A PRACTICAL APPLICATION OF CREDIBILITY TO EXPERIENCE RATING PLANS FOR HOSPITALIZATION AND MEDICAL-SURGICAL INSURANCE

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1. *Introduction*

This paper describes a rather simple application of credibility which was used to develop experience rating plans for Blue Cross and Blue Shield organizations in the United States. These are non-profit corporations which provide prepaid coverage for the cost of hospitalization and medical-surgical care. The benefits are in many instances full service benefits so that there is no additional cost to the subscribing member.

While coverage is being granted to individual applicants, the bulk of the unterwriting is composed of groups, that is employees of a given commercial entity. Since the plans are voluntary and, in many instances, the employer either acts only as collecting agent for his employees or else pays only a fraction of the premium, certain minimum participation percentages have been established to prevent anti-selection.

Because of the competion of Insurance Companies which have concentrated their efforts on larger and more profitable groups (especially those where the employer pays all of the premiums) it was early recognized that a uniform or "community" rate will result in a gradual loss of groups with good experience thereby requiring substantial increases in the average rates. The original program of experience rating which the author has developed for the Massachusetts Blue Cross in 1949 has been since adopted "mutatis mutandis" by a number of other Blue Cross and Blue Shield organizations.

2. *Credibility*

The first practical question is the determination of where to begin to attach some credence to the experience of a group and at

what point such experience fully indicative of the prospective cost, especially if we desire, for practical reasons, to restrict the experience to a single year. The second practical question is the basis of measuring the extent of the credibility. After due consideration of the various factors involved it was felt that a group producing an annual income of at least $ 5, 000. should receive some recognition of its experience and that such recognition shall increase until full credence be attained at an annual income of $ 86, 000. If we designate the value of $ 4, 000. by Q and the value of $ 86, 000. by S and consider a simple credibility formula:

$$z = (P + fK) \,/\, (P + K) \tag{1}$$

where P is the premium income, f is a function of P which varies from o for $P = Q$ to I for $P = S$ and K is a constant. The conditions for f are:

$$df/dP = \text{o for } P = Q \text{ and } P = S \tag{2.1}$$

$$df/dP \text{ is positive for } Q \text{ less than } P \text{ less than } S \tag{2.2}$$

Conditions (2) lead to the Bernoulli differential equation:

$$df/dP = Af^2 + Bf \tag{3}$$

and its solution is:

$$f = C \,/\, [\mathrm{I} + \exp (a + bP)] \tag{4}$$

The constants C, a and b are easily determined from the following relations for three suitably select edequidistant values f', f'', f''':

$$C = [2f'f''f''' - (f'')^2(f' + f''')]/(f'f''' - f''^2) \tag{5.1}$$

$$a = \ln[(C - f')/f'] \tag{5.2}$$

$$b = (\mathrm{I}/N)\ln[f'(C\text{-}f'')/f''(C - f')] \tag{5.3}$$

where N is the number of units on the P axis (one unit $= $ $ I, 000.).

The credibility based on equation (1) is a hyperbola. Since the curve for f in equation (4) satisfies the same conditions as those imposed on z but produces lesser values for lower values of P it was felt that the f-curve is also suitable as a credibility curve if it is desired to have a reasonable transition fron non-rated to rated groups.

Based on such a curve there was obtained a credibility table shown below:

Credibility	Income Range	Credibility	Income Range	Credibility	Income Range
.07	$ 5,000— 7,499	.39	$35,250—35,824	.71	$54,759—55,279
.08	7,500— 9,349	.40	35,825—36,374	.72	55,280—55,763
.09	9,400—10,849	.41	36,375—37,199	.73	55,764—56,285
.10	10,850—12,149	.42	37,200—38,024	.74	56,286—56,806
.11	12,150—13,324	.43	38,025—38,829	.75	56,807—57,365
.12	13,325—14,424	.44	38,830—39,609	.76	57,366—57,924
.13	14,425—15,449	.45	38,610—40,384	.77	57,925—58,445
.14	15,450—16,324	.46	40,385—41,087	.78	58,446—59,004
.15	16,325—17,149	.47	41,088—41,795	.79	59,005—59,600
.16	17,150—17,949	.48	41,796—42,465	.80	59,601—60,159
.17	17,950—18,749	.49	42,466—43,136	.81	60,160—60,755
.18	18,750—19,649	.50	43,137—43,769	.82	60,756—61,388
.19	19,650—20,549	.51	43,770—44,402	.83	61,389—62,021
.20	20,550—21,549	.52	44,403—45,035	.84	62,022—62,692
.21	21,550—22,369	.53	45,036—45,631	.85	62,693—63,362
.22	22,370—23,264	.54	45,632—46,227	.86	63,363—64,070
.23	23,265—24,129	.55	46,228—46,786	.87	64,071—64,815
.24	24,130—24,949	.56	46,787—47,382	.88	64,816—65,597
.25	24,950—25,724	.57	47,383—47,941	.89	65,598—66,417
.26	25,725—26,519	.58	47,942—48,500	.90	66,418—67,311
.27	26,520—27,319	.59	48,501—49,021	.91	67,312—68,354
.28	27,320—28,119	.60	49,022—49,580	.92	68,355—69,360
.29	28,120—28,994	.61	49,581—50,101	.93	69,361—70,589
.30	28,925—29,734	.62	50,102—50,623	.94	70,590—71,930
.31	29,735—30,494	.63	50,624—51,144	.95	71,931—73,345
.32	30,495—31,239	.64	51,145—51,666	.96	73,346—75,431
.33	31,240—31,974	.65	51,667—52,187	.97	75,432—77,066
.34	31,975—32,694	.66	52,188—52,672	.98	77,667—80,758
.35	32,695—33,399	.67	52,673—53,193	.99	80,759—86,010
.36	33,400—34,044	.68	53,194—53,715	1.00	86,011 and over
.37	34,045—34,674	.69	53,716—54,236		
.38	34,675—35,249	.70	54,237—54,758		

3. *Prospective Experience Rating*

Having thus established group credibility measured by the premium income the prospective experience rating plan determines the credible departure of the experience of the given group from the over-all experience of all groups. Toward this end the incurred claims of the given group are adjusted for cost trends from the midpoint of the experience period (calendar year or policy year) to the mid-point of the period for which the new rates will apply. Since at least three (3) months must elapse after the end of the experience period to permit the evaluation of the incurred experience, the new rates are usually effective six (6) months after the end of the experience period so that there is a projection of cost for one and one-half ($1\frac{1}{2}$) years. The adjusted incurred claim cost is then divided by the group premium income to obtain the *adjusted group loss ratio, R.* If the average rates are deemed to be adequate for the period for which the new rates will apply and if *e* represents the loading for expenses and contingencies expressed as a percentage of the rates, then $1.00 - e$ represents the *permissible loss ratio*, **P.** In order to recognize the variation of expenses by size of group the permissible loss ratio is slightly modified as may be seen from the illustration shown below for an organization where the average permissible loss ratio is 92%:

Credibility Range	Permissible Loss Ratio
Under .15	.908
.15—.39	.913
.40—.64	.918
.65—.84	.923
.85—.94	.928
.95—.99	.933
1.00	.938

The credible departure of a group is then calculated from the formula:

$$\text{Credible Departure} = (R - P).\,f \qquad (6)$$

where f is the credibility of the group. The rate modification is then obtained from:

$$\text{Rate Modification} = 1 + (R - P) . f/P \tag{7}$$

It should be noted that this rating procedure may be applied to the experience of all groups combined or other classes of risks to calculate the over-all change in rates. Should it develop that a significant change in average rates is needed then the individual group premiums are converted to the new rate level before the application of the rating procedure to the group and the resulting modification is applied to the new rates.

4. *Retrospective Experience Rating*

Hindsight is better than foresight. The "prospective rates are established in the anticipation that the experience of the group will, to some extent, repeat itself in the future and that the rate of increase in the cost will follow the assumed pattern. The actual results do not usually correspond to those anticipated and, in order to achieve an equitable treatment, the actual experience of the prospectively rated period is reviewed and a refund of premium granted whenever warranted. The Insurance Companies use a so called "retention" (a percentage of premium) which is added to the incurred cost and, if such total is less than the premium for the period, the balance is refunded to the group. The "retrospective" rating method described below is, in principle, similar to the retention method but the treatment of groups which do not receive full credibility is somewhat different.

The claims incurred during the period for which the prospective rates were in effect are multiplied by a factor representing claim administration expenses. For the organization used above as an illustration, 3% of claims represent the cost of handling such claims and the factor is, therefore, 1.03. Furthermore, since this is an "all credit" plan there is a small insurance charge to compensate for groups with unsatisfactory experience. Such insurance charges start at 3.5% for groups with credibilities under .15 and reduce to .7% for credibility of 1.00. We have then the following permissible loss ratios:

Permissible Loss Ratios

Credibility Range	(1) Prospective	(2) Insurance Charge	(3) Retrospective*
Under .15	.908	.035	.900
.15 — .39	.913	.030	.910
.40 — 64	.918	.025	.921
.65 — .84	.923	.020	.931
.85 — .94	.928	.015	.941
.95 — .99	.933	.010	.951
1.00	.938	.007	.959

$$* \ (3) = (1) \times 1.03 - (2)$$

The incurred claims for the group multiplied by the claim expense factor constitute the *actual group charges* L. The group premium ncoime multiplied by the permissible loss ratio constitutes the *expected group charges* E. The *full allowance amount* is the product of expected group charges by the complement of the group credibility or $A = E(1 - f)$.

The retrospective rating formulae are then as follows:

(a) If L is less than A:

$$Refund = (E - A) + (A - L).f \tag{8.1}$$

(b) If L is more than A but less than E:

$$Refund = E - L \tag{8.2}$$

(c) If L is equal to or more than E there is no refund but there is established a *carry-over*:

$$Carry\text{-}over = (L - E). f \tag{8.3}$$

Such "carry-over" is added to the actual group charges in the retrospective rating for the next period.

The following examples will illustrate the application of the above rating methods under the assumption that the number of insured lives is constant.

Element of Computation:	Group A	Group B	Group C
Prospective Rating			
1 Premium Income	$7,000.	$35,000.	$120,000.
2. Incurred Claims	4,000.	34,000.	80,000.
3. Loss Projection Factor 6% per annum).	1.092	1 092	1.092
4. Projected Claims: 2. × 3 .	4,368.	37,128.	87,360.
5. Projected Group Loss Ratio: 4./1.	.624	1.061	.728
6. Permissible Loss Ratio . .	.908	.913	.938
7. Credibility (based on 1.) . .	.070	.380	1.000
8. Modification: 1.000 + (5. — 6) × 7./6.	.978	1 061	.776
Retrospective Rating			
9. Premium Income 1. × 8 .	$6,846.	$37,135.	$93,120.
10. Incurred Claims (assumed)	5,000.	30,000.	85,000.
11. Actual Group Charges: 10. × 1.03	5,150.	30,900.	87,550.
12. Permissible Loss Ratio (Based on 9)	.900	910.	.959
13. Expected Group Charges: 13 × (1.00—7.)	6,161.	33,793.	89,302.
14. Ful Allowance Amount: 9. × 12.	5,730.	20,952.	—
15. Refund:	472.	2,983.	1,752.
16. Net Premium Income· (9 — 15)	6,374.	34,242.	91,368.
17. Net Loss Ratio: 10 /16. . .	.784.	.876.	.930
18 Insurance Charge	.035.	.030.	.007
19. 17. + 18.	.819.	906.	.937

Lines 16. to 19. have been added in order to show how the two plans operate to bring the group loss ratio closer to the permissible loss ratio. The degree of success depends on the group credibility as should have been expected from the manner in which the plans have been designed.

5. *Concluding Remarks.*

In actual practice these rating plans have found a wide acceptance by the public and the results have been eminently satisfactory to the Blue Cross and Blue Shield organizations where such plans have been in operation.

Below there is shown a comparison of credibility curves z and f:

$$Z = \frac{p + 80,000\,f}{p + 80,000}$$