Development and Model Construction of Home Long-Term Care Insurance

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Abstract. In today's society, with the background of aging problem, while the old-age dependency ratio has been growing constantly, the demand for LTC is accordingly increasing gradually. This paper discusses the development of family joint LTC (Long-term care) insurance and constructs a state transition matrix including healthy, mild disability, severe disability and death based on the CLHLS China Elderly Health Influencing Factors Tracking Survey data. Besides, with the calculation of net premium of family joint care insurance products, the pricing model of family joint care insurance was constructed under the assumption that age difference affects joint care insurance. Then, the paper concludes that compared with single home care insurance products, family joint care insurance products have obvious advantages on their cost efficiency and promotion.

Keywords: Long-term care insurance · Markov chain · Generalized linear model · Net premium

1 Introduction

As the society progresses, many countries and regions are facing the aging problem. By the latest definition of the United Nations, when the 65 + population accounts for more than 7% of the total population of a country, we call it an aging society. China has become an aging society since 1999. The fast development for the last two decades has led to the reductions in the size of the family, the decline of fertility rates driven by the improvement of education levels, which has not only exacerbated the aging problem, but also raised the needs of caring the elderly. During this process, care insurance has been introduced to the society. Regarding the foreign countries, commercial LTC insurance has already become one of the main insurance types in the United States. In addition, Japan, South Korea, Germany and other countries also have already established various forms of social LTC insurance systems.

In contrast with the existing medical insurance, critical illness insurance and endowment insurance in China, LTC insurance focuses on the reimbursement for the LTC provided to the disabled elderly. Due to the application of One-child policy, most families in China have a 4-2-1 structure, which sees a further reduction in the family size. According to the statistics of the Chinese Society of Gerontology and Geriatrics as of the end of 2019, the overall health conditions of the aged population in China was not

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optimistic. More than 180 million elderly people suffered from chronic diseases, with a high proportion of 75% of the total population were troubled by one or more chronic diseases. The number of disabled or partially disabled elders reached 40 million. Neither regular health insurance nor social Medicare cover the cost of long-term care. For individual families, the existence of disabled elderly means not only the high financial cost of treatment, but also the human cost due to the One-child policy. Overall, the introduction of LTC insurance in China meets both the challenge to the individual family, the heavy financial burden, and the needs of sustainable development of the nation.

The development of social LTC insurance in China can be traced back to 2016. The "Guiding Opinions on Carrying out the Pilot Program of LTC insurance System" issued by The Ministry of Human Resources and Social Security announced fifteen cities for the pilot program of LTC insurance in order to explore the application of The LTC insurance system, which is a strategic measure to cope with the pressing aging problem while promoting social and economic development. In 2018, eleven state departments including the National Health Commission and the National Development and Reform Commission jointly issued the "Guiding Opinions on Promoting the Reform and Development of the Nursing Service Industry", in order to encourage the development of commercial care insurance, in particular certain area where commercial insurance agencies were able to further introduce commercial insurance for long-term care, and other commercial health care insurance products related to caring for the elders. In 2020, the National Medical Security Administration and the Ministry of Finance issued the "Guiding Opinions on Expanding the Pilot Program of the LTC insurance System" to add 14 pilot provinces to accelerate the development of the LTC insurance systems in China. On the other hand, it is also clear from the document that the necessary insurance systems mentioned above only exist in those pilot regions and after all, the insurance systems only concentrate on those severely disabled elders. No doubt, LTC insurance in China has a long way to go.

Social care insurance is classified as a branch of nursing care insurance that can be reimbursed in medical insurance. That is to say, it is designed to deal with the difficulties those disabled and semi-disabled elders confront when paying for the LTC insurance and at the same time further improve the medical insurance mechanism, the medical insurance level of employees who pay social insurance with the rules and regulations. As mentioned above, there are several major cities that have already established LTC insurance systems within the basic social medical insurance policy. In addition, commercial care insurance is a type of commercial health insurance launched by insurance companies to compensate for nursing expenses for insureds who need long-term care, such as Cathay Life's Kangshun LTC insurance. With the aggravation of China's population aging, the old-age dependency ratio has risen, and the increased financial pressure has made medical insurance no longer to afford bear the cost of relevant nursing care. According to the data of the fourth, fifth and sixth population censuses in China, the dependency ratio of the elderly population in China reached 8.35% in 1990, and then increased to 9.92% and 11.9% respectively in 2000 and 2010 respectively. The figure in 2025 is predicted to arrive at a high point of 18.67%, and in 2050 the dependency ratio of the elderly population will soar to an even higher percentage of 32.18%. In addition, the unbalanced development among different regions also affects the overall progress of social care insurance. It is undeniable that the huge gap of the economic development

between regions hinders the implementation of social LTC insurance. Before a practical social LTC insurance policy, commercial care insurance plays an essential role on its early development as a supplementary product of the long-term insurance system.

LTC insurance covers a large range of status of the insured, including health, disability and death. Taking the advantage of the characteristics of multiple discrete states, the actuarial model can be constructed by using the multi-state model under the condition of continuous time. The Sverdrup was the first to apply the multi-state model to actuarial science [1, 2]. David Dickson then applied the multi-state model to practical issues in acturary, and introduced Euler's method into the multi-state model to simplify the calculation of LTC premiums [3, 4]. Instead of employing a transition intensity approach, Rickayzen and Walsh determined the functional form of health deterioration and improved transition probabilities [5, 6]. Fong, Shao, and Sherris applied the GLM generalized linear model to calculate the health transition status of the elderly, and for the first time discussed the possibility of recovery from mild disability [7, 8]. Wang Xinjun established a five-state Markov chain model based on CHARLS data, and classified and calculated the single-pay actuarial rate of LTC insurance [9]. Wang Xiaojun constructed a joint state transition model for spouses, and calculated the net premiums of joint LTC insurance for spouses [10]. In order to connect premium calculation of home care insurance better to the real-life situation, a solution to the age difference between the husband and the wife is added in this paper in addition to the research above. The first and second parts of the paper introduce the development of LTC insurance and the construction of state transition respectively. The third part focuses on the pricing of LTC insurance and the calculation of net premium. Summary and outlook are given in the fourth part of the paper.

2 State Transition Model Construction

Generally, the status of the insured is divided in into four statuses by home care insuranc: Health, Mild disability, severe disability and Death. ADLs (Activity of Daily Living) widely used to differentiate the standards of mild disability and severe disability. 6 types of ADLs are stated on the standardized list: eating, dressing, bathing, using toilet, incontinence, and immobility. Furthermore, the loss of cognitive abilities is also taken into account to define disability. Cognitive ability evaluation is generally defined by the Mini-Mental State Examination MMSE (Mini-Mental State Examination) and brain disorders, such as Parkinson's disease, dementia, and psychosis. However, due to individual differences and different degrees of ADL, the required nursing time and financial cost are different. Therefore, the disability state is divided into two states: mild disability and severe disability. If the abilities of an individual to ADLs fail only in less than three options, individual is considered as mildly disabled (Mild); it three or more options are failed, the individual is considered as severely disabled (Serious). Usually, it is believed that there is a possibility of returning to a normal state or worsening of the situation from a mildly disabled state to aggravate to severe disability, but it is impossible to turn a severely disabled state to a healthy state or a mildly disabled state. The health state transition matrix can be obtained in accordance with this (Fig. 1).

We analyzed the follow-up survey data between 2008 and 2018 selected from the CLHLS (China Long-Term Health Influencing Factors Tracking Survey), dividing the

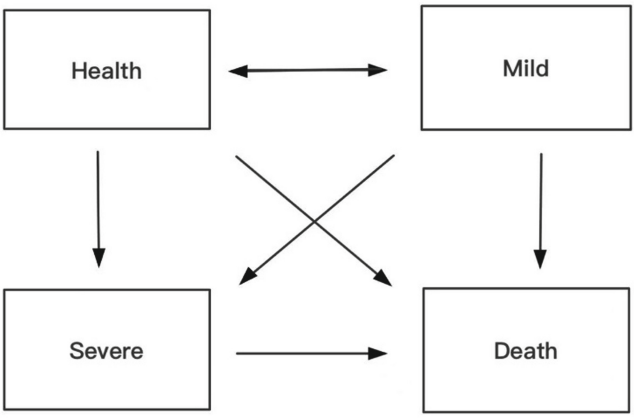

Fig. 1. State transition matrix.

Table 1. Number of males and females in each state in 2008, 2011, 2014 and 2018

Time	Health		Mild		Severe		Death	
	Female	Male	Female	Male	Female	Male	Female	Male
2008	7048	6056	1268	607	1362	495	0	0
2011	4178	3821	1015	639	1037	513	3448	2185
2014	1862	1845	2477	2089	1030	617	4309	2607
2018	887	900	1010	991	2480	2059	5301	3208

data into three intervals of 2008–2011, 2011–2014 and 2014–2018, of which the age-group between 60 and 65 is uniformly counted as the 65 age-group, and those over 100 years old are uniformly categorized as the 100 age-group. Additionally, the transition matrix assumes that the health conditions that cannot be traced, by default, gradually decline after a period of time when the health conditions remain stable. The following table shows the number of transfers between the three intervals from healthy to mild disability, healthy to severe disability, mild disability to severe disability, and severe disability to death for males and females respectively.

The data consist of a total of 16,836 samples, with 9,678 female samples and 7,158 males. Therefore, looking at the disability rate by calculating the net value, women in the early stage have a higher rate of mild disability than men, and the severe disability rate of men in the mid-term is higher than that of women. And the same rate is reached at the advanced stage, which is consistent with the average life expectancy and general situation in China. The average life expectancy of women is higher than that of men.

The following table (Table 1) shows the number of men and women in the four states at different times. Because the age distribution is uneven, no productive conclusions can be drawn. Nevertheless, it can be regarded as the number of risk exposures.

Based on the transition probabilities we calculated from the sample data, a generalized linear model was introduced to help us establish the health state transition strength with age. We assume that the state transition matrix strength data derived from the data

obtained from the questionnaire between 2008 and 2018 is the dependent variable, and the independent variable is age. It can be found that in the model, the model with high-order term of age has better fitting effect, which is in line with the trend of increasing disability rate with increasing age. Secondly, in the selection and comparison of models, under normal circumstances, multiple regression evaluation indicators such as AIC, BIC, and R2 should be compared. However, we choose R2, RMSE (Root Mean Square Error) and composite score to select the best model. The RMSE root mean square error is the square root of the ratio of the squared sum of the deviation between the observed value and the true value and the ratio of the number of observations m, and R2 refers to the fit of the regression line to the observed value. Therefore, we choose a model with a small RMSE, a large R2, and a high score. In addition, we need to consider whether there is a problem of overfitting of high-order terms when the linear model contains high-order terms. Therefore, in the calculation process, we also divide the data into training set and test set, and then use the training set to fit. After the model is obtained from the data, the training set is used for fitting to prevent over-fitting. Here in the generalized linear model we define the left side as transition probability versus transition intensity, x as age, and t as time (Table 2).

Model 1:

$$g(\alpha_{ij}(x,t)) = \beta_0 + \beta_1 x \tag{1}$$

Model 2:

$$g(\alpha_{ij}(x,t)) = \beta_0 + \beta_1 x + \beta_2 x^2 \tag{2}$$

Model 3:

$$g(\alpha_{ij}(x,t)) = \beta_0 + \beta_1 x + \beta_2 x^2 + \beta_3 x^3 \tag{3}$$

Model 4:

$$g(\alpha_{ij}(x,t)) = \beta_0 + \beta_1 x + \beta_2 x^2 + \beta_3 x^3 + \beta_4 x^4 \tag{4}$$

Model 5:

$$g(\alpha_{ij}(x,t)) = \beta_0 + \beta_1 x + \beta_2 x^2 + \beta_3 x^3 + \beta_4 x^4 + \beta_5 x^5 \tag{5}$$

According to the coefficient selection principle of small RMSE and large R2, the probability transfer model is selected. In order to verify whether the selected coefficient is optimal, we can observe it through the data fitting graph. For example, for severe disability, we selected linear models with secondary and tertiary age respectively. The data in the figure are the probability of severe disability with age change, and five lines are fitting lines for different sub-terms of age (female on the left and male on the right).

We can see from Fig. 2 that the probability of severe disability increases in general and declines in advanced age. This trend is caused by the increases in the probability of severe disability with age, with the sharp growth in the mortality rate of the elderly population. In addition to this, it is clear from the figure that males have a higher probability of severe disability than females. By selecting the best data fitting curve, we can find the coefficients of the Nth term of the four models' ages in Python (Table 3).

Table 2. Model fitting coefficients from healthy state H to four states.

	H-H			H-M		
model	Female	male	Total	Female	Male	Total
1	0.03/0.98	0.03/0.98	0.03/0.99	0.03/0.01	0.02/0.05	0.02/0.04
2	0.03/0.98	**0.03/0.99**	**0.02/0.99**	**0.02/0.47**	0.02/0.20	0.01/0.52
3	**0.03/0.99**	0.03/0.99	0.02/0.99	0.02/0.47	**0.02/0.28**	**0.01/0.58**
4	0.03/0.99	0.03/0.99	0.02/0.99	0.02/0.48	0.02/0.28	0.01/0.58
5	0.03/0.99	0.03/0.99	0.02/0.99	0.02/0.49	0.02/0.31	0.01/0.61
	H-S			H-D		
model	Female	Male	Total	Female	Male	Total
1	0.02/0.59	0.01/0.37	0.01/0.62	0.03/0.92	0.03/0.91	0.03/0.93
2	0.01/0.68	0.01/0.53	0.01/0.73	0.03/0.93	0.03/0.92	0.02/0.94
3	**0.01/0.70**	0.01/0.57	0.01/0.75	0.02/0.94	0.03/0.94	0.02/0.96
4	0.01/0.70	0.01/0.60	0.01/0.76	**0.02/0.95**	**0.02/0.95**	0.02/0.97
5	0.01/0.70	**0.01/0.61**	**0.01/0.77**	0.02/0.95	0.02/0.95	**0.02/0.98**

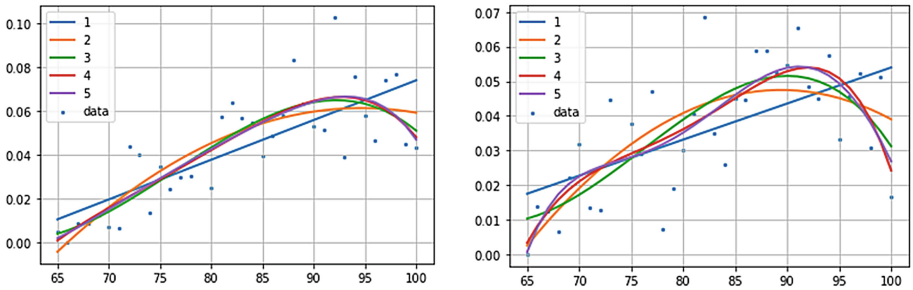

Fig. 2. Fitting diagrams of five models and data in the state of severe disability.

3 Pricing of Long-Term Care insurance

For the pricing of premiums, product design needs to be taken into account in the first place. LTC insurance is aimed at the expenses incurred by the disabled elderly who need nursing services due to disability, and the disability is divided into mild disability and severe disability. It is very likely to transform from a state of mild disability to a state of severe disability, so when mild disability is present, the insurance company pays insurance benefit with mild disability as 1 unit, and severe disability as twice as much as mild disability, which is 2 units of insurance benefits. During the effective period of the entire insurance product, there are four states: state 1 is the healthy period, the moment when the premium is paid; state 2 is the state of mild disability, with 1 unit of insurance money to be paid to the insured; state 3 is the state of severe disability, with 2 units of insurance money to be paid to the insured; state 4 is the death of the insured and the contract is terminated. This insurance product is a joint care insurance product for married couples. The state of the product is defined as, when any one spouse of the couple has mild disability, the product is in state 1. When any one spouse of the

Table 3. Optimized model coefficients.

	H-H			H-M		
Beta	Female	Male	Total	Female	Male	Total
b0	−4.04E+00	1.49E+00	1.38E+00	−1.16E+00	2.98E+00	1.88E+00
b1	2.05E−01	1.69E−03	4.58E−03	3.01E−02	−1.16E−01	−7.88E−02
b2	−2.61E−03	−1.52E−04	−1.69E−04	−1.81E−04	1.51E−03	1.10E−03
b3	9.83E−06				−6.43E−06	−4.97E−06
b4						
b5						
	H-S			H-D		
Beta	Female	Male	Total	Female	Male	Total
b0	1.66E+00	−7.70E+01	−3.77E+01	−4.87E+01	−5.01E+01	5.51E+01
b1	−6.99E−02	4.59E+00	2.21E+00	2.47E+00	2.56E+00	−3.94E+00
b2	9.54E−04	−1.08E−01	−5.15E−02	−4.69E−02	−4.92E−02	1.11E−01
b3	−4.15E−06	1.27E−03	5.94E−04	3.95E−04	4.17E−04	−1.54E−03
b4		−7.37E−06	−3.37E−06	−1.24E−06	−1.32E−06	1.05E−05
b5		1.69E−08	7.54E−09			−2.86E−08

couple has severe disability, the product is in state 2, and the insurance pays 2 units of premium. The transition between states is not considered for calculation. The calculation premium model only considers the present value of the continuous annuity that pays 1 unit when the state transitions from 1 to 2 and the continuous annuity cash that pays 2 units of insurance money when the state transitions from 1 to 3. Spouses of a couple are considered as independent individuals, assuming that there is no correlation between the couples, justifying the zero correlation between the state transition between husband and wife, and the state transition of two independent individuals is considered to have Markov property.

$$P_x^{01} = P_{xm}^{01} \times P_{xf}^{00} + P_{xf}^{01} \times P_{xm}^{00} + P_{xm}^{01} \times P_{xf}^{01} + P_{xm}^{01} \times P_{xf}^{03} + P_{xm}^{03} \times P_{xf}^{01} \tag{6}$$

$$\begin{aligned} P_x^{02} &= P_{xm}^{02} \times P_{xf}^{00} + P_{xm}^{00} \times P_{xf}^{02} + P_{xm}^{02} \times P_{xf}^{01} \\ &+ P_{xm}^{01} \times P_{xf}^{02} + P_{xm}^{02} \times P_{xf}^{02} + P_{xm}^{02} \times P_{xf}^{03} + P_{xm}^{03} \times P_{xf}^{02} \end{aligned} \tag{7}$$

$$\begin{aligned} a_x^{ij} &= E[\textstyle\int_0^\infty e^{-\delta t} I(Y(t) = j | Y(0) = i) dt] \\ &= \textstyle\int_0^\infty e^{-\delta t} E[I(Y(t) = j | Y(0) = i)] dt = \int_0^\infty e^{-\delta t} P_{ij}(x, t) dt \end{aligned} \tag{8}$$

The transition model for males and females is able to be constructed according to the best generalized linear model we calculated. Then, the probability of transition from healthy to mildly disabled and severely disabled at each age can be obtained through implementing assumed transition probability calculation method. Both formulas also give the calculation method of the transition probabilities from healthy to mildly disabled and from healthy to severely disabled for family union policies.

$$\int_a^b f(t)dt \approx \frac{h}{3}(f(a) + 4\sum_{j=1}^{n} f(a + (2j-1)h) + 2\sum_{j=1}^{n-1} f(a + 2jh) + f(b)) \tag{9}$$

The formula above is the discount factor. It is difficult to calculate the probability discount involving integration as time progresses, but Simpson formula is a way to simplify the equation to the integration between the interval (a, b) (x is the age): h = (b-a)/2n. We assume that a is 0 and b is 100-x, where x is age and n is 70 (n is the small segment divided on the interval. The larger the n, the more accurate the data. Here we select 70 as the segment for calculation). The net premium for male, female and joint products can be obtained by substituting the calculated ax into the net premium calculation formula specified earlier.

After calculating the separate premiums for each spouse of the couple, we can find the joint state transition matrix of the couple based on the probability and the number of exposures. According to the separate state transition probability matrices for males and females, with respective number of transitions and exposures we can get the combined number of transitions and exposures for a given age. The result is obtained by dividing the number of transitions for men or women by the corresponding sum of risk exposures. When looking at the corrections between the data of different groups, we perceived that the number of state transitions increases with the increase of the age. After obtaining the joint probability transition matrix of couples, the joint insurance premium of couples can be calculated by substituting the previous formula. Through compare the premiums of single gender groups (males and females) and couples at the same age, we observe that the combined premiums of couples are lower than the net premiums obtained by simply adding up the premiums of single gender groups.

According to the premium calculation results in Table 4, whether it is in the form of single gender groups or family unions, with the increase of age, the net premiums show a trend of increases followed by decreases. This is also related to the fact that the individual disability increases before the decline with the increase of age. In addition, women have higher net premiums than men because men have a higher mortality rate than women, and there are differences in the rates of mild and severe disability between men and women. The time at which the net premium of insurance products reaches the peak is different, but no doubt, the combined net premium of couples is higher than the net premium of family joint products, which is a more economical insurance product.

The above calculation is based on the state transition matrix of couples of a certain age, assuming that there is no difference in age between the couples. However, in real life, there is often an age difference between husbands and wives. If a single age is used, it may cause loss of interests and moral hazard, and there will be large deviations. Therefore, we take the age difference between husband and wife into consideration, and propose effective solutions for the age difference between husbands and wives. By adopting the treatment method of the People's Bank of China for family insurance products, we are able to calculate the additional age and use the calculated new age to obtain premiums. Assuming that the man is 50 years old and the woman is 45 years old, the age difference is 5. According to the additional age table, the converted age is 3, and $45 + 3 = 48$. Therefore, for this couple, we use 48 when calculating premiums based on age. The age calculated through such measure is more in line with the actual situation. The premium price of the age 48 is between the age 45 and the age 50, which can effectively avoid the high or low premium caused by charging according to the age

Table 4. Net Premiums by Age in Health Status.

Age	Joint	Female	Male
65	1.62	0.71	0.94
66	2.02	0.88	1.18
67	2.36	1.05	1.35
68	2.64	1.21	1.47
69	2.87	1.37	1.56
70	3.06	1.52	1.62
71	3.22	1.66	1.66
72	3.35	1.80	1.69
73	3.45	1.92	1.71
74	3.54	2.03	1.73
75	3.61	2.13	1.75
76	3.67	2.22	1.77
77	3.71	2.30	1.79
78	3.74	2.35	1.81
79	3.75	2.40	1.83
80	3.75	2.42	1.85
81	3.73	2.43	1.87
82	3.69	2.42	1.88
83	3.63	2.40	1.88
84	3.55	2.35	1.88
85	3.44	2.29	1.86

of one spouse. Pricing and premium calculations will be more accurate when applying this measure.

There is another type of care insurance that takes effect when the insured enters a state of mild disability. As a complement to the insurance product calculating the joint state transition matrix for couples whose initial state is healthy, this kind of insurance pricing is higher than the product related to that of health transition because people with mild disability are more likely to become severely disabled. On other words, they are more likely to transfer from mild disability to severe disability than those from a healthy state to a state of severe disability. This insurance is also divided into two situations: one spouse in a state of mild disability but another in a healthy state and both spouses in a state of mild disability. Premiums are highest when both are mildly disabled compared with the other situation. However, there are also some differences in the pricing model of former situation. This is mainly due to the higher possibility of female disability in the early and middle stages, but with the increase of age, the possibility of male disability increases rapidly. As a result, the gap in net premiums in the high age group narrows to an inconsiderable state. Therefore, specific analysis is required for different situations. For couples with age differences, the age difference should be taken into account when purchasing care insurance products, so that the pricing will be more accurate.

4 Conclusion

This paper to constructs a state transition model for elderly health, mild disability, severe disability and death by utilizing CLHLS data and explore the construction of care insurance products for the elderly through applying the multi-state transition model. The paper introduces the care insurance products from the origin to the development and then carried out the construction of the pricing model and its outlook for it. Distinct from the existing research, this paper adds a discussion on the age difference between husband and wife, combined with a pricing plan to solve the age difference of family joint insurance products. In addition, the net premiums of individual and family joint care insurance are calculated by dividing the disability status into mild disability and severe disability while constructing a state transition model with the data of 65–100-year-olds. However, there are some limitations about this paper. The treatment method of age difference is not based on the actual situation, and the physical condition that varies from person to person may cause errors, which can be solved by adding a damaged life table. Additionally, the correlation between the status transition between the husband and the wife is not considered; thus, further research is essential.

As far as the current situation is concerned, although the development of care insurance is still in its infancy, the market has a great potential. Firstly, in the international academic community, TFR (Total Fertility Rate) is the replacement level of the times at 2.1. When the TFR is lower than 1.5, it is considered to enter the low fertility trap. The TFR of China in 2019 reached 1.47, which was lower than 1.5 in recent years. The problem behind this is that the old-age dependency ratio continues to grow, which further aggravates the aging problem. In the future, it is inevitable that people's desire to have care insurance to relieve family pressure will keep increasing. As a matter of fact, when it comes to the policy making, it is unfeasible to implement a complete social LTC insurance model in China because the unbalanced development between urban and rural areas and between regions will lead to differences in payment and benefits, and many current studies have shown that in the future there will be a huge gap in China's pensions. The commercial insurance mentioned in the paper is a constructive model, which is an integral part of the model that combines social security and commercial insurance. While social security focuses on the disadvantaged group (those receive subsistence allowance) with capital investment in care insurance, those with healthy financial status can purchase commercial care insurance. The government can also setup a government-run private model for commercial nursing insurance. However, this model also has regulatory issues. How to effectively regulate the products and contents of commercial insurance and ensure the fairness of pricing and the stability of solvency in the market is worth discussing.

References

1. Dickson D.C.M, Hardy M.R, Waters H.R. Actuarial Mathematics for Life Contingent Risks New York: Cambridge University Press, 2009.
2. Fong. Joelle H., Adam W. Shao, and Michael Sherris. Multistate Actuarial Models of Functional Disability. North American Actuarial Journal, 2015; 19 (1): 41 - 59.

3. Robinson, J. (1996). A long-term care status transition model. The Old-Age Crisis - Actuarial Opportunities: The 1996 Bowles Symposium, Georgia State University, pages 72–79.
4. Rickayzen, B. D. and Walsh, D. E. P. (2002). A multi-state model of disability for the United Kingdom: Implications for future need for long-term care for the elderly. British ActuarialJournal, 8(2):341-393.
5. Society of Actuaries, SOA (1995). Long-term care insurance valuation methods. Transactions of the Society of Actuaries, 47:599-773.
6. Sverdru P. E. , 1965, Estimates and Test Procedures in Connection with Stochastic Models for Death, Recoveries and Transfer between Different States of Health [J], Scandinavian Actuarial Journal, 10(4), 184~211.
7. Congressional Budget Office(2004). Financing long-term care for the elderly. The Congress of the United States.
8. Fong, J. H., Koh, B. S., and Mitchell, O. S.(2012). Functional disabilities and nursing home admittance. Pension Research Council Working Paper 2012–19.
9. Haberman, S. and Renshaw, A. E.(1996). Generalized linear models and actuarial science. The Statistician, 45(4):407–436.
10. Oman, D., Reed, D., and Ferraral, A.(1999). Do elderly women have more physical disability than men do? American Journal of Epidemiology, 150(8):834–842. E.M. Clarke, E.A. Emerson, Design and synthesis of synchronization skeletons using branching time temporal logic, in: D. Kozen (Eds.), Workshop on Logics of Programs, Lecture Notes in Computer Science, vol. 131, Springer, Berlin, Heidelberg, 1981, pp. 52–71. DOI: https://doi.org/10.1007/BFb0025774

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