Using the Taiwan National Health Insurance Database to Explore the Need for Long-term Care

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Abstract

Several factors contribute to the lack of long-term care (LTC) insurance in Taiwan, and the insufficient experienced data and absence of unified definitions of LTC are two of them. In this study, we use LTC-related catastrophic illness (CI) as the assessment criteria to investigate the demand for LTC insurance. We selected 13 categories of CI and explored the spatial-temporal properties of LTC incidence rates and mortality rates from the National Health Insurance Research Database. The study shows that the incidence rates did not change much, while mortality rates decreased significantly. Taiwan's LTC population, which was 0.29 million in 2013, is accordingly expected to triple before 2040 based on the proposed Cohort Change Ratio (CCR) approach. Currently, Taiwan's government has planned to fund LTC insurance via a pay-as-you-go system. Furthermore, the increasing LTC population indicates that commercial insurance can play a vital role as a supplement to social LTC insurance.

Keywords: Population Aging, Long-Term Care Insurance, National Health Insurance Research Database, Catastrophic Diseases, Spatial-temporal Analysis

1. Introduction

Mortality reduction has become a common phenomenon in many countries since the end of the Second World War, and it is especially noticeable in the elderly and younger age groups (e.g., infants). As a result, life expectancy has been increasing steadily and the proportion of aging population in Asian countries has escalated rapidly. For example, the life expectancy of Taiwan's male and female populations increased from 71.3 and 76.8 years in 1990 to 77.7 and 84.2 years in 2020, respectively. In other words, the annual increment of prolonged lifespan in Taiwan was around 0.2-0.25 years over the past 30 years, and it is expected to continue in the near future (Source: National Development Council, Republic of China). Life expectancy in Asian countries is predicted to grow at a similar rate, with that of the female population in South Korea to reach 90 years in the 2030's (Kontis et al., 2017). Thus, the proportion of elderly population (ages 65 and over) in Japan, South Korea, and Taiwan will reach 30% in less than 20 years, creating a pressing problem across Asia.

Planning social insurance program is one approach to face the growing elderly population and its needs in Asian countries. To name a few, Taiwan's government implemented the National Health Insurance (NHI) in 1995 and National Pension Insurance in 2008, both of which are related to the medical and retirement financial needs of the elderly. However, implementing social insurance for long-term care (LTC) has not gone so smoothly. One of the main reasons is the changing family structure in Taiwan. In fact, many Asian countries, especially those with higher GDP (e.g., the Four Asian Tigers: Hong Kong, Singapore, South Korea, and Taiwan), have the lowest fertility rates in the world. These low fertility rates not only accelerate the aging of the population, but also make the process of seeking LTC providers more difficult. For example, the elderly in East Asia used to live with their adult children (or with extended family members) who could take care of them. Over time, more elderly people have tended to live alone or with a spouse, meaning that someone needs to look out for them if they are sick or injured.

In addition to the source of care providers, the lack of consensus on the criteria for determining if a person is qualified is another difficulty for implementing LTC insurance in Taiwan. Such insurance should cover personal care for those with chronic conditions or disabilities who require constant care. Activities of Daily Living (ADL) and Instrumental Activities of Daily Living (IADL) are often used by Taiwanese insurance companies as the LTC eligibility criteria. However, ADL and IADL measure whether an individual can live independently in a community, which means that even if including people with dementia, it still cannot cover all the people with LTC needs. Therefore, Taiwan has been assessing if the LTC service should be applied to people with mental disorders or intellectual disabilities since 2017.

Even if we can determine the LTC eligibility criteria, it is still difficult to obtain experienced data. This is especially the case for the older age groups, as accelerating life extension is one of the main reasons for not being easily able to acquire such data. The incidence rates of LTC conditions and the mortality rates of people with LTC conditions are necessarily required to determine LTC insurance premiums. However, acquiring this information is challenging and, alternatively, prevalence rates are adopted in most of the studies in Taiwan to estimate LTC needs. These estimations were all based on the results of sampling surveys and certain actuarial assumptions are applied in order to project the size of populations requiring LTC service (Wang et al., 2012; Cheng, 2016). Also, these surveys have been conducted only once and their sample sizes were only a few thousand, which indicates that the results of LTC projections are likely to be questionable.

All these restrictions, together with the unknown service cost, have challenged the implementation of LTC insurance. Originally the mandatory national LTC insurance was scheduled to be implemented in 2016. Later on, the Taiwan government then decided that LTC services should adopt a tax-based system rather than an insurance system, and there has been no further progress so far. Meanwhile, the sales of commercial LTC insurance products are also not going well, which is mainly due to the high insurance premium. The number of in-force contracts in 2021 was around 0.84 million, less than 4% of Taiwan's population. Nonetheless, the demand for LTC services is expected to grow rapidly owing to the population aging and prolonging life expectancy. Thus, the growth rate of LTC demand would be accordingly explored and discussed in this study.

Note that we will adopt a new LTC criterion. There are two reasons behind such decision, one of which is that the new criterion is stricter, and the other is that the experienced data would therefore be available. We do not intend to propose a standard which can cover all the LTC needs (which is not possible). The current study can be treated as an exploratory study for evaluating future needs. The new criterion is established on the basis of Catastrophic Illness (CI), which is an important feature of Taiwan's NHI, and there are about 0.9 million people (4% of Taiwan's population) diagnosed with CI. We treat certain types of CI patients as the population requiring LTC services, since they require prolonged hospitalization and/or recovery (Gillick, et al., 1982). We will use the NHI records to estimate the incidence and mortality rates of LTC population, and then apply different models, including Lee-Carter model (Lee and Carter, 1992) to predict the future LTC population. The growth rate of LTC service should be calculated and the LTC insurance should as well be evaluated to visualize the feasibility of the LTC insurance in Taiwan.

2. Data and Methodology

Taiwan launched NHI in 1995 and the relevant data have been collected ever since and stored in National Health Insurance Research Database (NHIRD). The data can be used to explore the health and medical utilization of Taiwanese people. For example, the CI population has the largest medical expenditures, and they used 28% of the overall medical expenditure in 2019 while the proportion of CI patients was about 4% of the population of Taiwan. This result is consistent with the original intent of the design that the CI patients have copayment waivers for medical visits, with the purpose of reducing the patients' financial burden. CI patients also have high mortality rates, and many of them may require assistance in daily life, thus, CI provides another possibility as an LTC criterion. There are strict review process steps and standards for CI, in addition to more than 20 years of experienced data. Although the CI group is only a subset of people requiring LTC services, we can use it as a pilot study to delve into trends in the LTC population in Taiwan.

We use NHIRD records to obtain the incidence and mortality rates of CI patients, as well as the prevalence rates, to predict the future LTC population. Only the data between 2003 and 2013 is considered, the size of which is around 0.5 TB (terabytes), primarily due to the issue of data quality. Additionally, population projection information from the National Development Council (NDC) will also be accounted.

The NDC usually conducts Taiwanese population projections every two years, and the projection results normally include the age-specific population sizes and the proportion of population of both genders. Most of the prediction of Taiwan LTC population is based on the estimation of prevalence rates from sampling surveys and the population projection. Furthermore, we will also refer to the projection results from 2020 to 2070 conducted by NDC to predict the LTC needs.

For when using the criteria to judge if a person requires the LTC service, the definition of CI is adopted. The medical expenditures are higher for CI patients, and frequent hospitalization is often required in a general sense. However, many of them require medical care for merely a short period (e.g., cancer patients under the age 65). Thus, we have selected 13 out of 30 CI categories, with patients in these groups often requiring assistance in their daily lives (Appendix 1). Still, some of the CI diseases (e.g., cancer) have shorter acute phases and are not applicable to LTC insurance. Therefore, an age restriction (i.e., age 65 and over) has been added to these CI diseases. For example, even after surviving cancers, most of the elderly patients would still need long-term support and services in the future (Lin, 2017). Worthy of note is that, as mentioned above, the proposed CI criteria are not complete, and they can only cover the LTC needs caused by illness. The proposed approach can be treated as a pilot study of evaluating Taiwan's LTC needs. Also, age restriction would be applied to these patients except for three categories (13: Patients Requiring Long-term Use of a Respirator, 18: Spinal Cord Injury, 29: Creutzfeldt-Jakob Disease), since not all patients in these 13 groups would require living assistance unless they are getting older. The patients in these three CI categories usually need assistance with daily lives, and for instance, mad cow disease (or Bovine Spongiform Encephalopathy) is a type of Creutzfeldt-Jakob Disease.

There are two types of projection approaches considered in this study. The first one is to apply the stochastic models to forecast the future incidence, mortality and prevalence rates of CI from NHIRD, and then combine them with the population projections from NDC. The second one is to apply projection methods based on the past CI populations, for which the Lee-Carter (LC) model (Lee and Carter, 1992) has been chosen. The LC model is probably the most popular stochastic model, which can provide fine forecasts in a lot of studies, not restricted to mortality reduction. The LC model assumes that

$$\ln(m_{xt}) = \alpha_x + \beta_x\kappa_t + \varepsilon_{xt} \quad (1)$$

where m_{xt} is the central death rate (or other values) of age *x* at time *t*, α_x and β_x are age-related parameters, and κ_t is a time-related parameter.

After acquiring the predictions of incidence, mortality and prevalence rates from stochastic models, the future LTC populations can be further obtained by directly multiplying the prevalence rates and future populations from NDC. This is exactly what most of the previous studies have done. Alternatively, we can apply the Demographic Balancing Equation (Preston et al., 2001) for population projection. The population at time *t+1* is determined by the population, births, deaths, and migrants at time *t*, or

$$\mathrm{P}(\mathrm{t}+1) = P(t) + B(t) - D(t) + I(t) - E(t) \quad (2)$$

where *P(t)*, *B(t)*, *D(t)*, *I(t)*, and *E(t)* are the numbers of population, births, deaths, immigrants, and emigrants at time *t*, respectively. Equation (2) can be modified into cohort component method (Whelpton, 1928) for population projection and, similarly, we can obtain the future births (new patients) from incidence rates and deaths from mortality rates. There is no need to consider immigrants and emigrants for the CI patients since CI conditions are usually irreversible.

Another projection method is to apply equation (2) based on the historic records, followed by the adoption of the Cohort Change Ratio (CCR), proposed by Hamilton and Perry in 1962. The CCR method combines the factors of births, deaths, and migrants into a single value,

$$R_x(t) = \frac{P_{x+1}(t+1)}{P_x(t)} \quad (3)$$

where $P_x(t)$ is the population of age *x* at time *t*. The CCR method is originally designed for sub-national population projections since it is difficult to collect the population information (especially migration data) of the county (and township) level. Smith and Tayman (2003) and Swanson and Tayman (2017) have shown that the CCR method is an effective projection method for sub-national populations. Yue et al. (2021b) showed that using the CCR can achieve fine population projection for both national and sub-national populations in Taiwan, about the same as those via the cohort component method.

In addition to population projection, we have also considered life table construction and mortality graduation methods to assess the life expectancy of average people and people with LTC needs. We chose the kernel method to smooth age-specific mortality rates (Gavin et al., 1995) and the graduated mortality rate $\hat{q}_x$ via kernel function is

$$\hat{q}_x = \frac{\sum d_i K(\frac{x-x_i}{h})}{\sum e_i K(\frac{x-x_i}{h})} \tag{4}$$

where e_i and d_i are the numbers of exposures and deaths at age x_i, h is the bandwidth, and K is the kernel function. The choice of bandwidth is of more significancy, and we usually opt for normal kernel function, or $\mathrm{K(x)} = \frac{1}{\sqrt{2\pi}} e^{-\frac{x^2}{2}}$, to obtain smoother estimates.

The results of two population projection methods will be compared in Section 4 and, in particular, we would like to know if there will be substantial differences between projection methods. In the next section, the trend of incidence, mortality and prevalence rates of LTC-related CI will firstly be explored, and check if it is feasible to use the LC model to predict these rates. If the LC model is a feasible approach, then it can also be utilized to evaluate the growth rate of LTC needs in Taiwan.

3. Exploratory Data Analysis of LTC Experienced Data

Among the 13 CI categories selected in this study, the numbers of patients with cancer and chronic renal failure are the largest. Thus, we have separated 13 CI categories into three groups (cancer, kidney & others) and there were enough samples in these groups to guarantee stable LTC estimates. This is also true for applying the LC model since the parameter estimates of LC model would be biased (especially α_x) in the case of small sample size (Wang et al., 2018; Yue et al., 2021a). Worth noting is that the female LTC patients outnumber the male ones (Figure 1). The numbers of female LTC patients 45-74 years old are the largest, while those of male LTC patients are primarily 50-79 years old. The pattern of age-specific LTC prevalence rates should be similar as the barplots in Figure 1. Also, the number of LTC patients is expected to significantly decrease if we apply age restriction (i.e., 65 years old) to the proposed LTC criteria. since cancer is the leading LTC category.

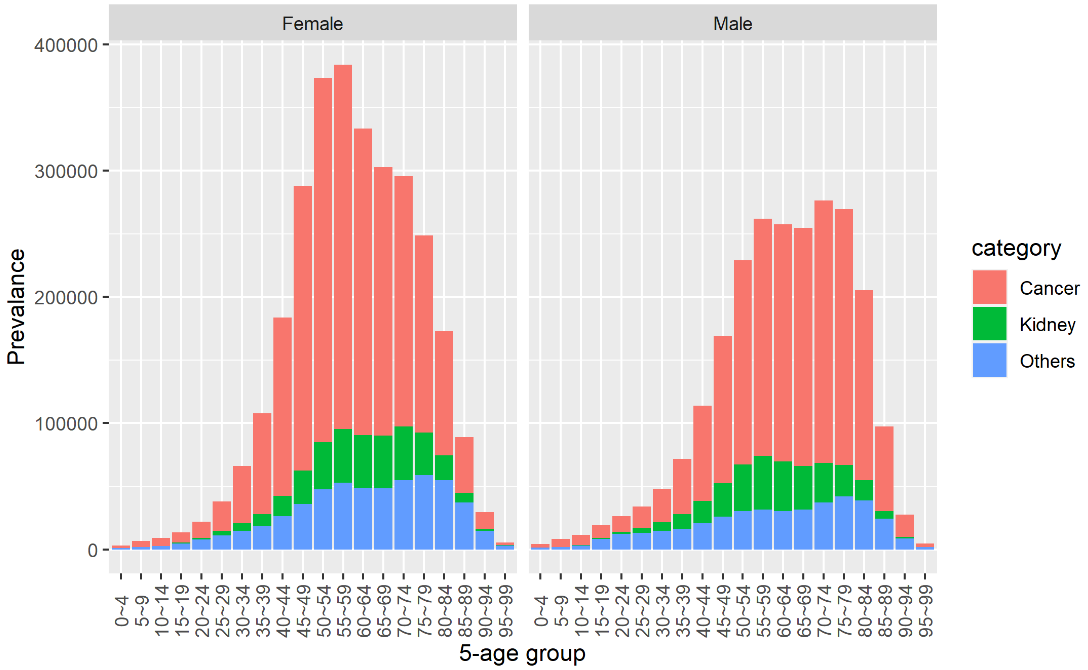

Figure 1. Numbers of patients with different CIs (2003-2013)

We can use the experienced prevalence rates, or incidence and mortality rates, to project the numbers of future LTC patients in Taiwan. The prevalence rate refers to the proportion of people in a population with a certain disease, while the incidence rate indicates the proportion of new cases with a certain disease in a population. One way to predict the number of LTC patients is to multiply the total population by prevalence rates in each year, as many studies of Taiwan LTC projection assume fixed prevalence rates. Another possibility is to obtain the numbers of new LTC patients via incidence rates and deduct the numbers of LTC patients who have passed away via mortality rates. This means that the whole population should be divided into individuals with and without LTC conditions. The first projection method is relatively simple, and the second method usually produces more accurate forecasts.

We will first explore the trend of LTC prevalence rate using the concept of SMR (Standardized Mortality Ratio), which is frequently used in public health and is the ratio of observed deaths in the study group to expected deaths in the general (or reference) population. The SMR is defined as

$$\text{SMR} = \frac{D^j}{\sum_x m_x^s \times P_x^j} \qquad (5)$$

where D^j is the number of deaths in the study group j, P_x^j is the number of people age x in the study group j, and m_x^s is the central death rate of age x in the reference population. If SMR > 1 (or SMR < 1), then the study group has higher (or lower) number of deaths than expected.

As expected, like many countries, the LTC prevalence rates in Taiwan rise with age. To explore the trend of prevalence rates, we treat the aggregation of all prevalence data as the reference population. Then, we use age-specific prevalence rates to replace central death rates in equation (5) and define SPR (Standardized Prevalence Ratio).

$$\text{SPR} = \frac{C^j}{\sum_x m_x^s \times P_x^j} \qquad (6)$$

where C^j is the number of disease cases in the study group j, P_x^j is the number of people age x in the study group j, and m_x^s is the central prevalence rate of age x in the reference population. Figure 2 shows the SPR of different types of LTC and all 30 categories of CI patients during the period between 2003 and 2013, and they all rise linearly over time at about the same rate, which is about 4% annually. This indicates that the LTC prevalence rates in Taiwan are increasing as time progresses, and the LC model may be applied to the prevalence rates. However, this approach seems to oversimplify the problem and correspondingly, the LTC projection results would possibly be over- or under-estimated, which will be discussed later in this study.

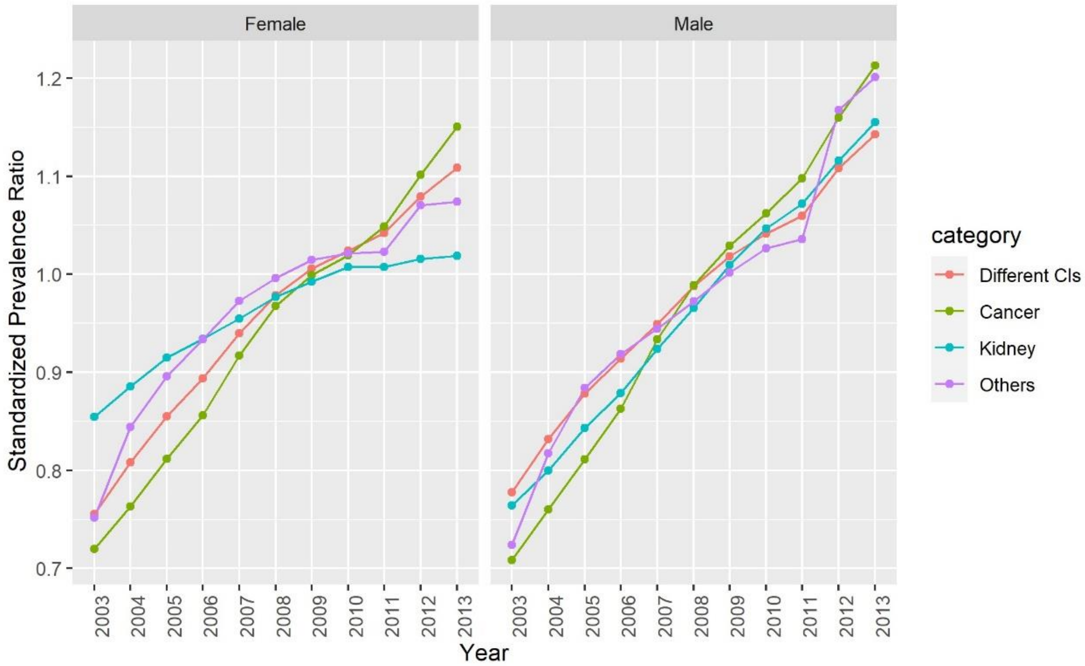

Figure 2. SPR of LTC prevalence rates (2003-2013)

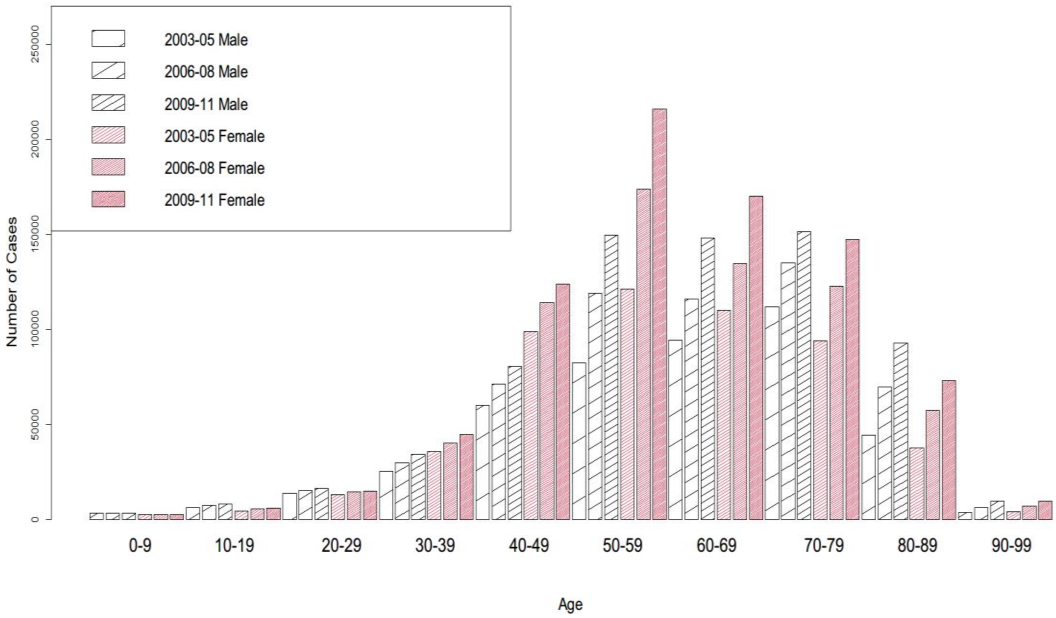

Figure 3. Age-specific number of cases of LTC patients (2003-2011)

We prefer using the incidence and mortality rates to acquire the LTC projections. Note that the LTC incidence rates and the number of LTC patients are often relatively low in certain age groups. The SMR is to be used to explore the trend of overall incidence mortality rates, with a view to avoiding interference of small incidence rates and cases in some age groups. For example, Figure 3 shows the number of cases for male and female LTC patients in the format of 10-age and 3-year groups, which is equivalent to the total number of 30 annual single-age cases. Apparently, there is not a significant number of cases in the younger groups (ages below 40) and the older groups (ages beyond 90), which might lead to fluctuations of mortality rates. Using SMR allows us to have a more comprehensive understanding about the mortality trend.

Figure 4 demonstrates the average incidence rates of all 30 categories of CI patients and different types of LTC patients in 2003-2013. The incidence rates are closely related to age, and they increase exponentially (or logarithms of the incidence rates increase linearly) with age, which is somewhat different from the mortality rates. The male incidence rates of CI groups are slightly larger than those of female, especially for the incidence rates of the kidney dialysis. However, unlike the prevalence rates, the incidence rates are almost fixed with time. Therefore, we have applied the average incidence rates in 2003-2013 for the LTC projection, and the LC model was not utilized to acquire the future incidence rates.

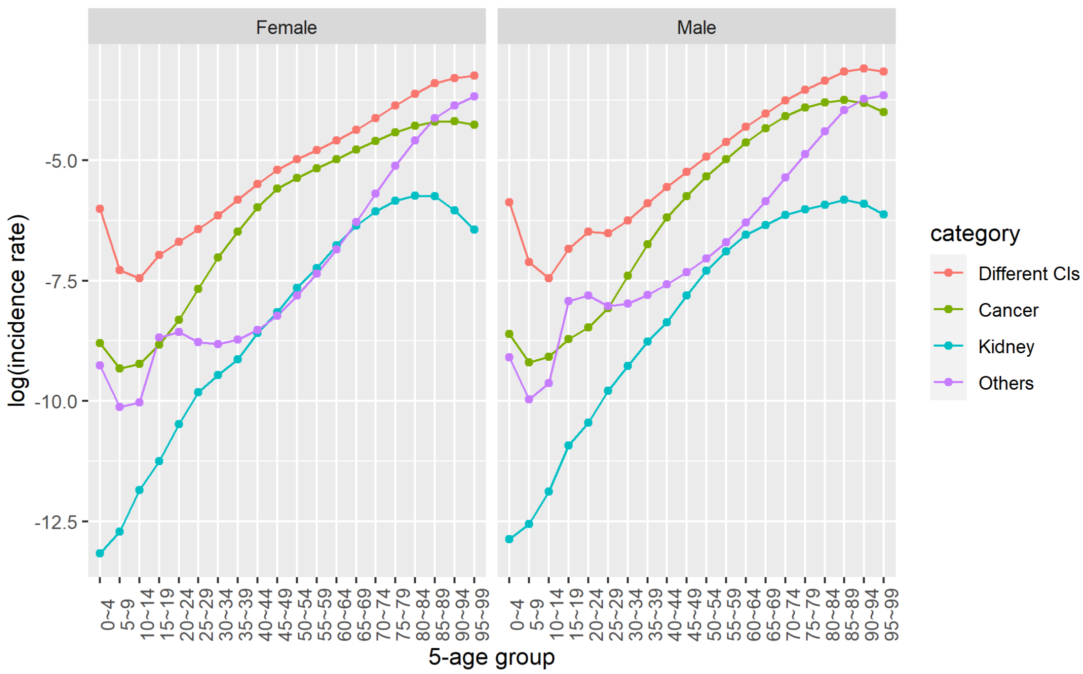

Figure 4. Incidence rates of patients with different CIs (2003-2013)

Figure 5 shows the average mortality rates of various LTC and all categories of

CI patients within the period from 2003 to 2013. The mortality rates of 3 groups of LTC patients (i.e., cancer, kidney, & others) are similar. Furthermore, the decline in mortality rates is also similar. Therefore, we can treat the overall 13 LTC categories as a whole while performing mortality prediction. Again, we treat the aggregation of all the mortality data as the reference population. Figure 6 shows the SMRs from 2003 to 2011, which presents similar decrements of time for all groups of data, including those of average people and CI patients. This suggests that the LC model can be applied to the mortality rates to all groups. Also, the mortality prediction of 13 LTC categories would be considered together, since their age patterns and decreasing trends of mortality rates are similar. Note that the information of two-year outpatient visits is referred to so as to determine if the LTC patients are still alive (Yue et al., 2019). Hence, we can only show the estimated mortality rates in 2003-2011.

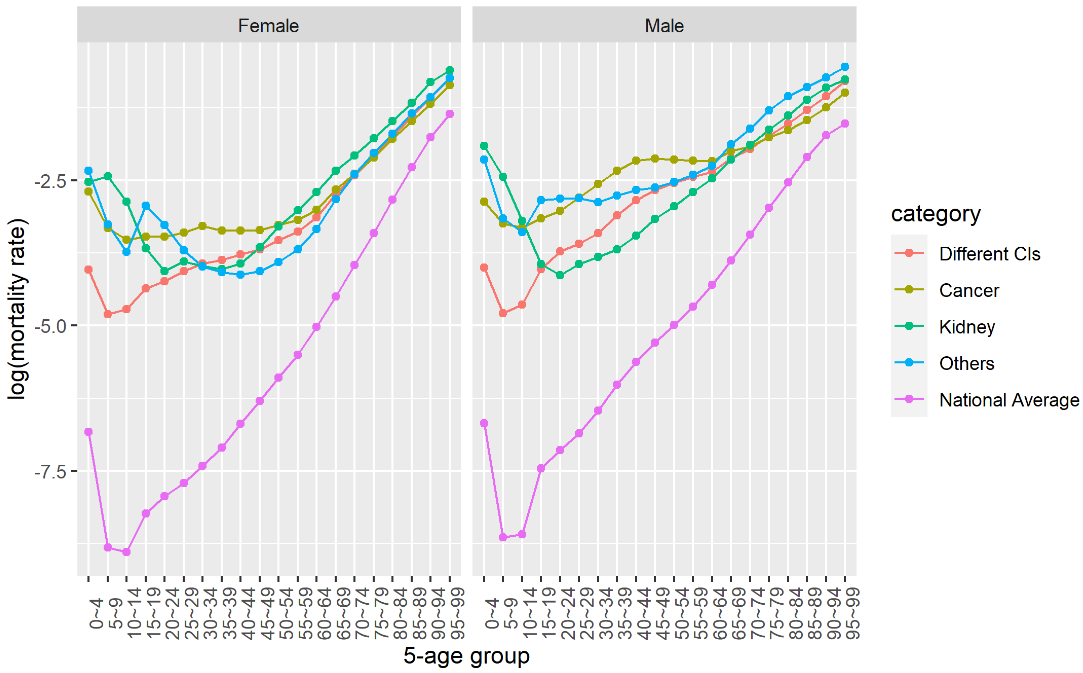

Figure 5. Mortality rates of patients with different CIs (2003-2011)

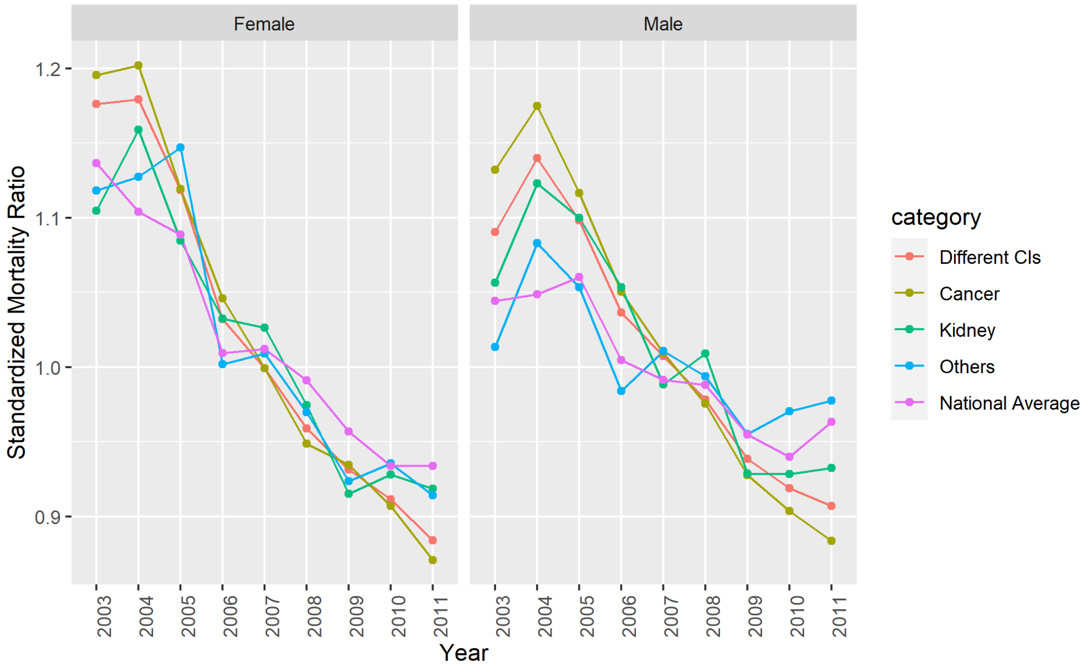

Figure 6. SMR of LTC patients (2003-2011)

The proposed LTC groups and all categories of CI patients have significantly higher mortality rates than those of the average people in Taiwan (Figure 5), and it is expected that the differences will continue in the future (Figure 6). In this case, the life expectancy of average people and the LTC groups could thus be computed, followed by the evaluation of the meaning of mortality differences with respect to longevity. We have applied the kernel method to graduate mortality rates and the ultimate age was set to be 100, similar to that in Taiwan's official life tables (Source: Ministry of the Interior). Referring to the Taiwan government's practice of utilizing data spanning three years to establish comprehensive life tables, we have consequently chosen to employ data from the period 2009 to 2011 for calculating life expectancy at various ages (Table 1). Similar to the mortality differences, the lifespan of LTC population is much shorter than that of average people, especially for the male. Also, based on the results in Table 1, we can obtain a rough idea of the required number of LTC years for those suffering from diseases. Introducing age restrictions to the proposed LTC criteria is a viable alternative, given that life expectancy of the LTC population noticeably decrease with advancing age

Table 1. Life Expectancy of Average People and LTC Patients (2009-2011)

Unit: Year

Age		0	10	20	30	40	50	60	70	80	90
Average	Female	82.47	72.98	63.11	53.32	43.65	34.21	25.15	16.76	9.76	4.67
	Male	75.96	66.51	56.72	47.14	37.94	29.35	21.32	14.11	8.38	4.29
LTC	Female	19.48	23.15	22.85	21.06	18.09	14.23	10.05	6.29	3.50	1.83
	Male	15.02	15.58	13.15	10.51	8.40	7.19	6.01	4.44	2.81	1.64

The analysis of the LTC incidence rates would be similar and could accordingly be omitted. The LC model could be adopted to predict the LTC incidence rates, as well as the prevalence rates and mortality rates. In the next section, the projected results of future LTC population will be presented using stochastic models and population projection approaches. Furthermore, we will assess the feasibility of implementing LTC insurance in Taiwan.

4. Projections of Taiwan's LTC Population

As mentioned in the second section, we have considered two types of methods to predict future LTC population in this study, one with Taiwan's population projection from NDC and the other without. The one with the NDC information is to have the LC model applied to forecast the prevalence rates or the LC model employed to predict the incidence rates and mortality rates. In this study, we will utilize the StMoMo module from the software R to estimate the parameters (α_x, β_x, and κ_t) of LC model. Subsequently, we will employ the MAPE (Mean Absolute Percentage Error) to gauge the accuracy of the LC model. The definition of MAPE is (unit: %)

$$\text{MAPE} = \frac{1}{n}\sum_{i=1}^{n}\left|\frac{\hat{y}_i - y_i}{y_i}\right| \tag{6}$$

where $\hat{y}_i$ and y_i are the i^{th} estimated and observed values, respectively and n is the number of observations. Table 2 displays the MAPEs resulting from applying the LC model to the prevalence, incidence and mortality rates of LTC data. It appears that the LC model is a suitable choice.

Table 2. Fitting Errors of LC Model (MAPE)

	Prevalence	Incidence	Mortality
Female	2.88%	3.36%	5.78%
Male	2.24%	3.16%	5.14%

Multiplying the prevalence rates by the projected population from NDC is the most straightforward method for estimating future LTC population, and it also serves as the most commonly used projection method in most of the past studies in Taiwan. The prevalence rates are assumed to be fixed in these studies, and we will consider it as the benchmark for evaluating our projection results. For the projections obtained by multiplying the prevalence rates with the NDC projected population, we will consider two scenarios: one where the prevalence rates are fixed, and another where they are not. The scenario with non-fixed prevalence rates is acquired by the LC model. Note that we can also merge the incidence and mortality rates with NDC projected populations into the projected LTC populations. This could be acquired by employing the Equation (2), and the number of new LTC patients as well as the number of deaths from current LTC patients could be obtained.

Our choice of the projection method without the information from NDC is the prediction method via the CCR $R_x(t)$ for different age *x*. In practice, we first computed the average of CCR, or $\bar{R}_x$, for every age from the historical data, and then obtained the LTC population at age *x*+1 and year *t*+1 from

$$\widetilde{\mathrm{P}}_{\mathrm{x+1}}(\mathrm{t}+1) = \widetilde{\mathrm{P}}_{\mathrm{x}}(\mathrm{t}) \times \overline{\mathrm{R}}_{\mathrm{x}} \tag{7}$$

where $\widetilde{\mathrm{P}}_{\mathrm{x}}(\mathrm{t})$ is the LTC population at age *x* and year *t*. The preceding projection method is affirmed to be stable and accurate in Taiwan's population projection (Yue et al., 2021b). Also, we suggest using the average of CCR from the past 10-20 years on the basis of our experiences.

We first presented the projection results of four different methods (average prevalence rates, prevalence rates via the LC model, incidence & mortality rates via the LC model, & CCR method) in 2012-2040 under the LTC criteria without age restrictions. The projections start from 2011 and 2011 is the latest actual data available. It is worth noting that we use medical records to judge if a patient is alive (Yue et al., 2019), and only the estimates of the mortality rates for the years 2003-2011 could be accessed. On the other hand, we can estimate the prevalence rates and the incidence rates within the period 2003-2013. However, for the sake of consistency, the population projection for all methods commences from 2012 (Figure 7). Interestingly, the projection methods of multiplying the (both fixed and LC model) prevalence rates by NDC population projections yield the most extreme results. The results of the fixed prevalence rates are the most conservative, while those derived from prevalence rates using the LC model are the most progressive (though its annual increment appears to be unreasonable). The projection results of applying the LC model to the incidence/mortality rates and the CCR are highly similar, but the annual increment is excessively large (about 9% annually). We will compare these projection results with those in the case of LTC criteria with age restrictions.

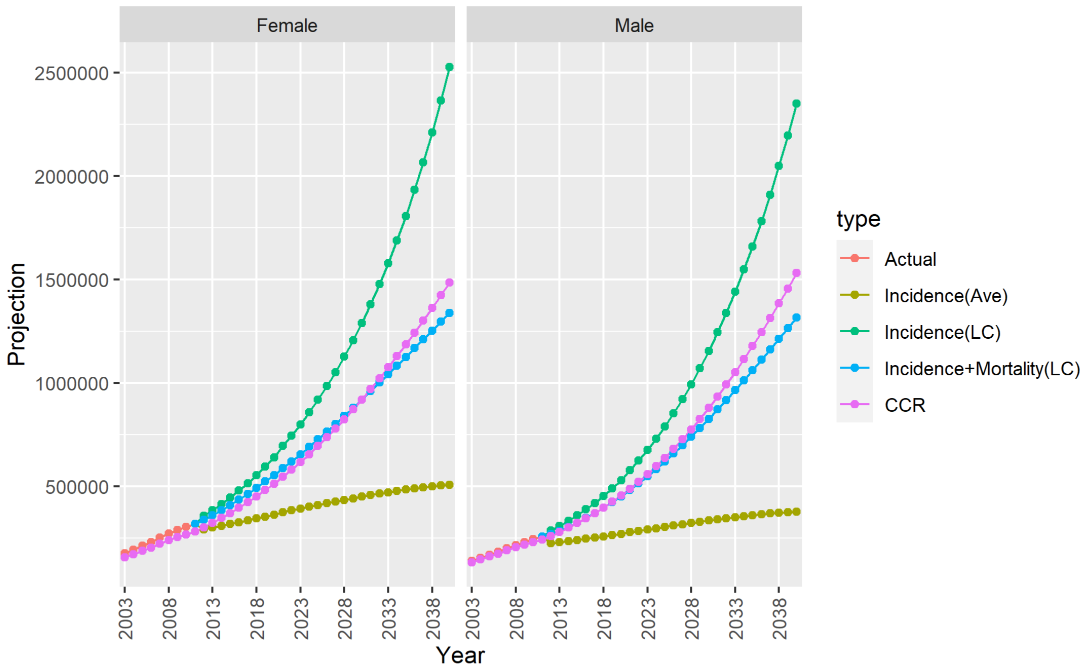

Figure 7. Projected LTC Populations (2012-2040, without age restriction)

The projection results of the four methods with age restrictions are slightly different (Figure 8). The results obtained by multiplying prevalence rates by NDC population projections still produce the most extreme outcomes. On the other hand, however, the projection results of using the CCR are significantly larger than those of applying the LC model to the incidence/mortality rates. The annual increment of the CCR projections is around 7%, larger than that of 5% for those via applying the LC model to the incidence/mortality rates. It seems that the outcomes of projection are obviously affected by the assumption and the approaches. Suppose we use the CCR to project LTC populations (which are not impacted by the NDC projection assumption), which means that Taiwan's LTC population will be more than tripled from 2013 to 2040. In other words, the cost of implementing national LTC insurance in Taiwan would increase considerably, which consequently makes this social insurance plan impractical.

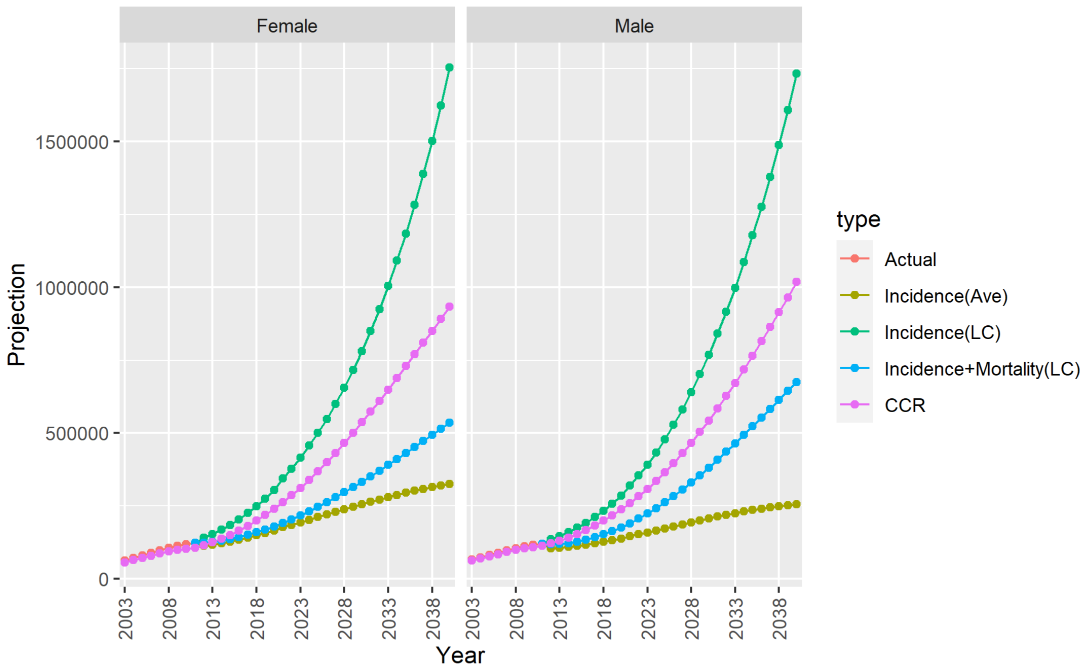

Figure 8. Projected LTC Populations (2012-2040, with age restriction)

There is another advantage of using the CI data to design LTC criteria, in addition to the strict review process in evaluating the CI status and the availability of experienced data. The medical records from NHIRD can be used to locate the place of normal residence (Yue et al., 2020), and thus we can apply spatial analysis to uncover the spatial properties of LTC, such as if more LTC services are needed in certain areas. For example, we can calculate spatial autocorrelation, such as Moran's I, for the incidence and mortality rates of LTC patients to assess the spatial inhomogeneity. We found that the LTC needs are spatially correlated and there exists autocorrelation and/or hot spots, i.e., locations with higher mortality risk (Kulldorff and Nagarwalla, 1995; Wang and Yue, 2013).

5. Discussions and Conclusion

The prolonging life does not show clear signs of slowing down in many countries, and it is expected that the life expectancy will reach 90 years old in East Asia. Thus, life arrangement after retirement becomes the focus of public attention. Unlike pensions and medical insurance, the progress of LTC insurance is relatively slow in Taiwan, attributable to the lack of LTC judgment criteria and experienced data. In this study, we have proposed using CI (13 out of 30 categories) from NHI as an alternative to design LTC insurance, since there are more than 20 years of experienced data available and strict review process for CI. Moreover, we have considered stochastic models and population projection methods to predict the future LTC population in Taiwan based on the proposed criteria.

The analysis results show that the combination of the fixed prevalence rates and population figures from NDC, which has been used by most of the studies in the past, producing the most conservative projection results. On the other hand, if the prevalence rates are predicted by the LC model in the preceding approach, the projection results would therefore be the highest. This suggests that using the prevalence rates only is likely to be unstable. As a result, we have then opted for the projection results through modelling the incidence and mortality rates or using the CCR method, and these two methods yield closer projection results. However, the annual increment of projected LTC population derived from these two methods is at least 5%, faster than the speed of the average GDP (Gross Domestic Product) and CPI (Consumer Price Index) in Taiwan, while the latter two are around 2% and 3%. This indicates that the financial burden of LTC social insurance is excessively heavy under a pay-as-you-go scheme. The burden will become even more pressing if we were to include the needs of aging and mental illness.

We can also use the CI experienced data to explore the spatial properties of LTC population. There exists a clear and positive correlation between different years of LTC incidence rates and mortality rates of LTC population at the county/township level. Moreover, the testing results of Moran's I demonstrate strong signs of spatial inhomogeneity, and the spatial analysis could be applied to explore if there are areas with higher LTC demands, i.e., hot spots. Although we have found that the LTC demand and supply grow in the same direction from further analysis, it seems that the supply is unable to keep pace with the demand. We suppose that the financial burden of LTC insurance is not the only concern, and further consideration regarding the sufficiency of LTC services' supply is required. While family remains the primary source of LTC labor in Taiwan, the projected LTC population reaching 2 million or 10% of the total population by 2040 (according to the CCR method in Figure 8) suggests that the introduction of foreign labor or exploration of alternative solutions would inevitably become necessary.

The rapidly increasing LTC population in Taiwan is mainly due to the population aging, or the combination of decreasing fertility rates and reducing mortality rates. These two factors could be commonly observed not only in Asia but also in many developing countries. However, a pay-as-you-go scheme is not ideally suited for LTC and pension insurance in the presence of significant population aging. Also, there will still be problems even with a fully funded or partially funded system for LTC insurance, as life expectancy still needs to be addressed (i.e., similar to the challenge of longevity risk). Although there are quite a lot of tools available to predict life expectancy, such as stochastic models, the accuracy and stability of prediction remain unknown. For example, the estimates of parameters in the LC model can differ a lot if we use data from the past 40 years compared to data from the past 20 years.

Increasing LTC demand is a global problem, and Taiwan is not the only country facing the challenge. We are able to enjoy the longest life expectancy in history; however, this also means that we are ignorant about life at higher ages. We have only been aware that certain conditions require LTC services, such as Alzheimer's disease and other forms of dementia, cancer, and mental disorders, and we are uncertain about the emergence of other conditions as we live longer. Finally, referring to the studies of longevity risk, questions like “who should be responsible for those who live longer” might be raised. Perhaps both individuals and governments should collectively be responsible for those who live longer and their LTC needs, but the key issue lies in whether we can afford this financially.

Appendix 1. Judging Criteria of LTC Insurance

Category	Description of Catastrophic Illness
1	Cancer
4	Chronic Renal Failure
5-3	Rheumatoid Arthritis
6-1	Senile and Presenile Organic Psychotic Conditions
12	Major Trauma
13	Patients Requiring Long-term Use of a Respirator
15	Air Embolism
16	Myasthenia Gravis
18	Spinal Cord Injury
20	Cerebrovascular Disease (Acute)
21	Multiple Sclerosis
28	Motor Neurone Disease
29	Creutzfeldt-Jakob Disease

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