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IFAC PapersOnLine 51-11 (2018) 1004–1009

Planning the home and facility-based care dynamics using the multiple decrement approach: The case study for Slovenia

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Abstract: Physical environment, especially urban facilities that are age-friendly are of particular importance for those growing older. Investments in facilities and changes in the environment can lower the disability threshold and travelling costs for caregivers and other suppliers. It influences the needs for care in each category of dependency, measured by care dependency scale. The good planning of a Home Health Care Structure requires a resolution of several complex challenges, dependent on dynamics of the rapid ageing of the European population. Therefore the spatial interaction model developed individually for each group of functional capacity can improve the forecast of overall dynamics of the structure according to age cohorts of older persons in care, and optimise investments in home care systems and other facilities in the framework of regional and urban spatial planning. The method for calculation of expected future structure of cohorts and human resources required for the care of older adults which are dependent on the help of others is given. As a novelty, the actuarial present value of lifetime care costs is a subject of criterion function at a given life expectancy. Here the disability thresholds are determined in a given environment, and the needed capacities are forecasted using the asymmetric Lowry-like gravity model associated with the multi-state transition approach. The numerical example shows how we can plan the dynamics of needed investments in facilities and human resources based on the forecasted structure of care dependency categories if some new financial mechanisms for seniors are available and the tax system is friendly to older cohorts.

Keywords: urban facilities, multi-state transition model, gravity model, human resources

The authors acknowledge the project PLANNING THE HOME AND FACILITY-BASED CARE DYNAMICS USING THE MULTIPLE DECREMENT APPROACH, ID Z7-7501 was financially supported by the Slovenian Research Agency

1. INTRODUCTION

In the context of ageing societies, the importance of Long-Term Care (LTC) is growing in all EU countries, where spending on long-term care as a share of GDP rises with the share of the population that is over 80 years old. Trends in severe disability among elderly populations across OECD countries are increasing rapidly, and the number of elderly that need assistance in carrying out activities of daily living is also growing. By 2050 it is projected to be three times higher than today (OECD, 2017). The needs of senior citizens may be satisfied if the supply networks and housing stock are specifically designed to meet their physical, emotional, recreational, medical, and social needs, but these needs are not included in the national housing programs in many countries, neither in Slovenia, prepared by Slovenian Ministry of the environment and spatial planning in 2015.

The LTC is a range of services required by persons with a reduced degree of functional capacity, physical or cognitive, and who are consequently dependent for an extended period of time on help with basic activities of daily living (ADL), such as bathing, dressing, eating, getting in and out of bed or chair, moving around and using the bathroom. This is frequently provided in combination with basic medical services. Long-term care services also include lower-level care related to help with instrumental activities of daily living (IADL), such as help with housework, transportation and similar. Long-term care can be received in institutions or at home", dependent on the level of functional decline, availability of the proper housing and other facilities and financing mechanisms which support the living standard of seniors (OECD, 2017). In case of home care, one of the main costs is transportation costs. The good planning and implementation of LTC services, especially Home Health Care (HHC), requires the resolution of several complex challenges. In the literature review of Di Mascolo et al. (2017), the authors gave an overview of current work dealing with planning activities in HHC structures and more particularly routing and scheduling of caregivers who can present up to 80% of all costs.

Falls have a major impact on the costs of health care among older adults and on migration to nursing homes as described by Hoffman et al. (2017). According to Nicklett et al. (2017) neighbourhood environment has a major impact on the incidence of falls among community-dwelling older adults. One of a possible solution to mitigate the risk of fall is a

Peer review under responsibility of International Federation of Automatic Control.
10.1016/j.ifacol.2018.08.476

migration to retirement village (Hu et al., 2017). Deciding between staying at home or moving was studied by Roy et al. (2018). Claudia Wood (2017) compares the UK statistics regarding the probability of fall in family homes and retirement communities. In her study (Wood, 2017) she states that there is not yet developed a proper model for determining the social value of retirement communities.

Therefore, we aim to give a first systematic approach to estimating the social value of retirement communities. The objective of this paper is to introduce the model of multistate transitions in housing for older cohorts (Bogataj et al., 2015) and connect it with Lowry-like gravity model (Drobne and Bogataj, 2012, 2015) where investments and fiscal policy are considered an important factor of attractiveness (Janež et al., 2016; Drobne and Bogataj, 2017) and the reverse mortgage embedded in the model increase the purchasing power and therefore the choice of users (Bogataj and Bogataj, 2015).

2. THE MODEL

2.1 Multiple decrements model

As the central objective, the multiple decrement approach is developed based on Care Dependency Scale (CDS) and applied in the spatial planning of housing and accompanying services needed for older citizens over their lifetime horizon. Required category of care depends on the built environment in our case on the type of dwellings which influences independence and autonomy of resident with declined physical functional capacities.

An example: Older adult in a wheelchair can even with impaired mobility live autonomously and can move independently in his apartment and surrounding of the building if the apartment has wide enough corridors and doors that he can enter an apartment and that he can enter in each room with a wheelchair. An apartment building needs to have an elevator, large enough that wheelchair can enter the elevator. There should not be barriers to stairs so that older adult in a wheelchair can enter the building from the outside. Surrounding of the building should not have barriers so the older adult can have access to shops and recreational areas and public transport needs to be adopted for the use of a person with a wheelchair.

Care intensity is estimated for each criterion from totally dependent, partially dependent, almost independent, or completely independent of care (Dijkstra et al., 2012). Regarding the level of reduced ability of self-sufficiency, it would be necessary to establish a unified categorisation of the older citizens for their ability to autonomous life and self-care capacity and associate them with suitable or relevant types of dwellings and other facilities as well as the intensity of care. Statistical monitoring of the level of autonomy and related facilities as well as human resources for support activities would improve the proper planning of types of dwellings and other facilities as well as required education of human resources in the studied municipality. On this basis, we can observe and further forecast the period of life of inhabitants that is spent in each category and on this base the further investments in built environment and other facilities can be forecasted. To this structure, the appropriate type of accommodation and related facilities can be determined separately for each category. This means that we shall take CDS and score for measuring the needs and dependence on others, which is used in planning for assistance in social welfare institutions, and apply it to the entire population of persons older than 65 years who are more or less dependent on others. To the number of seniors in each category, we shall add the results of net migrations achieved by the Lowry-like model, structured by the same categories. We have to develop further the projections according to the proper multistate transition model and adopt the program for (a) building proper facilities and (b) acquiring the human resources (educating the human resources). Figure 2 presents a graph of the transition model.

The transitions are successive according to the intensity of care and related housing: i=0: family housing unit without special facilities for seniors and with residents without need for care, where residents live with such functional capabilities that are autonomous (REH); i=1: homecare in existing home (HCEH); i=2: assisted living (ALSS, ALSU, ALGL); and i=3: nursing home (NH); i=4 dead. Here we introduced the following notation: i is the type of facility in which the resident is currently residing (i = 0 to 4); j is the type of facility in which the resident moves due to declining functional ability (resettlement from the type of facility i to j; j = 1 to 5).

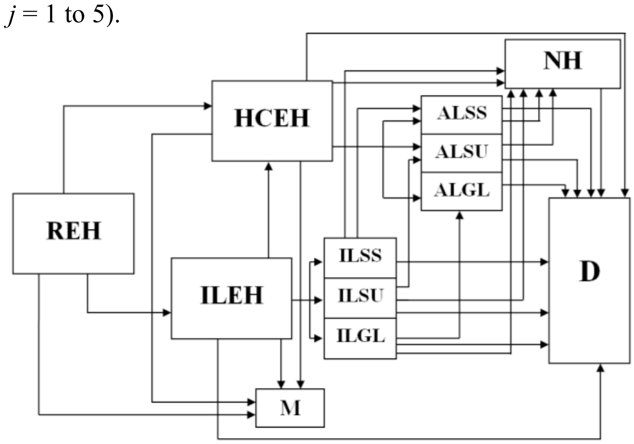

Fig. 2: The graph of different paths between different types of dwellings from existing home (EH) to nursing home (NH) in multiple decrement model

Notation:

Dwellings	Notation	Independent	Assistance
Family home - Existing Home	REH	ILEH	HCEH
Segregation in Retirement community	SS	ILSS	ALSS
Integration in urban society	SU	ILSU	ALSU
Suburban ground-level apartment*	GL	ILGL	ALGL
Nursing Homes	NH		
Migration from the town	M		
Dead	D		

* and other accessible dwellings outside the city centre close to existing homes

The details of the migrations can be modelled as a directed graph, as presented in figure 2. By observing all the possible paths from the initial state 0, through the transition to different types of dwelling in different care environments (transition nodes in the graph). Based on the demographic statistics, one can calculate the expected needs of older citizens in the study area. Such transitions can be financed by personal insurance products, properly developed reverse mortgages schemes or on the bases of national insurance schemes. To successfully forecast the different dwelling needs of seniors based on decreasing functional capacities of residents and effective demand, we must know the probability distribution of $T_i(x)$, the time that a senior resident will spend in the dwelling of type i, $i \in$H. In multiple decrement model, we have m dwelling options where an insured older adult can move after a substantial decline in his/her functional capacities. In the housing system, there are m different types of dwellings where a senior resident can move. Therefore all together there are m+1 different types of dwelling in the system.

We suppose that resident moves to the type of dwelling that optimally suits his/her functional capacities. The model has four groups of dwellings with different services: existing family home (ILEH, HCEH), independent living facilities (ILSS, ILSU, ILGL), assisted living facilities (ALSS, ALSU, ALGL) and nursing home (NH). The probability of transition in the model should be calculated by observations of moving from one dwelling type to another. We denote the initial state as state 0 and decrement, which requires dwelling of type j by the line of the graph from this child node to the state j, j = 1, 2,…, m. In a multiple-decrement setup, transitions between any two states, from i to j, $i > j$=1, 2,…, m, are not possible (directed graph). However, in a multi-state transition, we can also assume such transitions (see the basics in Gerber, 1997; and advanced solutions in Deshmukh, 2012).

The probability $q_x^{(i,j)}$ of moving from the facility of type i to facility type j due to declining functional ability for occupant age x is written by:

$$q_x^{(i,j)} = \frac{M_x^{(i,j)}}{S_x^{(i)}}; \qquad j = 1,2,3,4; \qquad j > i \tag{1}$$

Where $M_x^{(i,j)}$ is the number of residents that move from i to j, and $S_x^{(i)}$ is the total number of residents who were previously living in i-1 or came from other municipalities. Here $p_x^{(i)}$ is probability to stay in the dwelling. The final allocation of residents by type of facility for each cohort (x years old) in the year τ is described by the following matrix, as the transition based on Allignol et al. (2011) and Sieber et al. (2012), now adapted to the given built environment:

$$\mathbf{P}_{x,\tau} = \begin{bmatrix} p_x^{(0)} & q_x^{(0,1)} & q_x^{(0,2)} & q_x^{(0,3)} & q_x^{(0,4)} & q_x^{(0,5)} \\ 0 & p_x^{(1)} & q_x^{(1,2)} & q_x^{(1,3)} & q_x^{(1,4)} & q_x^{(1,5)} \\ 0 & 0 & p_x^{(2)} & q_x^{(2,3)} & q_x^{(2,4)} & q_x^{(2,5)} \\ 0 & 0 & 0 & p_x^{(3)} & q_x^{(3,4)} & q_x^{(3,5)} \\ 0 & 0 & 0 & 0 & p_x^{(4)} & q_x^{(4)} \end{bmatrix}_\tau \tag{2}$$

and vector ${}_{(i)}S_{x,\tau}$ as the sum of the number of residents moving in the cohort from the lower state in the facilities of this municipality $ZS_x^{(i)}$ in the year τ plus net migration into i-the cohort $NM_x^{(i)}$ in the same year is

$$\mathbf{S}_{x,\tau} = \begin{bmatrix} S_x^{(0)} & S_x^{(1)} & S_x^{(2)} & S_x^{(3)} & S_x^{(4)} \end{bmatrix}_\tau = \begin{bmatrix} ZS_x^{(0)} & ZS_x^{(1)} & ZS_x^{(2)} & ZS_x^{(3)} & ZS_x^{(4)} \end{bmatrix}_\tau + \\ + \begin{bmatrix} NM_x^{0} & NM_x^{(1)} & NM_x^{(2)} & NM_x^{(3)} & NM_x^{(4)} \end{bmatrix}_\tau \tag{3}$$

Allocation of residents by type of facility for the studied cohort in the year τ+1 y (when they are x+1 years old) we can calculate:

$$\mathbf{S}_{x+1,\tau+1} = \mathbf{S}_{x,\tau}\mathbf{P}_{x,\tau} = \\ = \begin{bmatrix} S_x^{(0)} & S_x^{(1)} & S_x^{(2)} & S_x^{(3)} & S_x^{(4)} \end{bmatrix}_\tau \cdot \begin{bmatrix} p_x^{(0)} & q_x^{(0,1)} & q_x^{(0,2)} & q_x^{(0,3)} & q_x^{(0,4)} & q_x^{(0,5)} \\ 0 & p_x^{(1)} & q_x^{(1,2)} & q_x^{(1,3)} & q_x^{(1,4)} & q_x^{(1,5)} \\ 0 & 0 & p_x^{(2)} & q_x^{(2,3)} & q_x^{(2,4)} & q_x^{(2,5)} \\ 0 & 0 & 0 & p_x^{(3)} & q_x^{(3,4)} & q_x^{(3,5)} \\ 0 & 0 & 0 & 0 & p_x^{(4)} & q_x^{(4)} \end{bmatrix}_\tau = \\ = \begin{bmatrix} S_{x+1}^{(0)} & S_{x+1}^{(1)} & S_{x+1}^{(2)} & S_{x+1}^{(3)} & S_{x+1}^{(4)} \end{bmatrix}_{\tau+1} \tag{4}$$

S is subject to parameters in Lowry-like gravity model, where taxation policy and subventions are included (Janež et al., 2016). Norms and standards of required human resources per capita of seniors in EC for given type of housing including other facilities are described by vector H:

$$\mathbf{H} = \begin{bmatrix} H^{(0)} & H^{(1)} & H^{(2)} & H^{(3)} & H^{(4)} \end{bmatrix}^T \tag{5}$$

The tradeoff between facilities and human resources can be subject to additional study. The dynamics of required human resources for EC in the studied urban area we calculate according to the following formula:

$$HR = \sum_{x=65}^{110} \left\{ \begin{matrix} \begin{bmatrix} ZS_x^{(0)} & ZS_x^{(1)} & ZS_x^{(2)} & ZS_x^{(3)} & ZS_x^{(4)} \end{bmatrix} + \\ + \begin{bmatrix} NM_x^{(0)} & NM_x^{(1)} & NM_x^{(2)} & NM_x^{(3)} & NM_x^{(4)} \end{bmatrix} \end{matrix} \right\} \cdot \mathbf{H} \tag{6}$$

2.2 Actuarial model of LTC insurance

We will use the following notation (Gerber, 1997):

P_x^{LTC}	single premium for LTC insurance for person x years old;
$P_{x:h\rceil}^{LTC}$	yearly premium for LTC insurance for person x years old payable for h years (coverage for LTC claims starts at $x+h$ years of age);
e_x	Life expectancy of person x years old;
$LTC\ddot{a}_x$	actuarial present value of lifetime expenditures for LTC services for person x years old;
γ_2	percentage of the administrative fee that insurance company charges for each payment of benefit;
γ_1	percentage of the administrative fee that insurance company charges at each payment of premium;
${}_j p_x$	Probability: x years old will survive j years;
$p_x^{LTC(k)}$	the probability that person x years old is in the category of care k;
c_k	yearly expenditure for LTC in category k;
i	interest rate;
$\upsilon = \frac{1}{1+i}$	discounting factor

Actuarial present value of lifetime care expenditures for covering LTC services for older adult x years old is

$$LTC\ddot{a}_x = (1+\gamma_2) \cdot \sum_{j=0}^{100-x} {}_j p_x \cdot \upsilon^j \cdot \left(p_{x+j}^{LTCI} \cdot c_1 + p_{x+j}^{LTCII} \cdot c_2 + p_{x+j}^{LTCIII} \cdot c_3 \right)$$

If the society wants to minimise LTC costs, we have to introduce a policy for urban development and investments in the urban age-friendly environment under the condition of minimisation of the actuarial present value of lifetime care costs $\min(LTC\ddot{a}_x)$ at the constraint that longevity e_x does not decrease.

Single premium for lifetime LTC insurance for person x years old is:

$$P_x^{LTC} = (1+\gamma_2)\cdot LTC\ddot{a}_x =$$
$$= (1+\gamma_2)\cdot \sum_{j=0}^{100-x} {}_j p_x \cdot \upsilon^j \cdot \left(p_{x+j}^{LTCI}\cdot c_1 + p_{x+j}^{LTCII}\cdot c_2 + p_{x+j}^{LTCIII}\cdot c_3\right) \quad (7)$$

Therefore, we have to introduce a policy for urban development and investments in the built environment under the condition $\min(LTC\ddot{a}_x)$ at the constraint that longevity e_x does not decrease.

Yearly premium for LTC insurance for person x years old where the premium is payable h years – in working period:

$${}^bP_{x:h|}^{LTC} = \frac{{}_h p_x \cdot \upsilon^h \cdot (1+\gamma_2)\cdot LTC\ddot{a}_{x+h}}{(1-\gamma_1)\cdot \sum_{j=0}^{h-1} {}_j p_x \cdot \upsilon^j} =$$

$$= \frac{{}_h p_x \cdot \upsilon^h \cdot (1+\gamma_2)\cdot \sum_{j=0}^{100-(x+h)} {}_j p_{x+h} \cdot \upsilon^j \cdot \left(p_{x+h+j}^{LTCI}\cdot c_1 + p_{x+h+j}^{LTCII}\cdot c_2 + p_{x+h+j}^{LTCIII}\cdot c_3\right)}{(1-\gamma_1)\cdot \sum_{j=0}^{h-1} {}_j p_x \cdot \upsilon^j} \quad (8)$$

3. THE CASE STUDY FOR SLOVENIAN LTC EXPENDITURES BASED ON THE 2018 AGEING REPORT

Based on the demographic data and mortality tables from The 2018 Ageing Report (European Commission, 2017) and data reported in 2017 from nursing homes in Slovenia, which would need to be collected on the national level, the transition matrix could be written. Let us say that structure of residents 80 years old by type of facility for each cohort (x years old; x=80) is written by the following vector S_x as the sum of internal reallocations and the net migrations of cohort:

$$S_x = \begin{bmatrix} S_x^{(0)} & S_x^{(1)} & S_x^{(2)} & S_x^{(3)} & S_x^{(4)} \end{bmatrix} = \begin{bmatrix} 21.510 & 390 & 230 & 436 & 71 \end{bmatrix} +$$
$$+ \begin{bmatrix} 20 & 19 & 13 & 102 & 60 \end{bmatrix} = \begin{bmatrix} 21.530 & 409 & 243 & 538 & 131 \end{bmatrix}$$

$$\mathbf{P}_{80}^{2015} = \begin{bmatrix} p_x^{(0,\tau)} & q_x^{(0,1)} & q_x^{(0,2)} & q_x^{(0,3)} & q_x^{(0,4)} & q_x^{(0,5)} \\ 0 & p_x^{(1,\tau)} & q_x^{(1,2)} & q_x^{(1,3)} & q_x^{(1,4)} & q_x^{(1,5)} \\ 0 & 0 & p_x^{(2,\tau)} & q_x^{(2,3)} & q_x^{(2,4)} & q_x^{(2,5)} \\ 0 & 0 & 0 & p_x^{(3,\tau)} & q_x^{(3,4)} & q_x^{(3,5)} \\ 0 & 0 & 0 & 0 & p_x^{(4,\tau)} & q_x^{(4,5)} \end{bmatrix}_{2015} =$$

$$= \begin{bmatrix} 0,98164 & 0,00162 & 0,00167 & 0,00172 & 0,00176 & 0,01159 \\ 0 & 0,83415 & 0,04867 & 0,05111 & 0,05355 & 0,01252 \\ 0 & 0 & 0,9035 & 0,03993 & 0,04405 & 0,01252 \\ 0 & 0 & 0 & 0,76037 & 0,22711 & 0,01252 \\ 0 & 0 & 0 & 0 & 0,8344 & 0,16560 \end{bmatrix}$$

Allocation of residents by type of facility for the studied cohort in the following year (when they are x+1 year old) we can calculate:

$$\mathbf{S}_{81}^{2015} = \mathbf{S}_{81}^{2015}\mathbf{P}_{81}^{2015} = \begin{bmatrix} S_{81}^{(0)} & S_{81}^{(1)} & S_{81}^{(2)} & S_{81}^{(3)} & S_{81}^{(4)} \end{bmatrix}_{2016}$$

Norms and standards of required human resources for elder care for each type of facilities is described by vector H:

$$\mathbf{H} = \begin{bmatrix} H^0 & H^1 & H^2 & H^3 & H^4 \end{bmatrix}^T = \begin{bmatrix} 0 & 0.1 & 0.2 & 0.3 & 0.5 \end{bmatrix}^T$$

The required human resources for eldercare in the studied urban area we calculate according to following formula:

$$HR(80) = S_x H = \left[S_x^0\ S_x^1\ S_x^2\ S_x^3\ S_x^4\right]_{\tau+1} H =$$
$$= [21135\ 376\ 275\ 476\ 302][0\ 0.1\ 0.2\ 0.3\ 0.5] = 387$$

It means that in such case 387 workers in LTC will be needed to serve the 80 years old inhabitants in the municipalities. Summarizing the results for all age cohorts we can also calculate a total number of required human resources for the next year and further gradually for all time horizon. In Slovenia, there is not enough capacity in nursing homes to provide for all persons that applied for nursing homes (from publications of Institute of macroeconomic analysis and development – Urad RS za makroekonomske analize in razvoj, UMAR, 2014)

According to different sources of data, we can see that we have 17,783 nursing home residents older than 64 years at the end of 2016 (data provided by Slovenian national health institute – Zavod za zdravstveno zavarovanje Slovenije ZZZS, 2017), 7,100 home care users at the end of 2015 and 6,417 applicants for a nursing home in 2016 (data provided by Association of social institutions – Skupnost socialnih zavodov Slovenije SSZS, 2017). Based on the data of ZZZS for the year 2016, we have calculated the probability that person in the certain cohort will be dependent on the help of others in the certain category of care. In a population of older adults (65+-year-old) in Slovenia at the end of 2016 was 380,102 persons: no. of male 157,527 and no. of female 222,575 (data provided by National Statistical Office – Statistični urad Republike Slovenije, SURS).

According to the study of the Slovenian Social Protection Institute – Inštitut RS za socialno varstvo, IRSSV (2015), there were 883 assisted living housing units in Slovenia in the year 2014, and according to the research done by authors till 2017, the number has increased to 933. According to data provided by SSZS, there were 20,602 beds in nursing homes in September 2017 in Slovenia. Currently, capacities in assisted living facilities present less than 5% of capacities in nursing homes in Slovenia.

Currently, we have available only yearly data regarding institutional care in the nurse homes, separately by age, gender and category of nursing care from I to III. We have added to this data the number of persons in home care and number applications for institutional care. We have calculated the probabilities that the senior dependent on help of others will be in the certain category of care.

Table 1: Number of users and applications of LTC in Slovenia (age 65+)

	Indepen-dent	Homecare users 31.12.2015	Applicants 12.9.2017	Nursing homes residents 31.12.2016
Male	149,677	1,781	1,609	4,460
Female	199,125	5,319	4,808	13,323
Total	**348,802**	**7,100**	**6,417**	**17,783**
	91.8%	**1.9%**	**1.7%**	**4.7%**

Table 2: Probability of being in category I-III

Age	Indep-endent	Nursing home		
		dependent cat I	dependent cat II	dependent cat III
65	0,9895	0,0011	0,0004	0,0045
75	0,9585	0,0048	0,0015	0,0173
85	0,7915	0,0256	0,0077	0,0852
95	0,2694	0,0920	0,0230	0,3001

Table 3: Probability that older person will be dependent on the help of others and will need care in a certain category.

Age	Estimate demand for LTC		
	dependent cat I	dependent cat II	dependent cat III
65	0,0019	0,0007	0,0079
75	0,0085	0,0026	0,0304
85	0,0451	0,0135	0,1499
95	0,1618	0,0405	0,5283

Table 4: Category of care - State probability matrix

Age	Male population				Female population			
	Indepen-dent	Dependent			Indepen-dent	Dependent		
		Cat I	Cat II	Cat III		Cat I	Cat II	Cat III
65	0.989	0.002	0.001	0.008	0.992	0.001	0.001	0.008
75	0.970	0.009	0.002	0.026	0.965	0.008	0.003	0.034
85	0.888	0.031	0.008	0.102	0.810	0.051	0.016	0.172
95	0.662	0.106	0.012	0.307	0.362	0.175	0.047	0.580

Table 5: Home care users from 1998 to 2015 in Slovenia

Year	Home care users	Year	Home care users
1998	3.909	31. 12. 2011	6.624
2002	4.590	31. 12. 2014	6.888
2004	4.732	31. 12. 2015	7.100
2007	5.595		

To cover expenses for optimal adaptation of housing and services to declining functional capacities, for the cohorts with parameters are given in tables 1-5, the insurance product for LTC is advised as developed in chapter 4.

4. SIMULATION OF DEVELOPMENT OF ASSISTED LIVING FACILITIES

If municipalities in Slovenia developed 7000 units together in assisted living (AL) facilities to satisfy the demand for long-term care in community there would be a possibility to reallocate 4.842 residents from nursing homes (NH) to assisted living facilities and nursing homes would be able to accept 4.670 applicants of category III from the waiting list (WL). Remaining 1.747 applicants from the waiting list (categories I and II) would become residents in the assisted living facilities.

Table 6: Simulation of reallocation of older adults between different types of dwellings

From (Cat, location)	Before reallocation	I, II NH	I, II WL	III WL	After reallocation
To (loc.)		AL	AL	NH	
Independent	348,156				348,156
Home care	7,100				7,100
Waiting list	6,417		-1,747	-4,670	0
Assisted living	646	4,842	1,747		7,235
Nursing homes	17,783	-4,842		4,670	17,611
Population in Slovenia (age 65+)	**380,102**	**0**	**0**	**0**	**380,102**

Table 7: State probability matrix after reallocation

Age	Male population				
	Indepen-dent	Dependent			
		Cat I-III HC	Cat I AL	Cat II AL	Cat III NH
65	0.989	0.003	0.002	0.001	0.006
75	0.970	0.009	0.008	0.002	0.020
85	0.888	0.032	0.027	0.006	0.079
95	0.662	0.096	0.090	0.010	0.237
Age	**Female population**				
	Indepen-dent	**Dependent**			
		Cat I-III HC	**Cat I AL**	**Cat II AL**	**Cat III NH**
65	0.989	0.002	0.001	0.000	0.006
75	0.970	0.010	0.007	0.003	0.026
85	0.888	0.054	0.044	0.014	0.133
95	0.662	0.182	0.148	0.040	0.449

5. CASE STUDY OF THE LTC ANNUITY

Let us suppose that person dependent on the help of others needs the intensity of care as presented in Table 8.

Table 8: Yearly expenditure for LTC – based on intensity and expenditure for social care

Cat.	Intensity of care		EUR per			
	Hours/ day	Min/ Day	hour*	day	month	year
I	0.75	45	16	12	360	4,320
II	1.25	75	16	20	600	7,200
III	1.75	105	16	28	840	10,080

*Source: SSZS – Association of Social institutions (*data of Applicants and amount per day)*

Here is calculated the single premium for LTC insurance for men 65 years old from cohorts with demographic characteristics of inhabitants in Slovenia for LTC annuity with the actuarial present value $LTCa_{65}$. Benefits are paid after age 65 when a person becomes dependent on the help of others. Single premium for lifetime LTC insurance for men 65 years old:

$$P_{65}^{LTC} = \left(1+\gamma_2\right)\cdot LTC\ddot{a}_{65} =$$
$$= \left(1+\gamma_2\right)\cdot \sum_{j=0}^{100-65} {}_j p_{65}\cdot \upsilon^j \cdot \left(p_{65+j}^{LTCI}\cdot c_1 + p_{65+j}^{LTCII}\cdot c_2 + p_{65+j}^{LTCIII}\cdot c_3\right) =$$
$$= \left(1+0.05\right)\cdot \sum_{j=0}^{100-65} {}_j p_{65}\cdot \upsilon^j \cdot \left(p_{65+j}^{LTCI}\cdot 4{,}320 + p_{65+j}^{LTCII}\cdot 7{,}200 + p_{65+j}^{LTCIII}\cdot 10{,}080\right) =$$
$$= \left(1+0{,}05\right)\cdot 6{,}426.57 = 6{,}747.90€$$

6. CONCLUSIONS

Based on the demographic data (The 2018 Ageing report and the national statistics) and projections considering Lowry-like model and multistate transition model as well as the current taxation in Slovenia a new insurance product can be launched on the market which will enable to adopt the available residential units to declining functional capacities and needs of seniors in Slovenia. This new tool will enable better forecasting of dynamics of the care, logistics, and housing as a function of age for senior citizens with decreasing functional capacities. This will enable more accurate calculations of contribution rates and insurance premiums for public and private long-term care insurance providers in the context of changing the level of services and housing needs over the lifetime horizon of senior citizens.

There is a reason to expect that more proper age-friendly environment and community care would increase life expectancy and reduce the cost of care. But we can expect an increase in LTC premiums. So, further studies of risks mitigated by LTC insurance and longevity insurance embedded in a reverse mortgage is proposed. Further study regarding social value of sheltered housing and its influence on urban land rent is proposed, especially in connection with the influence of sheltered housing and assisted living facilities on health and health-related expenditures of residents.

REFERENCES

Allignol, A., Schumacher, M., and Beyersmann, J. (2011) Empirical Transition Matrix of Multi-State Models *Journal of Statistical Software* 38(4), 1–15.

Bogataj, D. and Bogataj, M. (2015). Housing equity withdrawal in the portfolio choice for deferred pension income. *International journal of social sciences and humanities invention*, 2(7), 1459–1473.

Bogataj, D., Ros McDonnell, D., and Bogataj, M. (2016). Management, financing, and taxation of housing stock in the shrinking cities of ageing societies. *International Journal of Production Economics*, 181(SI:2–13).

Bogataj, D., Ros-Mcdonnell, D., and Bogataj, M. (2015). Reverse mortgage schemes are financing urban dynamics using the multiple decrement approach. *Springer proceedings in mathematics & statistics,* 135, 27–47.

Deshmukh, S. (2012). *Multiple Decrement Models in Insurance*, An Introduction Using R, Springer. 219 pg.

Di Mascolo, M., Espinouse, M.L., and El Hajri, Z. (2017). Planning in Home Health Care Structures: A literature review, *IFAC PapersOnLine* 50-1, 4654–4659.

Dijkstra, A., Yönt, G.H., Korhan, E.A., Muszalik, M., Kędziora-Kornatowska, K., and Suzuki, M. (2012). The care dependency scale for measuring basic human needs. *Journal of advanced nursing*, 68 (10), 2341–2348.

Drobne, S. and Bogataj, M. (2012). A method to define the number of functional regions: An application to NUTS 2 and NUTS 3 levels in Slovenia. *Geodetski vestnik,* 56(1), 105–150.

Drobne, S. and Bogataj, M. (2014). Regions for Servicing Old People: a Case study of Slovenia. *Business Systems Research Journal,* 5(3), 19–36.

Drobne, S. and Bogataj, M. (2015). Optimal allocation of public service centers in the central places of functional regions. In: Dolgui, A. et al. (eds), INCOM 2015, *IFAC-PapersOnLine,* 48(3), 2362–2367.

Drobne, S. and Bogataj, M. (2017). The impact of public investments in facilities on the potential housing market for older persons. *Facilities,* 35(7/8), 422–435.

European Commission. (2017). *The 2018 Ageing Report: Underlying Assumptions and Projection Methodologies*. https://ec.europa.eu/info/publications/economy-finance/2018-ageing-report-underlying-assumptions-and-projection-methodologies_en

Gerber, H.U. (1997) *Life Insurance Mathematics,* Swiss Association of Actuaries Zürich, Springer. 211 pg.

Hoffman, G.J., Hays, R.D., Shapiro, M.F., Wallace, S.P., and Etter, S.L. (2017). The costs of fall-related injuries among older adults: annual per-faller, service component, and patient out-o-pocket costs. *Health Services Research*, 1794–1816.

Hu, X., Xia, B., Skitmore, M., Buys, L., and Hu, Y. (2017). What is a sustainable retirement village? Perceptions of Australians developers. *Journal of Cleaner Productions*, 164, 179–186.

Janež, P. and Bogataj, M., and Drobne, S. (2016). Impact of the real estate taxation and municipal revenue on dynamics of internal migration : case study for city Municipal of Ljubljana. *Geodetski vestnik,* 60(4), 644–684.

Nicklett, E.J., Lohman, M.C., and Smith, M.L. (2017). Neighborhood Environment and falls among community-dwelling older adults. *International Journal of Environment Research and Public Health*, 14, 175.

OECD, 2017. Health Statistics 2017, http://www.oecd.org/els/health-systems/health-data.htm

Roy, N., Dubé, R., Després, C., Freitas, A., and Légaré, F. (2018). Chossing between staying at home or moving: A systematic review of factors influencing housing decisions among frail older adults. *Plos one*, 13(1), e0189266.

Siebert, U., Alagoz, O., Bayoumi, A.M., Jahn, B., Owens, D.K., Cohen, D.J., and Kuntz, K.M. (2012). State-Transition Modeling: A Report of the ISPOR-SMDM Modeling Good Research Practices Task Force-3. *Medical Decision Making*, 32(5, SI): 690–700.

Wood C. (2017). The social value of sheltered housing. *Demos*, 1–14.