in the data, which could be explained by the presence of Duplicates (which have evaded exclusion) or additional risk factors not reflected in the model or expected basis. More generally, violation of the assumptions regarding the independence of the observed Claim events within and between cells, and the normality of the relative deviations, will distort the distribution of X^2 and may lead to low values for $p(\chi^2)$.

5.5 *Poisson deviance and chi-squared test*

The Poisson deviance is an alternative to the Pearson X^2 for the chi-squared test.

The deviance of a model is defined as the difference between the maximum log likelihood of the fitted model, and the log likelihood of a saturated model in which there are enough parameters so that the expected number of events is equal to the actual number in each and every cell.

If the events are assumed to be Poisson distributed then a Poisson deviance is defined for each data cell, without grouping, as:

$$2 \times (A \times \ln(A/E) - (A - E)) \qquad \text{if } A \neq 0$$
$$2 \times E \qquad \text{if } A = 0$$

The total deviance is then the sum of these values over all data cells. The Poisson deviance, like the Pearson X^2, is then distributed as χ_{df}^2 , a χ^2 distribution with *df* degrees of freedom where:

- When the test is performed using the expected Claim events, E, *df* is equal to the number of non-empty data cells used, without grouping, in the summation.
- When the test is performed using the scaled expected Claim events, E^*, *df* is equal to the number of non-empty data cells used, reduced by one to allow for the constraint that the total scaled expected, ΣE^*, is made equal to the total actual, ΣA.

The values of the total Poisson deviance, *df* and $p(\chi^2)$ are shown in the experience analysis summary results tables and may be interpreted in the same way as those of the Pearson chi-squared test.

Both the Pearson X^2 and Poisson deviance chi-squared test results are included in the experience analysis summary results tables for the time being. This allows comparison of the results and retains the former for comparability with previous reports.

The Poisson deviance gives accurate results for all values of *A* and *E*. In contrast, the Pearson chi-squared test suffers some approximation error to the extent that the individual *z*'s are not normally distributed; this error is reduced by grouping to achieve appropriate minimum numbers in each cell. As such grouping is not necessary for the Poisson deviance, it has the advantage that the method and result are unique, whereas those of the Pearson X^2 are dependent on the algorithm chosen for grouping the data. This advantage is greatest for the Claim Terminations analyses where heavy grouping has always been found to be necessary for the Pearson chi-squared test.

Subject to further evaluation of the results, the Committee is minded to move in future to showing only the Poisson deviance results for the chi-squared test.

5.6 *Signs Test*

While a χ^2 test is usually satisfactory, it can sometimes give misleading results. The value may seem to be too high simply because of a 'rogue' result in a single data cell of the table. Or it may seem to be too low when all, or nearly all, the deviations are of the same sign, but not of very high value. In order to counter these cases it is useful also to consider non-parametric tests of the distribution of the signs of the deviations.

The statistics used for the 'signs test' are the counts of the number of cells where the deviation, $A - E$, is positive or negative. If the observations are in accordance with those expected, and if for each cell the distribution of the number of Claim events has its mean equal to its median (as is the case with the normal distribution, but not the Poisson distribution), then for each deviation the probabilities that its sign is positive or negative are both equal to one half, so that positives and negatives should occur with equal frequency. These conditions may be assumed to be met provided the signs test is performed on the grouped data cells.

The numbers of positive and negative signs, #(+) and #(–), may be assumed to be binomially distributed as $B(N, \frac{1}{2})$ where *N* is the number of grouped data cells. Exact probabilities can then be calculated from the Binomial distribution.

We use the signs test to test whether the observed numbers of positives and negatives are more extreme than might be expected. For this, a 'two-tailed' test is appropriate:

Let $n = \min \{ \#(+), \#(-) \}$

Calculate $p(+/-) = P[\ \#(+) \le n\ ] + P[\ \#(-) \le n\ ]$

For example, if there were just one positive cell out of 10 cells, p(+/–) would be the probability of there being zero or one positives, plus the probability of there being zero or one negatives, and would take the value 0.0215 [= 22 / 1,024].

The values of #(+), #(–) and p(+/–) are shown in the experience analysis summary results tables. If the value of p(+/–) is too low, such as less than 0.05, then the distribution of signs is unexpectedly extreme with the observed number of Claim events being too far to one side or the other of the expected numbers (above if #(+) > #(–), below if #(+) < #(–)) so that the expected basis is unlikely to be a satisfactory representation of the experience.

If the expected basis is a poor fit to the overall level of the experience, so that the overall $100 \times A/E$ is not close to 100, then p(+/–) is likely to be low and adds little new information. However, the Signs test applied to the adjusted basis, E^*, should always provide some useful insight into the fit of the adjusted basis by Age and duration Sick.

5.7 *Runs Test and Bonds Test*

A second non-parametric test is the runs test, or the sign-change test, to test whether the signs of the deviations, $A - E$, can be treated as randomly distributed. This test is not concerned with the balance of positive and negative deviations; instead it starts with the observed numbers of positive and negative deviations, #(+) and #(–), and simply tests whether these are arranged at random.

First consider the runs test applied to the single-dimension column of cells, by Age, for a selected investigation in the Claim Inceptions experience analysis. If the observations are in accordance with those expected, then deviations at successive cells should be independent and the signs of the deviations should be randomly distributed, with neither too many nor too few runs of successive deviations with the same sign.

Although grouping of cells may not be strictly necessary for this test, it is convenient to use the grouped cells so that the numbers of positive and negative signs, #(+) and #(–), are the same as those used for the signs test. If the signs are arranged at random within the sequence of N grouped data cells, then the distribution of the number of runs, of one or more consecutive deviations with the same sign, can be calculated exactly. For example, the calculation of the probability that there are exactly r runs (with r even) starts by considering the number of ways in which the #(+) positive signs may be arranged into $r/2$ non-empty groups and the #(–) negatives may be arranged into another $r/2$ non-empty groups.

To apply the runs test we calculate the probability that the number of runs is less than or equal to the observed value:

Let #(Runs) = Observed number of runs

Calculate p(Runs) = P[$r \leq$ #(Runs)]

The values of #(Runs) and p(Runs) are shown in the experience analysis summary results tables. A one-tailed test is appropriate: a low value of p(Runs) is potentially significant; a high value tells us little.

If the value of p(Runs) is too low, such as less than 0.05, then the sequence of signs is unexpectedly extreme with too few runs or, equivalently, too great a concentration of cells of a similar sign. This would generally indicate a poor fit across some part of the age range when comparing the observed experience with the expected basis.

A too high value for p(Runs) could, for example, indicate that a graduation followed the observed experience too slavishly, weaving on either side of the observed rates – an indication of over-fitting. However, such high values rarely occur when testing the results of an experience analysis, and even then would be of less significance.

As with the Signs test, calculating the Runs test using E may add little information if the expected basis is a poor fit to the overall level of the experience, but recalculating p(Runs) using the adjusted basis, E^*, should always provide some useful insight.

For the Claim Terminations experience analysis a two-dimensional equivalent of the runs test is required. Such a test has been devised for application to the CMI IP investigation and it is described in detail in CMIR 15 (particularly 'Appendix B', pages 124-129).

This test investigates the relationship between adjacent cells, either in a horizontal (by Age) or a vertical (by duration Sick) direction, within the results array (which, because of grouping of cells, may no longer be rectangular, but irregular within the rectangular frame). If the observed deviations, $A - E$, in two adjacent cells have the same sign, the relationship is described as a *bond*, and if they have different signs it is described as a *break*.

Given the observed numbers of positive and negative deviations, #(+) and #(–), and an assumption that these are arranged at random within the array, the distribution of the number of bonds and breaks may be estimated by simulation.

To apply this two-way 'bonds test' we calculate the probability that the number of bonds is greater than or equal to the observed value:

Calculate $p(B) = \text{P[Number of bonds} \geq \text{Observed number of bonds]}$

The value of $p(B)$ is shown to 3 decimal places, indicating the number of simulations that met the criterion out of the 1,000 performed.

If the number of observed bonds is too great, say $p(B) \leq 0.050$, the result is equivalent to too few runs in the runs test, showing excessive concentration of cells of a similar sign. This would indicate a substantial lack of fit in some region when comparing the observed experience with the expected basis. Further investigation of the results array would be necessary to see where the discrepancy lies: it might be that the number of events in one group of Ages or one group of durations Sick is unusually high or low, compared with the expected basis, or there may be an excess or a deficit in some specific region of Age and duration Sick.

In applying the Bonds test to the adjusted expected, E^*, the revised numbers of positive and negative signs are used. However, a different assumption could have been adopted such that for each simulation each cell had an equal chance of containing a positive or negative sign.

5.8 *Kolmogorov-Smirnov Test*

The final test reported in the experience analysis summary results tables is the Kolmogorov-Smirnov test. This is another non-parametric test and it considers the distribution of the maximum absolute deviation between two cumulative distributions.

The standard form of the Kolmogorov-Smirnov test may be applied to the single-dimension column of cells, by Age, for a selected investigation in the Claim Inceptions experience analysis, by considering the distributions of the actual $\{A_x\}$ and expected $\{E_x\}$ Claim Inceptions.

Assuming an Age range from x_1 to x_2, using the data cells without grouping, define the total actual and expected Claim Inceptions as:

$$A = \sum_{i=x_1}^{x_2} A_i \qquad \text{and} \qquad E = \sum_{i=x_1}^{x_2} E_i$$

Then define the (scaled or proportional) cumulative distributions as:

$$F(x) = \left(\sum_{\mathrm{i=x_i}}^{\mathrm{x}} A_i\right)/A \qquad \text{and} \qquad G(x) = \left(\sum_{i=x_1}^{\mathrm{x}} E_i\right)/E$$

Calculate the maximum absolute difference between the cumulative distributions, D, and a scaling factor, C, as:

$$D = \mathrm{Max}\,|F(x) - G(x)|$$

$$C = \sqrt{(AE)/(A+E)} = 1/\sqrt{(1/A) + (1/E)}$$

Finally, calculate the Kolmogorov-Smirnov statistic:

$$\text{K-S} = D \times C$$

The statistic K-S has a known distribution, generally accessed via published tables or statistical software packages, and so the probability, p(K-S), of a value as large as, or larger than, that actually obtained for K-S can be calculated.

Note the Kolmogorov-Smirnov test does not require any distributional assumption for the numbers of Claim events in each cell and so is applied without grouping any cells. Also note that the value of D will be the same whether the calculations are based on E or E^*, but that the value of C, and therefore of K-S and p(K-S) would differ.

The value of p(K-S) is shown in the experience analysis summary results tables. If the value of p(K-S) is too low, such as less than 0.05, then a poor fit between the experience and the expected basis is indicated (with too high a value for the maximum deviation). For comparison, note that satisfactory graduations often produce values of p(K-S) higher than 0.9, sometimes exceeding 0.99.

For the Claim Terminations experience analysis a two-dimensional extension of the Kolmogorov-Smirnov test is required. An appropriate test is described in Press, W.H. et al, "Numerical Recipes in C" (Cambridge University Press, 1992) and further references therein.

Assume the array of data cells has m rows, each representing a distinct range of durations Sick, and n columns, each representing a distinct Age group. As there is no need to group data cells for this test, the array remains rectangular. Let the actual number of observed Claim events in each cell be A_{ij} and the expected number E_{ij}, and let the totals, summing over i =1, …, m and j = 1, …, n, by A and E (as above).

Imagine splitting up the array into four quadrants, by drawing two lines, one horizontally between any two rows, say rows I and I+1, and the other vertically between any two columns, say columns J and J+1. The "top left" quadrant has cells such that $i \leq I$, and $j \leq J$, and the other four quadrants, top right, bottom left and bottom right, are correspondingly defined. Count the proportion of the A_{ij}'s that are in each quadrant, and call these A_{TL}, A_{TR}, A_{BL} and A_{BR} (*TL* for top left, *TR* for top right, etc.). Similarly count the proportion of the E_{ij}'s that are in each quadrant, and call these E_{TL}, E_{TR}, E_{BL} and E_{BR}. Calculate the differences between corresponding proportions, $D_{TL} = A_{TL} - E_{TL}$, etc. Take the maximum absolute value of the four differences, and store it, calling it D_{IJ}.

Repeat these calculations for every possible choice of I and J from I = 0 to m and J = 0 to n, thus including those where the lines cross at the edge of the table. Then calculate the maximum value of all the maximum absolute differences that have been found, denoting it D. If the lines cross at any of the corners, the proportion in one quadrant is unity and in the others is zero, for both A and E. But the maximum difference might occur when the table is split into two parts, with only two quadrants being void.

Now calculate the usual (Pearson product-moment) correlation coefficients of the A_{ij}'s (by Age and duration Sick) and of the E_{ij}'s, assuming that the cells in the rows and columns are evenly spaced and denote these ρ_A and ρ_E. Then calculate:

$$B = \sqrt{1 - (\rho_A + \rho_E)^2/4}$$

and (as before)

$$C = \sqrt{(AE)/(A+E)}$$

Finally, calculate the "Two-way" Kolmogorov-Smirnov statistic:

$$\text{TW-KS} = D \times C \,/\, \{ 1 + B \times (1 - 3/C)/4 \}$$

The statistic TW-KS has the same, known distribution as the K-S statistic, and so the probability, p(TW-KS), of a value as large as, or larger than, that actually obtained for TW-KS can be calculated using published tables or a statistical software package.

The value of p(TW-KS) is reported in the experience analysis summary results tables. A too low value p(TW-KS) indicates a poor correspondence between the distributions of the A_{ij}'s and the E_{ij}'s.

The two-way Kolmogorov-Smirnov test and the bonds test show rather different things, the former looking at the whole balance of the data in its four quadrants at each point, the latter looking for local irregularities – or rather local regularities in the sense of too many neighbouring positives or negatives. If the actual events show a very different pattern from those expected, both tests will show this up. But there may be cases where one test shows up a feature that the other test does not, so both tests are useful. An advantage of the two-way Kolmogorov-Smirnov test is that it does not require grouping of data cells, whereas the signs test does, and the bonds test relies on the signs. So the former test is applicable even when the data is sparse, although it might then take a rather large irregularity to show up.

5.9 *Overall interpretation of the battery of statistical tests*

A suggested approach to reviewing the results presented in each summary table is as follows.

Start by asking the question: *is the expected basis a satisfactory representation of the observed experience?*

Equivalently, could the experience reasonably be described as being consistent with the basis used for calculating the number of expected Claim events?

First consider the overall level of the experience. If the overall 100 × *A*/*E* result lies outside the approximate 95% probability interval $100\ (E \pm 1.96\sqrt{E})\ /\ E \quad [= 100\ \pm\ \left(196\ /\sqrt{E}\right)]$ then the total number of Claim events is significantly different, at the 5% level, from the number expected. In this case, it is likely that all of the other statistical tests (based on the expected basis, *E*) will also show unsatisfactory results (low probability values) as the expected basis would clearly not be an acceptable representation of the observed experience.

If the overall level of experience is reasonably consistent with the expected basis, then the results of the statistical tests based on *E* should be examined more closely. If none of these tests shows a low probability score then the expected basis may be considered to be a satisfactory representation of the observed experience. Conversely, unsatisfactory results, particularly if from more than one test, would lead to the conclusion that the experience does not conform sufficiently closely to the expected basis.

See below for further comments on assessing the results of these tests in combination, but note that tests applied to the expected basis, using *E*, are assessing both the level and shape (by Age and duration Sick) of the experience. A lack of fit may result from either aspect, or from a combination of the two, so that in general one might expect the results of the tests to be more satisfactory the closer the overall 100 × *A*/*E* result is to 100.

Next, and particularly if the expected basis is not a satisfactory representation of the observed experience, ask the question: *would a simple multiplicative rescaling of the expected basis provide a better and satisfactory representation of the observed experience?*

Equivalently, could the experience reasonably be described as being consistent with the basis defined by: $E^* = E \times [\sum A\ /\sum E]$ – that is, by a simple multiplicative adjustment to the expected basis so that $\sum A = \sum E^*$ for the table overall?

The best estimate for the overall level of the experience, expressed as a basis multiplier *r*, is *A*/*E* [actually $\sum A/\sum E$], with an approximate 95% confidence interval: $\left(A \pm 1.96\sqrt{A}\right)/E$.

Now the results of the statistical tests based on $E^* = r \times E$ should be examined more closely. The adjusted basis, E^*, ensures a match on the overall level of experience, so the tests using E^* are focused on assessing the shape (by Age and duration Sick) of the experience.

The chi-squared tests provide the most comprehensive measure of the ‘goodness of fit’ of the observed experience to the (adjusted) expected basis. A low probability value in combination with other satisfactory test results would indicate that even the adjusted basis is not an acceptable representation of the observed experience. However, an isolated unsatisfactory chi-squared test result may arise simply as the result of 'rogue' results in a small number of data cells or through some over-dispersion in the data.

The Signs test considers the balance of positive and negative deviations – differences between the observed and (adjusted) expected results – so that a low value for *p*(+/–) may indicate a bias with the *A*/*E* results for the majority of cells lying to one side of the expected, offset by some large deviations on the other side. This could indicate a problem with the shape of the experience, relative to the basis, or arise from 'rogue' results in a few data cells. Inspection of the *A*/*E* values for Age groups or duration Sick ranges may clarify the problem.

The Runs (or Bonds) test considers the sequence, or distribution, of positive and negative deviations. A low value for *p*(Runs) or *p*(*B*) may indicate that the (adjusted) expected basis misses features of the experience – perhaps a gradient in *A*/*E* values by Age or duration Sick.

The Kolmogorov-Smirnov tests consider the distribution of the maximum absolute deviation between two the cumulative distributions of the actual and expected Claim events. A low value for *p*(K-S) or *p*(TW-KS) may also indicate that the (adjusted) expected basis misses features of the experience. Again, inspection of the *A*/*E* values for Age groups or duration Sick ranges may clarify the problem.

Satisfactory values for Signs, Runs and K-S tests would show that the (adjusted) expected basis runs comfortably ‘through the middle’ of the observed experience.

When the battery of tests applied to E^* are considered altogether, it may be found that the fit of the adjusted expected basis to the experience is obviously satisfactory, having passed all the tests, and in other cases the fit may be obviously unsatisfactory. In practice there are also many intermediate cases requiring further investigation and judgement. If only the chi-squared test result is unsatisfactory then it is likely that this is because of the data rather than because the different basis would offer a significantly better result.

Note also that we would expect 1 in every 20 test results to appear ’unsatisfactory’, as indicated by our highlighting of *p*-values of 0.05 or lower, even if the underlying experience conformed to the expected basis used for the test. Similarly, when reviewing the full set of results – the battery of tests applied to each of the 60+ tables of the experience (Sexes by Deferred Periods by Occupation Classes) – many tests may appear as if they were significant at a 5% level, but many fewer at say a 1% level.

6 ANALYSIS OF CHANGE

6.1 *Overview of the analysis of change*

Individual IP business experiences for 1991-94, 1995-98 and 1999-2002 were reported, in CMIRs 18, 20 and 22 respectively, using SM1975-78 as the basis of comparison and using the 'old' methodology as described in CMIR 15. An analysis of the experience for 2003-06, using the same basis and methodology, was released to CMI member offices in 2010.

The results for these four quadrennia have been re-stated, alongside this Paper and CMI Working Paper 60, using the IPM 1991-98 graduations as the basis of comparison and incorporating a number of methodology refinements into the analysis. To support this transition, this Section presents a high-level analysis of the change in reported results.

The analysis separates out the two broad components of the change. First the effect of the methodology changes is quantified. The overall methodology-related change in 100 × *A*/*E* is small relative to the inherent uncertainty of IP experience (arising for example from the sample size and from variations in experience over time and between offices), although there are some notable effects on *A* and *E*. These features are explained in the following Sections alongside a brief summary of the material refinements to the methodology.

Second, the effect of the change of comparison basis is quantified. Here the effect relates mainly to the expected Claim events, *E*, with corresponding movement in 100 × *A*/*E*, but there are some small effects on the count of actual Claim events, *A*. The basis-related change in 100 × *A*/*E* varies substantially across the analyses reflecting the complex pattern of change between the SM1975-78 and IPM 1991-98 rates. A summary of the movement in the graduated rates was set out in CMI Working Paper 48 but is incorporated again here for ease of reference.

The analysis of change is presented separately for Claim Inceptions and Claim Terminations. The changes in *A*, *E* and 100 × *A*/*E* are illustrated using the 2003-06 experience for males in Occupation Class 1; further tables then provide a summary of the change in 100 × *A*/*E* for other quadrennia, and for females, and for all Occupation Classes combined.

This analysis of change also demonstrates that, as expected by design, IPM 1991-98 provides a reasonable fit (using the new methodology) to the experience of males, Occupation Class 1, over 1991-98. More notably it also shows, through comparison of the beginning and end results for 100 × *A*/*E*, that IPM 1991-98 provides a significantly closer fit than SM1975-78 for the experiences of 1999-2006, and is therefore generally a better starting point for analysis of more recent experience.

6.2 *Claim Inceptions*

An analysis of the change in reported results for Claim Inceptions experience of males, in Occupation Class 1, for 2003-06, is set out in Table 4. Separately for *A*, *E* and 100 × *A*/*E*, the previously stated results, using SM1975-78 and the 'old' methodology, are shown followed by the movements due to methodology and basis changes, leading to the revised totals reported using IPM 1991-98 and the 'new' methodology.

For Claim Inceptions, the methodology-related change has been split into two parts. Under the ‘old’ methodology, the cum Duplicates numbers of Inceptions were reported (with an adjustment to the standard errors in the statistical analysis to allow for Duplicates) so the first step in the analysis looks at methodology changes whilst retaining all the results on a cum Duplicates basis. Under the ‘new’ methodology, the ex Duplicates numbers of Inceptions are reported (allowing for Duplicates more directly in the analysis) so the final step in the analysis captures the change from reporting cum Duplicates to reporting ex Duplicates.

The analysis of change is therefore presented using five rows for each element:

- The previously published results – SM1975-78, old methodology, cumD
- *Change* in methodology – the *movement* to SM1975-78, *new methodology*, cumD
- *Change* in basis – the *movement* to *IPM 1991-98*, new methodology, cumD
- *Change* from cumD to exD – the *movement* to IPM 1991-98, new methodology, *exD*
- These rows sum to give the re-stated results – IPM 1991-98, new methodology, exD.

Table 4: High-level analysis of change for Claim Inceptions experience results
Males, Occupation Class 1, 2003-06, by Deferred Period

	DP 1	DP 4	DP 13	DP 26	DP 52
Actual Inceptions, *A*					
SM1975-78; Old methodology	4,777	879	609	682	279
Change in methodology	391	-9	-8	1	1
Change in basis	0	0	0	0	0
Change from cumD to exD	-3,079	-284	-113	-156	-53
IPM 1991-98; New methodology	2,089	586	488	527	227
Expected Inceptions, *E*					
SM1975-78; Old methodology	6,826	1,835	1,168	695	160
Change in methodology	448	-4	-22	-7	0
Change in basis	-662	-599	-149	277	280
Change from cumD to exD	-3,907	-380	-187	-216	-89
IPM 1991-98; New methodology	2,704	852	811	750	352
100 × *A*/*E*					
SM1975-78; Old methodology	70	48	52	98	174
Change in methodology	1	0	0	1	1
Change in basis	7	23	8	-28	-111
Change from cumD to exD	-1	-2	0	0	1
IPM 1991-98; New methodology	77	69	60	70	64

Note: Figures shown have been rounded individually so the summations, particularly for 100 × *A*/*E*, are subject to rounding differences.

To complement the detailed analysis shown above, Table 5, parts A to D (at the end of this Section 6.2), provides a broad summary of the movements in 100 × *A*/*E* by Sex, Occupation Class (only showing Class 1 and All Classes combined), quadrennia and Deferred Period. The count of actual Claim events, as reported using the ‘new’ basis and methodology, is also shown to illustrate the scale of the data in each part of the tables.

The material changes to methodology are:

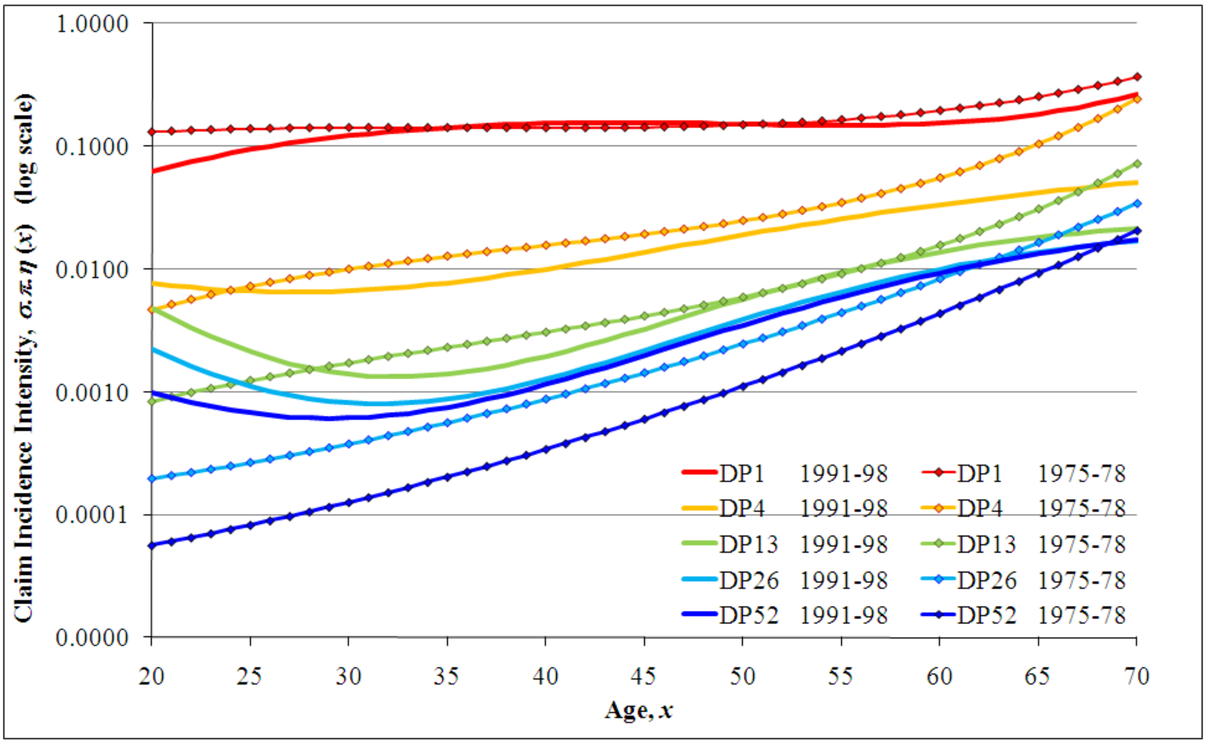
- The Deferred Periods for DP1 and DP52 are now set to 6 (instead of 7) and 364 (instead of 365) days respectively. For DP1, this increases the numbers of Claims treated as Inceptions considerably. However, this is matched by a similar increase in *E* for DP1 so that the 100 × *A*/*E* ratios are still about the same. This is because the adjusted exposure has been calculated using the values of $\pi_{x+½,d}$ for a six-day Deferred Period rather than a seven-day one, so the adjusted exposure is correspondingly larger.
- Records with Deferred Periods not 1, 4, 13, 26 or 52 weeks are now excluded from the analysis. In particular, under the old methodology, the numbers for DP0, DP2 and DP8 were included with those for DP1, DP4 and DP13 respectively, but these have now been removed. This leads to small reductions in both *A* and *E*, particularly for the shorter DPs.
- The algorithm applied to identify and exclude unacceptable Claim records has been changed – see Part A of CMI Working Paper 46 for details. In particular, False One-day Claims are now omitted. The effect of these changes may be positive or negative, but is generally small and only visible in *A*.
- The calculation of exposed-to-risk has been further refined, including the restoration of the deduction for time spent Sick but not Claiming, and changes to the way ages are defined and grouped. This leads to a small reduction in *E* (and increase in 100 × *A*/*E*) although the effect typically increases with the length of the Deferred Period.

Overall, the methodology-related change in 100 × *A*/*E* is small but typically positive. There are, however, larger differences when the numbers of Claims are fairly small, and also for DP52, where the 100 × *A*/*E* ratios using the new methods are fairly consistently higher than those reported previously under the old methodology.

The basis-related movement in results reflects the complex pattern of change between the SM1975-78 and IPM 1991-98 rates. Figure 2 provides a graphical comparison of the two sets of Claim Inception rates. The ratio of the Claim Inception rates for the two sets of graduations varies significantly by Deferred Period:

- For DP1, the Claim Inception rates are reasonably similar (after aligning the assumed Deferred Period at 6 days) over the age range 30 to 55, with the IPM 1991-98 rates being lower at the extreme ages. Overall this results in around a 5% increase in 100 × *A*/*E*.
- For DP4, the IPM 1991-98 rates are around 30% lower at most ages, but are higher at younger ages. Overall this results in around a 50% increase in 100 × *A*/*E* for DP4.
- For DP13, the comparison is similar to DP4 at most ages, but with a smaller typical reduction and with greater divergence at younger ages. Overall this results in around a 15% increase in 100 × *A*/*E* for DP13.
- For DP26, the IPM 1991-98 rates are around 50% higher at most ages (and rather more at younger ages). Overall this results in around a 35% decrease in 100 × *A*/*E* for DP26.
- For DP52, the IPM 1991-98 rates are substantially higher at almost every age, and much closer to the DP26 rates than was the case for the SM1975-78 rates. Overall this results in around a 65% decrease in 100 × *A*/*E* for DP52.
- The typical pattern of the rates by age, for most DPs, has changed so that, in general terms, the IPM 1991-98 rates rise relative to the SM1975-78 rates below age 30, and tail down relative to the SM1975-78 rates above age 55.

Figure 2: Graduated Claim Inception intensities by age and Deferred Period, for the experience of 1991-98 (IPM 1991-98) and 1975-78 (SM1975-78).



[Note: The Claim Inception rates shown in Figure 2 have been derived from the graduated Sickness Inception and Termination rates using identical methodology for both SM1975-78 and IPM 1991-98, so that the comparison shown is on a like-for-like basis as regards the underlying experience. The SM1975-78 rates have been adjusted from those published in CMIR 12 for changes in the assumed Deferred Period (in particular to reflect the current view, informed by practitioners, that the effective Deferred Period for DP1 is 6 days not 7) and require some additional assumptions for DP52 for which no formal basis was published for SM1975-78.]

The change of comparison basis may also lead to some small changes in the count of actual Claim Inceptions, *A*. These arise through the restriction which ensures that Claims are only counted in cells for which there is positive exposure – the Claim Termination rates in the comparison basis influence the exposure deduction to allow for lives Sick but not claiming, and so a change of basis may change some cells from zero to positive exposed-to-risk, or vice versa, and therefore lead to a change in a particular Claim being included or excluded. There are however, no examples of this is Table 4.

The third step in the analysis shows the reductions in *A* and *E* when the results are re-stated from a cum Duplicates to an ex Duplicates basis. The reduction in *A* is derived directly from the Claims data file using an algorithm to identify Duplicate records. However, Duplicates cannot be identified in the In force data files, and so the reduction of exposed-to-risk and *E* is made by scaling down the cumD values (at the analysis cell level) by the ratio of exD to cumD Claim Inceptions (smoothed by using counts across neighbouring cells by Age).

Whilst the reductions in *A* and *E* are significant, particularly for DP1, the net effect on the all-age 100 × *A*/*E* results is small: the average change is –0.6% and the changes for the great majority of tables lie in the range –4% to +2%. As noted in Section 3.4, the current methodology is a development on that used in producing the IPM 1991-98 graduations. The refinement – smoothing the scaling factors by Age – corrects the systematic understatement, averaging around 2% on the all-age *A*/*E*s, which resulted from that earlier methodology.

Table 5A: Summary analysis of change for Claim Inceptions experience results
Males, Occupation Class 1, by Deferred Period and Quadrennium

	DP 1	DP 4	DP 13	DP 26	DP 52
1991-1994; 100 × *A/E*					
SM1975-78; Old methodology	98	72	97	141	276
Change in methodology	2	0	1	2	17
Change in basis	2	35	17	-40	-185
Change from cumD to exD	1	0	0	0	-6
IPM 1991-98; New methodology	104	108	115	103	101
1991-1994 ; Actual Inceptions					
IPM 1991-98; New methodology	*5,351*	*1,166*	*467*	*428*	*160*
1995-1998; 100 × *A/E*					
SM1975-78; Old methodology	92	69	86	152	321
Change in methodology	4	-1	1	2	9
Change in basis	3	32	13	-45	-213
Change from cumD to exD	1	-1	-1	-1	-3
IPM 1991-98; New methodology	100	99	99	108	113
1995-1998 ; Actual Inceptions					
IPM 1991-98; New methodology	*4,345*	*1,138*	*658*	*679*	*342*
1999-2002; 100 × *A/E*					
SM1975-78; Old methodology	81	52	71	127	269
Change in methodology	2	0	2	2	1
Change in basis	5	24	11	-39	-175
Change from cumD to exD	0	-1	0	0	-1
IPM 1991-98; New methodology	88	74	84	89	93
1999-2002 ; Actual Inceptions					
IPM 1991-98; New methodology	*3,080*	*891*	*863*	*808*	*383*
2003-2006 ; 100 × *A/E*					
SM1975-78; Old methodology	70	48	52	98	174
Change in methodology	1	0	0	1	1
Change in basis	7	23	8	-28	-111
Change from cumD to exD	-1	-2	0	0	1
IPM 1991-98; New methodology	77	69	60	70	64
2003-2006 ; Actual Inceptions					
IPM 1991-98; New methodology	*2,089*	*586*	*488*	*527*	*227*

Note: Figures shown have been rounded individually so the summations are subject to rounding differences.

Table 5B: Summary analysis of change for Claim Inceptions experience results
Males, All Occupation Classes, by Deferred Period and Quadrennium

	DP 1	DP 4	DP 13	DP 26	DP 52
1991-1994; 100 × *A/E*					
SM1975-78; Old methodology	95	101	129	148	282
Change in methodology	5	-1	-6	-1	6
Change in basis	2	47	19	-43	-182
Change from cumD to exD	0	6	3	0	-4
IPM 1991-98; New methodology	103	153	145	104	103
1991-1994 ; Actual Inceptions					
IPM 1991-98; New methodology	*5,420*	*4,795*	*2,216*	*1,140*	*417*
1995-1998; 100 × *A/E*					
SM1975-78; Old methodology	90	72	108	164	347
Change in methodology	5	-1	-4	-1	7
Change in basis	3	33	15	-49	-229
Change from cumD to exD	0	-1	2	1	-1
IPM 1991-98; New methodology	98	103	121	115	125
1995-1998 ; Actual Inceptions					
IPM 1991-98; New methodology	*4,354*	*3,021*	*1,949*	*1,287*	*615*
1999-2002; 100 × *A/E*					
SM1975-78; Old methodology	80	58	91	157	290
Change in methodology	2	0	3	4	7
Change in basis	5	27	14	-50	-194
Change from cumD to exD	-1	0	2	1	0
IPM 1991-98; New methodology	86	85	110	112	103
1999-2002 ; Actual Inceptions					
IPM 1991-98; New methodology	*3,089*	*2,633*	*2,568*	*1,659*	*714*
2003-2006 ; 100 × *A/E*					
SM1975-78; Old methodology	69	48	63	102	173
Change in methodology	2	0	0	1	-1
Change in basis	7	23	10	-30	-111
Change from cumD to exD	-1	-1	1	0	0
IPM 1991-98; New methodology	77	70	74	72	62
2003-2006 ; Actual Inceptions					
IPM 1991-98; New methodology	*2,089*	*1,435*	*1,468*	*942*	*394*

Note: Figures shown have been rounded individually so the summations are subject to rounding differences.

Table 5C: Summary analysis of change for Claim Inceptions experience results
Females, Occupation Class 1, by Deferred Period and Quadrennium

	DP 1	DP 4	DP 13	DP 26	DP 52
1991-1994; 100 × *A/E*					
SM1975-78; Old methodology	121	141	200	367	596
Change in methodology	-1	7	10	47	66
Change in basis	5	57	40	-166	-469
Change from cumD to exD	0	-3	2	-2	-8
IPM 1991-98; New methodology	125	202	252	246	185
1991-1994 ; Actual Inceptions					
IPM 1991-98; New methodology	*892*	*433*	*144*	*126*	*49*
1995-1998; 100 × *A/E*					
SM1975-78; Old methodology	126	104	137	302	618
Change in methodology	0	3	7	19	42
Change in basis	2	39	23	-124	-465
Change from cumD to exD	-2	-5	-2	0	3
IPM 1991-98; New methodology	126	141	165	197	198
1995-1998 ; Actual Inceptions					
IPM 1991-98; New methodology	*704*	*336*	*207*	*240*	*148*
1999-2002; 100 × *A/E*					
SM1975-78; Old methodology	95	65	120	282	519
Change in methodology	0	0	2	14	14
Change in basis	1	24	18	-111	-373
Change from cumD to exD	-4	-3	0	-1	-1
IPM 1991-98; New methodology	93	86	140	184	159
1999-2002 ; Actual Inceptions					
IPM 1991-98; New methodology	*425*	*289*	*321*	*405*	*244*
2003-2006 ; 100 × *A/E*					
SM1975-78; Old methodology	72	64	105	198	407
Change in methodology	-3	1	2	6	19
Change in basis	7	25	18	-74	-293
Change from cumD to exD	-5	-3	0	-1	2
IPM 1991-98; New methodology	70	87	125	128	135
2003-2006 ; Actual Inceptions					
IPM 1991-98; New methodology	*291*	*197*	*222*	*236*	*154*

Note: Figures shown have been rounded individually so the summations are subject to rounding differences.

Table 5D: Summary analysis of change for Claim Inceptions experience results
Females, All Occupation Classes, by Deferred Period and Quadrennium

	DP 1	DP 4	DP 13	DP 26	DP 52
1991-1994; 100 × *A/E*					
SM1975-78; Old methodology	121	147	198	430	669
Change in methodology	-1	6	7	39	50
Change in basis	5	59	31	-186	-500
Change from cumD to exD	-1	-2	2	2	-5
IPM 1991-98; New methodology	125	209	238	285	214
1991-1994 ; Actual Inceptions					
IPM 1991-98; New methodology	*899*	*743*	*339*	*304*	*106*
1995-1998; 100 × *A/E*					
SM1975-78; Old methodology	126	103	161	342	700
Change in methodology	-1	0	1	4	52
Change in basis	2	39	24	-135	-531
Change from cumD to exD	-2	-4	-1	0	0
IPM 1991-98; New methodology	125	139	185	211	222
1995-1998 ; Actual Inceptions					
IPM 1991-98; New methodology	*705*	*519*	*408*	*396*	*249*
1999-2002; 100 × *A/E*					
SM1975-78; Old methodology	95	69	134	342	572
Change in methodology	0	1	6	25	29
Change in basis	1	26	20	-140	-424
Change from cumD to exD	-4	-1	1	-1	-1
IPM 1991-98; New methodology	92	95	161	226	176
1999-2002 ; Actual Inceptions					
IPM 1991-98; New methodology	*425*	*489*	*647*	*733*	*434*
2003-2006 ; 100 × *A/E*					
SM1975-78; Old methodology	72	60	106	194	387
Change in methodology	-3	2	3	9	11
Change in basis	7	24	17	-77	-278
Change from cumD to exD	-5	-2	0	-1	1
IPM 1991-98; New methodology	70	83	126	125	121
2003-2006 ; Actual Inceptions					
IPM 1991-98; New methodology	*291*	*321*	*480*	*403*	*289*

Note: Figures shown have been rounded individually so the summations are subject to rounding differences.

6.3 *Claim Terminations*

An analysis of the change in reported results for Claim Terminations experience of males, in Occupation Class 1, for 2003-06, is set out in Table 6, for Claimant Recoveries, and Table 7 for Claimant Deaths. Separately for *A*, *E* and 100 × *A*/*E*, the previously stated results, using SM1975-78 and the 'old' methodology, are shown followed by the movements due to methodology and comparison basis changes, leading to the revised totals reported using IPM 1991-98 and the 'new' methodology.

For Claim Terminations, both old and new methodologies operate and report results on an ex Duplicates basis. The third step (cumD to exD) used in the Claim Inceptions analysis is therefore not required for Claim Terminations. The analysis of change is therefore presented using four rows for each element:

- The previously published results – SM1975-78, old methodology, exD
- *Change* in methodology – the *movement* to SM1975-78, *new methodology*, exD
- *Change* in basis – the *movement* to *IPM 1991-98*, new methodology, exD
- These rows sum to give the re-stated results – IPM 1991-98, new methodology, exD.

To complement the detailed analysis shown below, Table 8, parts A to D, for Claimant Recoveries, and Table 9, parts A to D, for Claimant Deaths (at the end of this Section 6.3), provide a broad summary of the movements in 100 × *A*/*E* by Sex, Occupation Class (only showing Class 1 and All Classes combined), quadrennia and Deferred Period. The count of actual Claim events, as reported using the 'new' basis and methodology, is also shown to illustrate the scale of the data in each part of the tables.

Table 6: High-level analysis of change for Claimant Recoveries experience results
Males, Occupation Class 1, 2003-06, by Deferred Period

	DP 1	DP 4	DP 13	DP 26	DP 52	All DP
Actual Recoveries, *A*						
SM1975-78; Old methodology	1,816	551	421	260	68	3,116
Change in methodology	182	7	0	12	2	203
Change in basis	0	0	0	0	0	0
IPM 1991-98; New methodology	1,998	558	421	272	70	3,319
Expected Recoveries, *E*						
SM1975-78; Old methodology	1,826	930	756	456	134	4,102
Change in methodology	150	3	-7	9	5	161
Change in basis	-85	-411	-407	-264	-95	-1,262
IPM 1991-98; New methodology	1,892	523	341	201	44	3,001
100 × *A*/*E*						
SM1975-78; Old methodology	99	59	56	57	51	76
Change in methodology	2	1	0	1	-1	2
Change in basis	5	47	67	77	108	33
IPM 1991-98; New methodology	106	107	123	135	158	111

Note: Figures shown have been rounded individually so the summations, particularly for 100 × *A*/*E*, are subject to rounding differences.

Table 7: High-level analysis of change for Claimant Deaths experience results
Males, Occupation Class 1, 2003-06, by Deferred Period

	DP 1	DP 4	DP 13	DP 26	DP 52	All DP
Actual Deaths, *A*						
SM1975-78; Old methodology	33	46	92	90	41	302
Change in methodology	4	9	6	5	0	24
Change in basis	0	0	0	0	0	0
IPM 1991-98; New methodology	37	55	98	95	41	326
Expected Deaths, *E*						
SM1975-78; Old methodology	88	93	148	172	76	577
Change in methodology	9	11	18	23	10	70
Change in basis	-59	-47	-71	-86	-40	-302
IPM 1991-98; New methodology	39	57	95	109	46	345
100 × *A*/*E*						
SM1975-78; Old methodology	37	50	62	52	54	52
Change in methodology	1	3	-3	-3	-6	-2
Change in basis	58	44	44	38	42	44
IPM 1991-98; New methodology	96	97	103	87	89	95

Note: Figures shown have been rounded individually so the summations, particularly for 100 × *A*/*E*, are subject to rounding differences.

The material changes to methodology are:

- The Deferred Periods for DP1 and DP52 are now set to 6 (instead of 7) and 364 (instead of 365) days respectively. For DP1, this increases the numbers of Claims treated as recoveries considerably. However, this is broadly matched by a similar increase in *E* for DP1, arising from the 'additional' exposure for day 7, so that the 100 × *A*/*E* ratios are still about the same.
- The definition of a Duplicate Claim record has been revised and the algorithm applied to identify and exclude unacceptable Claim records has been changed – see Part A of CMI Working Paper 46 for details. The new method of identifying Duplicates produces a larger number of exD cases than the old methodology. This leads to modest increases in both *A* and *E*, but these are partly offset by the removal of further categories of Claim records with invalid data, in particular those Claim records which are deemed to be False One-day Claims, Premature Revivals or Premature Benefit Changes.
- Records with Deferred Periods not 1, 4, 13, 26 or 52 weeks are now excluded from the analysis. In particular, under the old methodology, the numbers for DP0, DP2 and DP8 were included with those for DP1, DP4 and DP13 respectively, but these have now been removed. This leads to small reductions in both *A* and *E*, particularly for the shorter DPs.
- The estimation of Age last birthday at start of Sickness, given the limitations of the data, has been revised to correct the error noted in CMI Working Paper 5. This leads to a small reduction in *E* and around a 1% increase in 100 × *A*/*E* for Recoveries, but an increase in *E* and a small reduction in 100 × *A*/*E* for Deaths.
- The calculation of expected Claim Terminations has also been refined. The duration units used in the calculation have been reduced to each single day rather than set periods of weeks and years. Within each unit, the mid-point is taken and the Termination intensities as at that duration are applied to the exposure over the whole unit (for each Age), so using

shorter, even, time intervals increases the accuracy of the calculation. This leads to a small increase in *E* for Claimant Recoveries and a reduction in 100 × *A*/*E*.

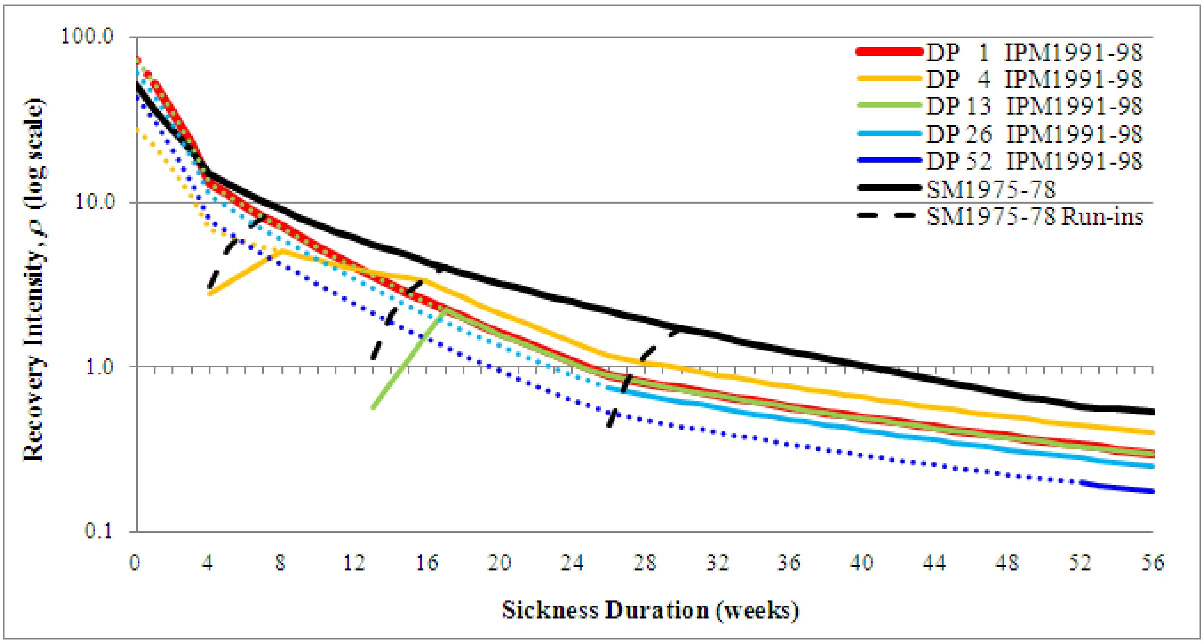
- The new methodology for calculating expected Claim Terminations also enables the calculations to cover all durations, whereas durations over 11 years were omitted under the old methodology, leading to small increases in both *A* and *E*.

Overall, the methodology-related change in 100 × *A*/*E* is small – of the order ±2%. However, the ratios typically increase for Recoveries but reduce for Deaths.

The basis-related movement in results reflects the complex pattern of change between the SM1975-78 and IPM 1991-98 rates.

Figure 3 shows a graphical comparison of the two sets of rates for Claimant Recoveries. The coloured lines show a sample of graduated Sickness recovery rates for IPM 1991-98 and the solid black line shows the corresponding rates for SM1975-78 (which did not vary by Deferred Period except for the run-in effects shown by the dotted black lines).

Figure 3: Graduated recovery intensities for Sicknesses starting at exact age 40, by Sickness duration, for each Deferred Period, for the experience of 1991-98 (IPM 1991-98) and 1975-78 (SM1975-78).



Comparing the graduated recovery rates for DP1, the IPM 1991-98 rates are higher for the first few weeks of Sickness, but fall more sharply relative to the SM1975-78 rates as duration Sick increases so that, after about 4 weeks, they are always lower. At 26 weeks Sickness, the ratio of IPM 1991-98 to SM1975-78 Recovery rates reaches a low point of around 40%, but it then climbs a little to settle at 55% or so for the longer durations Sick.

Compared with the SM1975-78 graduations, the IPM 1991-98 graduations introduced significant differentials in recovery rates by Deferred Period, and also reflect different observations for the run-in periods for DP4 (more complex than SM1975-78) and DP26 (no longer present).

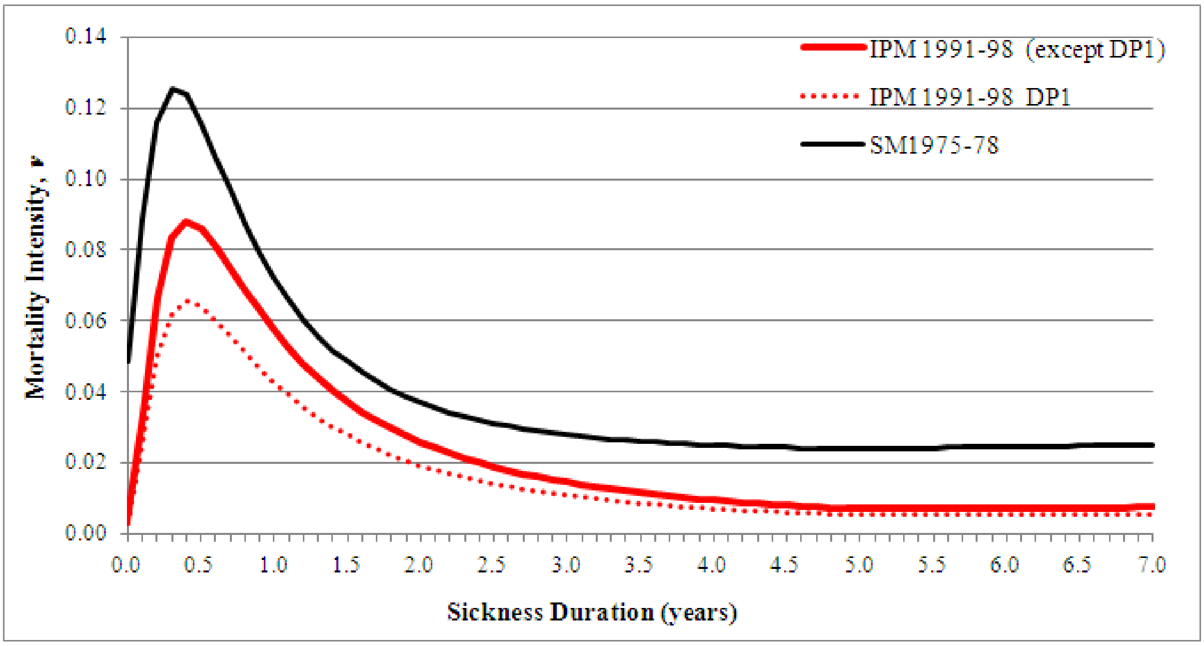
For DP 1 week, IPM 1991-98 leads to higher numbers of expected Recoveries in the early durations and lower numbers at longer durations. These changes broadly balance out leaving the overall *E* and 100 × *A*/*E* roughly unchanged for DP1.

For all other Deferred Periods, the change in the comparison basis leads to a significant reduction in *E* and therefore to a large increase in 100 × *A*/*E*; they have no effect on *A*. The basis-related change varies markedly by Deferred Period:

- For DP4, the 100 × *A*/*E* ratios increase overall by a factor of around 1.5 to 2.0
- For DP13 and DP26, the increase factor is around 2.0 to 2.5
- For DP52, the 100 × *A*/*E* ratios increase overall by a factor of around 3.0 to 3.5.

A graphical comparison of the IPM 1991-98 and SM1975-78 graduated rates for Deaths from Sick is shown in Figure 4. The graduated mortality rates for the 1991-98 experience are significantly lower than those for 1975-78. Ignoring DP1, the ratio of IPM 1991-98 to SM1975-78 mortality rates is around 70% at the peak of mortality in Sickness at duration 20 weeks, rises to around 80% after the first year of Sickness, and then falls to around 30% for Sickness durations of 5 years and longer. The IPM 1991-98 graduations also introduced separate, even lower, mortality rates for DP1.

Figure 4: Graduated mortality intensities for Sicknesses starting at exact age 40, by Sickness duration, for the experience of 1991-98 (IPM 1991-98) and 1975-78 (SM1975-78).



For deaths from Sick, the change in the comparison basis leads to a significant reduction in *E*, and therefore to a large increase in 100 × *A*/*E*, for all Deferred Periods, but the proportionate change is greatest for DP1; the change in basis has no effect on *A*. Overall:

- For DP1, the 100 × *A*/*E* ratios increase by a factor of around 2.0 to 3.0
- For other Deferred Periods the increase factor is around 1.5 to 2.0.

For further information on the features of the SM1975-78 and IPM 1991-98 graduations see Section 3.3 and Tables A1 and A2 in the Appendix.

Table 8A: Summary analysis of change for Claimant Recoveries experience results
Males, Occupation Class 1, by Deferred Period and Quadrennium

	DP 1	DP 4	DP 13	DP 26	DP 52	All DP
1991-1994; 100 × *A*/*E*						
SM1975-78; Old methodology	100	61	49	43	31	82
Change in methodology	6	1	0	-2	-2	4
Change in basis	-4	50	65	62	74	17
IPM 1991-98; New methodology	101	112	114	103	103	104
1991-1994 ; Actual Recoveries						
IPM 1991-98; New methodology	*5,219*	*1,254*	*340*	*144*	*24*	*6,981*
1995-1998; 100 × *A*/*E*						
SM1975-78; Old methodology	101	53	44	41	29	76
Change in methodology	4	1	-2	0	0	3
Change in basis	-2	42	54	60	72	22
IPM 1991-98; New methodology	103	96	96	101	100	101
1995-1998 ; Actual Recoveries						
IPM 1991-98; New methodology	*4,094*	*936*	*353*	*212*	*46*	*5,641*
1999-2002; 100 × *A*/*E*						
SM1975-78; Old methodology	96	52	41	42	41	67
Change in methodology	4	2	1	-1	1	3
Change in basis	3	42	52	57	98	31
IPM 1991-98; New methodology	103	96	94	98	140	101
1999-2002 ; Actual Recoveries						
IPM 1991-98; New methodology	*2,921*	*794*	*521*	*286*	*88*	*4,610*
2003-2006 ; 100 × *A*/*E*						
SM1975-78; Old methodology	99	59	56	57	51	76
Change in methodology	2	1	0	1	-1	2
Change in basis	5	47	67	77	108	33
IPM 1991-98; New methodology	106	107	123	135	158	111
2003-2006 ; Actual Recoveries						
IPM 1991-98; New methodology	*1,998*	*558*	*421*	*272*	*70*	*3,319*

Note: Figures shown have been rounded individually so the summations are subject to rounding differences.

Table 8B: Summary analysis of change for Claimant Recoveries experience results
Males, All Occupation Classes, by Deferred Period and Quadrennium

	DP 1	DP 4	DP 13	DP 26	DP 52	All DP
1991-1994; 100 × *A*/*E*						
SM1975-78; Old methodology	98	56	56	48	49	69
Change in methodology	7	1	-1	-2	-3	3
Change in basis	-4	44	70	67	115	32
IPM 1991-98; New methodology	101	100	125	112	162	104
1991-1994 ; Actual Recoveries						
IPM 1991-98; New methodology	*5,240*	*3,926*	*1,292*	*334*	*69*	*10,861*
1995-1998; 100 × *A*/*E*						
SM1975-78; Old methodology	100	54	47	43	30	66
Change in methodology	4	1	-2	-2	-2	2
Change in basis	-2	42	56	59	69	32
IPM 1991-98; New methodology	103	96	101	100	97	100
1995-1998 ; Actual Recoveries						
IPM 1991-98; New methodology	*4,100*	*2,319*	*970*	*364*	*72*	*7,825*
1999-2002; 100 × *A*/*E*						
SM1975-78; Old methodology	95	52	43	41	33	58
Change in methodology	5	1	1	0	0	2
Change in basis	3	40	53	56	76	38
IPM 1991-98; New methodology	103	93	98	97	109	98
1999-2002 ; Actual Recoveries						
IPM 1991-98; New methodology	*2,928*	*2,061*	*1,336*	*519*	*117*	*6,961*
2003-2006 ; 100 × *A*/*E*						
SM1975-78; Old methodology	99	58	61	59	57	71
Change in methodology	2	1	0	1	0	1
Change in basis	5	46	73	78	119	42
IPM 1991-98; New methodology	106	105	134	138	176	114
2003-2006 ; Actual Recoveries						
IPM 1991-98; New methodology	*1,998*	*1,220*	*1,025*	*430*	*125*	*4,798*

Note: Figures shown have been rounded individually so the summations are subject to rounding differences.

Table 8C: Summary analysis of change for Claimant Recoveries experience results
Females, Occupation Class 1, by Deferred Period and Quadrennium

	DP 1	DP 4	DP 13	DP 26	DP 52	All DP
1991-1994; 100 × *A/E*						
SM1975-78; Old methodology	96	59	50	40	32	72
Change in methodology	3	2	-1	-1	6	3
Change in basis	-7	46	62	56	95	24
IPM 1991-98; New methodology	92	107	111	96	132	98
1991-1994 ; Actual Recoveries						
IPM 1991-98; New methodology	*922*	*470*	*124*	*60*	*11*	*1,587*
1995-1998; 100 × *A/E*						
SM1975-78; Old methodology	90	56	46	47	34	65
Change in methodology	0	1	0	0	0	1
Change in basis	-3	41	54	64	80	28
IPM 1991-98; New methodology	86	98	100	111	114	93
1995-1998 ; Actual Recoveries						
IPM 1991-98; New methodology	*695*	*332*	*157*	*113*	*31*	*1,328*
1999-2002; 100 × *A/E*						
SM1975-78; Old methodology	93	45	41	46	31	52
Change in methodology	1	2	1	1	2	2
Change in basis	-1	33	48	62	74	38
IPM 1991-98; New methodology	93	80	90	109	107	92
1999-2002 ; Actual Recoveries						
IPM 1991-98; New methodology	*434*	*289*	*247*	*212*	*53*	*1,235*
2003-2006 ; 100 × *A/E*						
SM1975-78; Old methodology	73	52	50	68	63	60
Change in methodology	-2	2	1	-1	-1	0
Change in basis	3	38	57	83	128	39
IPM 1991-98; New methodology	74	92	108	150	190	99
2003-2006 ; Actual Recoveries						
IPM 1991-98; New methodology	*282*	*222*	*230*	*176*	*67*	*977*

Note: Figures shown have been rounded individually so the summations are subject to rounding differences.

Table 8D: Summary analysis of change for Claimant Recoveries experience results
Females, All Occupation Classes, by Deferred Period and Quadrennium

	DP 1	DP 4	DP 13	DP 26	DP 52	All DP
1991-1994; 100 × *A/E*						
SM1975-78; Old methodology	95	57	52	44	42	67
Change in methodology	3	1	-1	2	4	2
Change in basis	-6	43	64	65	110	30
IPM 1991-98; New methodology	92	101	115	111	156	99
1991-1994 ; Actual Recoveries						
IPM 1991-98; New methodology	*927*	*655*	*234*	*111*	*23*	*1,950*
1995-1998; 100 × *A/E*						
SM1975-78; Old methodology	90	53	45	45	29	59
Change in methodology	0	1	-1	0	0	0
Change in basis	-3	38	52	60	68	32
IPM 1991-98; New methodology	86	92	96	105	97	91
1995-1998 ; Actual Recoveries						
IPM 1991-98; New methodology	*696*	*457*	*239*	*167*	*39*	*1,598*
1999-2002; 100 × *A/E*						
SM1975-78; Old methodology	93	42	38	44	37	48
Change in methodology	1	2	0	1	1	1
Change in basis	-1	31	44	60	85	39
IPM 1991-98; New methodology	93	75	81	105	123	88
1999-2002 ; Actual Recoveries						
IPM 1991-98; New methodology	*435*	*406*	*354*	*304*	*93*	*1,592*
2003-2006 ; 100 × *A/E*						
SM1975-78; Old methodology	73	49	54	74	67	60
Change in methodology	-2	0	0	-1	-1	0
Change in basis	3	35	60	90	136	44
IPM 1991-98; New methodology	74	85	114	162	202	104
2003-2006 ; Actual Recoveries						
IPM 1991-98; New methodology	*282*	*287*	*352*	*250*	*109*	*1,280*

Note: Figures shown have been rounded individually so the summations are subject to rounding differences.

Table 9A: Summary analysis of change for Claimant Deaths experience results
Males, Occupation Class 1, by Deferred Period and Quadrennium

	DP 1	DP 4	DP 13	DP 26	DP 52	All DP
1991-1994; 100 × *A/E*						
SM1975-78; Old methodology	48	58	80	61	86	63
Change in methodology	-4	4	-3	-1	-7	-1
Change in basis	65	43	49	38	51	49
IPM 1991-98; New methodology	109	105	126	98	130	111
1991-1994 ; Actual Deaths						
IPM 1991-98; New methodology	*60*	*87*	*93*	*73*	*31*	*344*
1995-1998; 100 × *A/E*						
SM1975-78; Old methodology	36	51	62	57	50	52
Change in methodology	-2	-2	-1	0	-2	-1
Change in basis	51	37	42	38	34	41
IPM 1991-98; New methodology	85	86	102	95	82	92
1995-1998 ; Actual Deaths						
IPM 1991-98; New methodology	*46*	*71*	*101*	*101*	*34*	*353*
1999-2002; 100 × *A/E*						
SM1975-78; Old methodology	30	41	58	39	22	41
Change in methodology	-2	-3	-3	0	0	-2
Change in basis	42	30	39	28	18	32
IPM 1991-98; New methodology	70	68	94	67	39	72
1999-2002 ; Actual Deaths						
IPM 1991-98; New methodology	*33*	*52*	*124*	*92*	*22*	*323*
2003-2006 ; 100 × *A/E*						
SM1975-78; Old methodology	37	50	62	52	54	52
Change in methodology	1	3	-3	-3	-6	-2
Change in basis	58	44	44	38	42	44
IPM 1991-98; New methodology	96	97	103	87	89	95
2003-2006 ; Actual Deaths						
IPM 1991-98; New methodology	*37*	*55*	*98*	*95*	*41*	*326*

Note: Figures shown have been rounded individually so the summations are subject to rounding differences.

Table 9B: Summary analysis of change for Claimant Deaths experience results
Males, All Occupation Classes, by Deferred Period and Quadrennium

	DP 1	DP 4	DP 13	DP 26	DP 52	All DP
1991-1994; 100 × *A*/*E*						
SM1975-78; Old methodology	48	47	63	59	76	56
Change in methodology	-5	1	-3	-2	-4	-1
Change in basis	64	32	37	37	49	39
IPM 1991-98; New methodology	107	80	97	94	121	93
1991-1994 ; Actual Deaths						
IPM 1991-98; New methodology	*60*	*173*	*203*	*133*	*51*	*620*
1995-1998; 100 × *A*/*E*						
SM1975-78; Old methodology	36	44	53	53	46	48
Change in methodology	-2	-1	-2	0	-2	-1
Change in basis	51	33	35	36	32	36
IPM 1991-98; New methodology	84	77	86	89	76	83
1995-1998 ; Actual Deaths						
IPM 1991-98; New methodology	*46*	*141*	*192*	*150*	*47*	*576*
1999-2002; 100 × *A*/*E*						
SM1975-78; Old methodology	31	37	43	44	21	39
Change in methodology	-3	-1	0	-2	0	-1
Change in basis	42	29	30	31	17	30
IPM 1991-98; New methodology	69	66	73	72	37	67
1999-2002 ; Actual Deaths						
IPM 1991-98; New methodology	*33*	*120*	*214*	*165*	*32*	*564*
2003-2006 ; 100 × *A*/*E*						
SM1975-78; Old methodology	37	45	64	52	53	53
Change in methodology	1	1	-5	-2	-5	-3
Change in basis	58	39	44	40	43	43
IPM 1991-98; New methodology	96	85	103	90	91	94
2003-2006 ; Actual Deaths						
IPM 1991-98; New methodology	*37*	*96*	*198*	*143*	*63*	*537*

Note: Figures shown have been rounded individually so the summations are subject to rounding differences.

Table 9C: Summary analysis of change for Claimant Deaths experience results
Females, Occupation Class 1, by Deferred Period and Quadrennium

	DP 1	DP 4	DP 13	DP 26	DP 52	All DP
1991-1994; 100 × *A/E*						
SM1975-78; Old methodology	25	27	50	65	46	44
Change in methodology	0	-4	-2	-4	-3	-3
Change in basis	42	15	26	37	32	28
IPM 1991-98; New methodology	67	38	74	98	74	70
1991-1994 ; Actual Deaths						
IPM 1991-98; New methodology	*3*	*7*	*12*	*19*	*4*	*45*
1995-1998; 100 × *A/E*						
SM1975-78; Old methodology	15	42	21	23	34	27
Change in methodology	-1	-3	-1	-1	-2	-1
Change in basis	23	29	13	15	24	19
IPM 1991-98; New methodology	37	68	33	37	56	45
1995-1998 ; Actual Deaths						
IPM 1991-98; New methodology	*2*	*13*	*8*	*11*	*8*	*42*
1999-2002; 100 × *A/E*						
SM1975-78; Old methodology	35	29	45	34	33	36
Change in methodology	0	-2	-2	2	-1	0
Change in basis	57	20	29	27	28	28
IPM 1991-98; New methodology	92	48	72	63	60	64
1999-2002 ; Actual Deaths						
IPM 1991-98; New methodology	*4*	*10*	*31*	*35*	*16*	*96*
2003-2006 ; 100 × *A/E*						
SM1975-78; Old methodology	19	38	48	57	40	46
Change in methodology	-1	0	-5	-6	-4	-4
Change in basis	29	30	32	45	37	37
IPM 1991-98; New methodology	46	69	75	96	73	79
2003-2006 ; Actual Deaths						
IPM 1991-98; New methodology	*2*	*11*	*25*	*35*	*15*	*88*

Note: Figures shown have been rounded individually so the summations are subject to rounding differences.

Table 9D: Summary analysis of change for Claimant Deaths experience results
Females, All Occupation Classes, by Deferred Period and Quadrennium

	DP 1	DP 4	DP 13	DP 26	DP 52	All DP
1991-1994; 100 × *A*/*E*						
SM1975-78; Old methodology	25	27	45	65	47	44
Change in methodology	0	-3	0	-5	-3	-2
Change in basis	41	15	24	37	34	28
IPM 1991-98; New methodology	66	40	69	97	78	70
1991-1994 ; Actual Deaths						
IPM 1991-98; New methodology	*3*	*11*	*20*	*29*	*7*	*70*
1995-1998; 100 × *A*/*E*						
SM1975-78; Old methodology	15	34	33	26	27	29
Change in methodology	-1	-2	-1	-2	-2	-1
Change in basis	23	23	20	16	19	19
IPM 1991-98; New methodology	37	55	51	40	44	47
1995-1998 ; Actual Deaths						
IPM 1991-98; New methodology	*2*	*15*	*19*	*18*	*9*	*63*
1999-2002; 100 × *A*/*E*						
SM1975-78; Old methodology	33	23	39	28	28	31
Change in methodology	2	-1	-1	1	-1	0
Change in basis	57	16	24	22	23	23
IPM 1991-98; New methodology	92	38	62	51	50	53
1999-2002 ; Actual Deaths						
IPM 1991-98; New methodology	*4*	*12*	*41*	*42*	*20*	*119*
2003-2006 ; 100 × *A*/*E*						
SM1975-78; Old methodology	19	28	53	53	38	45
Change in methodology	-1	0	-4	-6	-3	-4
Change in basis	29	23	37	42	35	36
IPM 1991-98; New methodology	46	50	86	89	69	77
2003-2006 ; Actual Deaths						
IPM 1991-98; New methodology	*2*	*11*	*41*	*43*	*21*	*118*

Note: Figures shown have been rounded individually so the summations are subject to rounding differences.

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APPENDIX: FEATURES OF COMPARISON TABLES

A.1 A summary of the features of SM1975-78

Table A1: A Summary of the Features of SM1975-78
Underlying dataset • CMI Individual IP, *Standard* data, Males, 1975-78. These graduations reflect the experience for males, of broadly CMI Occupation Class 1, only. No adjustments are made for females or other Occupation Classes. Therefore, when SM1975-78 is used as the basis for calculating expected Claim Inceptions and Terminations, differences in 100 × *A*/*E* by Sex and Occupation Class directly represent differences in the observed Claim event rates.
Sickness Inception Rates • Separate rates were required to fit the data for each DP, with Sickness rates falling as the DP lengthened. • The inferred Sickness rates are 'U'-shaped by age, with a minimum around age 50. • The original graduations only covered DP 1, 4, 13 and 26 weeks; DP 52 weeks was added later by setting the Sickness rate equal to $0.68926.\sigma_x$ where σ_x is the graduated rate for DP 26 weeks. Claim Inception Rates • The corresponding Claim Inception rates naturally fall with increasing DP, reflecting recoveries during the DP as well as the pattern of Sickness rates by DP noted above. • Claim Inception rates increase with age but considerably less quickly than all-cause mortality rates do.
Claimant Recovery Rates • Claimant Recovery rates fall with increasing Age at falling Sick and with increasing Sickness duration. • The influences of Age at falling Sick and of Sickness duration were found to be largely independent of each other and broadly multiplicative in effect. The dominant factor was the duration of Sickness, with Recovery rates falling very rapidly over the early weeks and months of Sickness. • A single bi-variate 'table' of graduated Recovery rates was found to be an acceptable fit to the data for all the DPs for most durations of Sickness. • A 4-week run-in period of significantly lower Claimant Recovery rates applies for DP 4, 13 and 26 weeks. • Recovery rates for DP 52 week business were set equal to the graduated rates for DP 26 weeks but without the run-in period adjustment.
Claimant Death Rates • The rate of mortality from Sick tends to rise from the start of Sickness to a peak after about 4 months, after which it declines fairly rapidly. • The rate of mortality from Sick rises with age attained but, again, the dominant factor, for at least the first few years of Sickness, is duration of Sickness. Age becomes dominant at longer durations, where mortality from Sick could be broadly equated to typical insured life mortality plus a constant addition of the order of 20 per mille p.a.. • A single bi-variate 'table' of graduated mortality rates provides an acceptable fit to the data for all DPs. • There was no statistically significant evidence of a 'run-in' period similar to that observed for Claim Recovery rates (although it is quite plausible that one exists).
Further Reference • CMIR 12, Sections B (Terminations) and C (Inceptions); CMIR 15 Section 2 (for DP52).

A.2 A summary of the features of IPM 1991-98

Table A2: A Summary of the Features of IPM 1991-98
Underlying dataset • CMI Individual IP, *Standard** data, Males, CMI Occupation Class 1, 1991-98. These graduations reflect the experience for males in CMI Occupation Class 1 only. No adjustments are made for females or other Occupation Classes. Therefore, when IPM 1991-98 is used as the basis for calculating expected Claim Inceptions and Terminations, differences in 100 × *A*/*E* by Sex and Occupation Class directly represent differences in the observed Claim event rates.
Sickness Inception Rates • Separate rates were required to fit the data for each DP, with rates generally falling as the DP lengthened. • There were no strong and consistent features to the pattern of inferred Sickness rates by age. Claim Inception Rates • The corresponding Claim Inception rates naturally fall with increasing DP, reflecting recoveries during the DP as well as the general pattern of Sickness rates by DP noted above. • Claim Inception rates for DP 1 week vary little with age over the age range 30 to 60, but are lower for younger ages and higher for older ages. • In contrast, Claim Inception rates for DP 4 – 52 weeks increase steadily with age (apart from an initial fall from age 20 to 30). The rate of increase in Claim Inception rates with age is greater for the longer DPs, but even then is considerably less quick than for all-causes mortality rates.
Claimant Recovery Rates • Claim Recovery rates fall with increasing Age at falling Sick and with increasing Sickness duration. • The influences of Age at falling Sick and of Sickness duration were found to be largely independent of each other and broadly multiplicative in effect. The dominant factor was the duration of Sickness, with Recovery rates falling very rapidly over the early weeks and months of Sickness. • A single bi-variate rate 'table' was found to be an acceptable fit to the 'shape' of Recovery rates across all the DPs at most durations, but differences in the overall level of rates are reflected through a multiplicative factor: taking the level for DP 1 week as 100%, the applied multipliers are 132% for DP 4, 99% for DP 13, 84% for DP 26 and 59% for DP 52 weeks. These factors apply equally for all durations of Sickness, so that the modelled 'core' Recovery rates are highest for DP 4 weeks and lowest for DP 52 weeks at all durations. • A 4-week run-in period of significantly lower Claimant Recovery rates applies for DP 4 and 13 weeks; in addition a further (but shallower) adjustment applies for DP 4 weeks over Sickness weeks 8 to 16.
Claimant Death Rates • The rate of mortality from Sick tends to rise from the start of Sickness to a peak after 4 or 5 months, after which it declines fairly rapidly. • The rate of mortality from Sick rises with age attained but, again, the dominant factor, for at least the first few years of Sickness, is duration of Sickness. Age becomes dominant at longer durations, where mortality from Sick could be broadly equated to typical insured life mortality plus a constant addition of the order of 10 per mille p.a.. • A single bi-variate rate 'table' was found to be an acceptable fit to the 'shape' of mortality rates across all the DPs but, to reflect differences in the overall level of rates, the rates for DP 1 week are set at 74% of the graduated mortality rates for all other DPs combined. • There was no statistically significant evidence of a 'run-in' period similar to that observed for Claim Recovery rates (although it is quite plausible that one exists).
Further Reference • CMI Working Paper 48 provides an overview of the IPM 1991-98 graduations. Further detail is set out in CMI Working Papers 5 (Terminations) and 47 (Inceptions).