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The impact of population aging on medical expenses: A big data study based on the life table

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Summary **This study shed light on the amount and structure of utilization and medical expenses on Shanghai permanent residents based on big data, simulated lifetime medical expenses through combining of expenses data and life table model, and explored the dynamic pattern of aging on medical expenditures. 5 years were taken as the class interval, the study collected and did the descriptive analysis on the medical services utilization and medical expenses information for all ages of Shanghai permanent residents in 2015, simulated lifetime medical expenses by using current life table and cross-section expenditure data. The results showed that in 2015, outpatient and emergency visits per capita in the elderly group (aged 60 and over) was 4.1 and 4.5 times higher than the childhood group (aged 1-14), and the youth and adult group (aged 15-59); hospitalization per capita in the elderly group was 3.0 and 3.5 times higher than the childhood group, and the youth and adult group. People survived in the 60-64 years group, their expected whole medical expenses (105,447 purchasing power parity Dollar) in the rest of their lives accounted for 75.6% of their lifetime. A similar study in Michigan, US showed that the expenses of the population aged 65 and over accounted for 1/2 of lifetime medical expenses, which is much lower than Shanghai. The medical expenses of the advanced elderly group (aged 80 and over) accounted for 38.8% of their lifetime expenses, including 38.2% in outpatient and emergency, and 39.5% in hospitalization, which was slightly higher than outpatient and emergency. There is room to economize in medical expenditures of the elderly people in Shanghai, especially controlling hospitalization expenses is the key to saving medical expenses of elderly people aged over 80 and over.**

Keywords: Population aging, life table, big data, lifetime medical expenses

1. Introduction

China had entered an aging society by the end of the last century. According to "2015 Statistical Bulletin of National Economy and Social Development", people aged 60 and over accounted for 16.1% (222.00 million) of the total population, and people aged 65 and over accounted for 10.5% (183.86 million) of the total population in 2015 in China (*1*). Shanghai is one of the Chinese cities where population aging emerged earliest. It showed that people aged 60 and over accounted for 30.21% (4.36 million) of Shanghai's registered population in 2015 (*2*). As age increases, health status and medical demands change correspondingly, while along with social and economic development, income improvement and medical technology progresses, the impact of population aging on medical expenses has become an enormous challenge for the healthcare system.

Healthcare demands are considerable, and growing

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with an aging population. Take Shanghai as an example, Xu (2005) found that the overall health status of elderly people was below average, 70-80% of elderly people aged 60 and over had chronic diseases, and the prevalence of the elderly was 4.2 times higher than the total (*3*).The direct consequence of high prevalence of chronic disease is mounting medical expenditures. Yan (2013) reported that the proportion of medical expenses for the elderly was 75.2% of total family medical expenses in 2006 (*4*), and Tao (2010) revealed the prevalence of chronic disease was 73.76%among the elderly in the Nanhui District of Shanghai in 2010 (*5*). A study in Hubei Province by Zhang (2015) showed similar results (*6*). Therefore, some studies took population aging as the factor driving increasing medical expenses. Huang (2012) indicated that the growth of the aging population was one of the factors leading to medical expenses soaring, especially the rising death rate in the population aged 65 and over (*7*). However, other studies found that increasing medical expenditures were affected by multiple factors, aging was one of these but not the most important one. Wang (2014) thought that aging would gently release the demands for medical services in the elderly population, but the income improving, medical insurance expanding and technology progressing would rapidly boost medical expenses (*8*). Ma (2015) realized that gender, age, marriage status and urban-rural disparities all had an appreciable impact on medical expenditure in elderly people (*9*). Yu (2011) conducted a study based on panel data from 20 provinces from 2002-2008, and found that population aging could only explain 3.9% of per capita increased medical expenses, and 5.7% of per capita increased medical expenses rates (*10*).

International research showed that the growth rate of medical expenses per capita in the elderly population was higher and increased faster than other age groups. An investigation by Cutler &Meara (1998) found that between 1953-1987, the average medical expense growth rate of people aged 65 and over was 8%, higher than the population aged 1-64 (4.7%) (*11*). Waldo &Lazenby (1984) (*12*), Buchner &Wasem (2006) (*13*) illustrated that population aging would aggravate the burden of medical expenses. The reason was that when age increased, health status got worse, which led to rising medical services demands and expenses. Reinhardt (2003) found that population aged 65 and over was 3 times more that population aged 34-44 (*14*). Lassman *et al*. (2014) drew the conclusion that medical expenses per capita in the elderly was 5 times more that the children group (*15*). Alemayehu (2004) adopted a lift table model, using cross sectional medical expenses and death data of every single individual enrolled, to construct a hypothetical current population longitudinal medical expenses data from birth to death. It was noted that from 65 and over, the expected medical expenses accounted for 1/2 of lifetime medical expenses, and females were 1/4 higher than males (*16*).

From the comparison of domestic and oversea studies, it is notable that the domestic studies had the following weaknesses: First, in regard to the data source, majority of studies are sampling surveys, few are whole sample studies, and are not able to represent the whole population. Second, in terms of the methods, most are qualitative analysis, few are quantitative studies. The statistics measurements and modeling need to be explored, especially when there is a lack of mature method references for measuring lifetime medical expenses. Moreover, some attribution studies used general regression analysis, but general regression analysis, analysis of variance or analysis of covariance do not conform to the characteristics of medical services utilization and medical expenses, since medical expenses may be a non-normal distribution.

There is a greater need for the elderly population and medical expenses evidence to support elderly policies in China. With the development of health information technology, medical big data is gradually captured, therefore exploring information to serve policy making is optimal. In regard to methodology, the internationally recognized method has matured after nearly a half century of development. It is appropriate to use a life table to conduct the study on population aging and medical expenses, and to provide evidence references for policy making. This study shed light on the amount and structure of utilization and medical expenses in Shanghai permanent residents based on big data, constructed using hypothetical "lifetime" medical expenses through a combination of life table model and cross-sectional medical expenses data, and explored the dynamic pattern of aging on medical expenses. Shanghai permanent residents refers to residents who live in Shanghai for over 6 months, while Shanghai registered residents refers to residents registered with Shanghai Public Security Bureau. In 2015, Shanghai registered residents were 24.15 million, Shanghai permanent residents were 14.43 million (*2*).

2. Data and Methods

2.1. *Data*

Data of this study was collected from the entitlement of use of the Health Information Web of Shanghai Municipal Health and Family Planning Commission Information Center. Take 5 years as the class interval, gather the medical services utilization and medical expenses information for all ages of Shanghai permanent residents in 2015. Simulate lifetime medical expenses by using current life table and cross-section medical expenses data. In the life table, take age 0-1 as a separated group from the group aged 0-4, since the medical services utilization of infants is different from other children. The data was classified by outpatient

and emergency visits, and hospitalization. All medical institutions in Shanghai were covered, including hospitals, community health centers, maternal and child health hospitals, specialized disease prevention and control institutions, and outpatient departments. In this study, the elderly group was defined as population aged 60 and over, population aged 1-14, 15-59 was defined as the childhood group, and the youth and adult group, respectively. Shanghai total population of current life table data (5 years as the class interval) in 2015 was gathered by Shanghai Center for Disease Control and Prevention Center.

2.2. *Descriptive analysis*

Take 5 years as the class interval, describe the age and gender structure of Shanghai permanent residents, and the distributions in outpatient and emergency visits, hospitalization utilization and expenses per capita.

2.3. *Life table model*

Current life table and cross-sectional medical expenses data were used to construct hypothetical lifetime medical expenses. It was assumed that the technology, prices and other factors which would affect the healthcare service costs were kept constant, therefore the disease prevalence, incidence, development process and healthcare service costs did not change for ongoing time, and the age distribution of medical expenditures could present the hypothetical lifetime distribution of medical expenditures. The advantage of a life table model is that it eliminates the impact from confounding factors, including healthcare service prices, technology development, etc.

In the lifetime medical expenses model, the lifetime expenditure per capita at a given age a, projected from birth 0, the lifetime expected cost referred to the expenditure remaining after age a to death of the hypothetical life table person. Two kinds of lifetime expected costs at birth were estimated as follows:

(1) Lifetime expected cost at birth (LECB) Per capita LECB is the lifetime expected cost divided by the original cohort of 100,000 people. Lx is the person years lived by the cohort in the age interval x. Cx is per capita medical cost at the age interval x (x = 0-, 1-, 5-, 10-, .., 90-).

It could be drawn that per capita LECB at the age interval x:

$$LECB_a=\sum_{x=a}^{95}\left(\frac{C_xL_x}{l_0}\right)$$

The relative lifetime expected cost at the age interval x (RLECB):

$$RLECB_a=LECB_a/LECB_0=\sum_{x=a}^{95}\left(\frac{C_xL_x}{l_0}\right)/\sum_{x=0}^{95}\left(\frac{C_xL_x}{l_0}\right)$$

(2) Lifetime expected cost for survivors (LECS) Per capita LECS is the lifetime expected cost divided by the cohort of people who survived at the age interval x, since some people could die before this age interval x.

We could conduct that per capita LECS at the age interval x:

$$LECS_a=\sum_{x=a}^{95}\left(\frac{C_xL_x}{l_a}\right)$$

The relative lifetime expected cost for survivors at the age interval x (RLECB):

$$RLECS_a=LECS_a/LECS_0=\sum_{x=a}^{95}\left(\frac{C_xL_x}{l_a}\right)/\sum_{x=0}^{95}\left(\frac{C_xL_x}{l_0}\right)$$

3. Results

3.1. *Demographic characteristics*

There were 24.15 million permanent residents in Shanghai in 2015. 2.17 million were the childhood group aged 0-14, which accounted for 9.00% of the total population; 17.27 million were the youth and adult group aged 15-59, which accounted for 71.50% of the total population; 4.71 million were the elderly group aged 60 and over, which accounted for 19.50% of the total population. Among the elderly group, taking 5 years as class interval, the group aged 90 and over had the least population, 0.11 million accounted for 0.43 of the total. Figure 1 shows the age and gender distribution in Shanghai population in 2015.

3.2. *Medical services utilization and expenses*

From outpatient and emergency visits point of view, the per capita visits in 2015 changed as the age went up, with multi peaks. The group aged 20-24 had the lowest per capita visits (0.81 times), which increased with rising age. After age 60, the per capita visits boosted remarkably, with per capita visits 1.6 times/month, and reached the highest value when at the group aged 80-84, with per capita visits 3.8 times/month, then slightly dropped. The per capita visits of the children, youth and adult and elderly group in 2015 were 6.0, 5.4 and 24.5 times, respectively. The number of the elderly group was 4.1 and 4.5 times higher than the children, youth and adult group.

Figure 2 represents the age and gender distribution in Shanghai per capita outpatient and emergency visits, and hospitalization in 2015, Figure 2A refers to outpatient and emergency visits, while Figure 2B refers to hospitalization. As per the figure, the per capita outpatient and emergency visits was slightly higher in the group aged 5-9, then decreased. After age 60, it was notable that the per capita outpatient and emergency visits increased fast, and kept dropping after age 80. The per capita hospitalization presented a rough "U" shape trend, with high values at the two ends and low in the middle. The per capita hospitalization of childhood, youth and adult and elderly groups in 2015 were 0.07, 0.06 and 0.21 times, respectively. The number of the

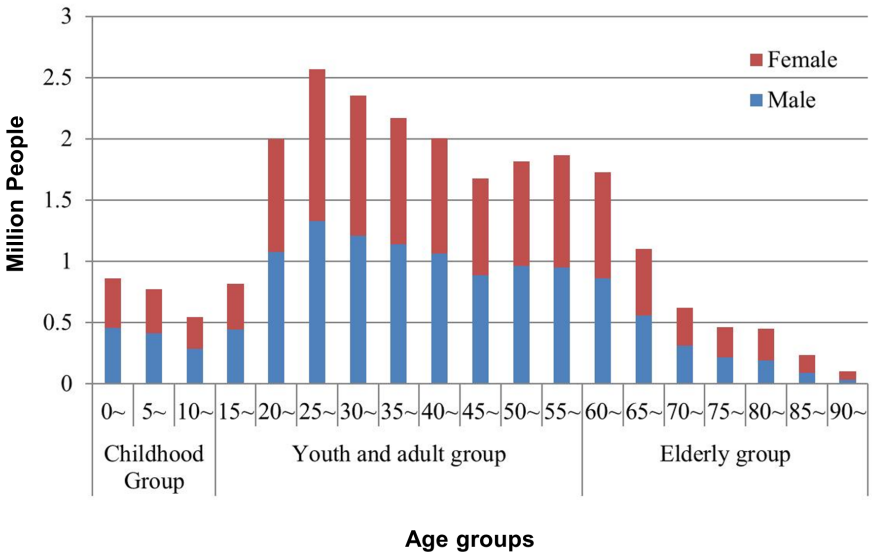

Figure 1. Shanghai population distribution by 5 year intervals and gender, in 2015 (Unit: Million people).

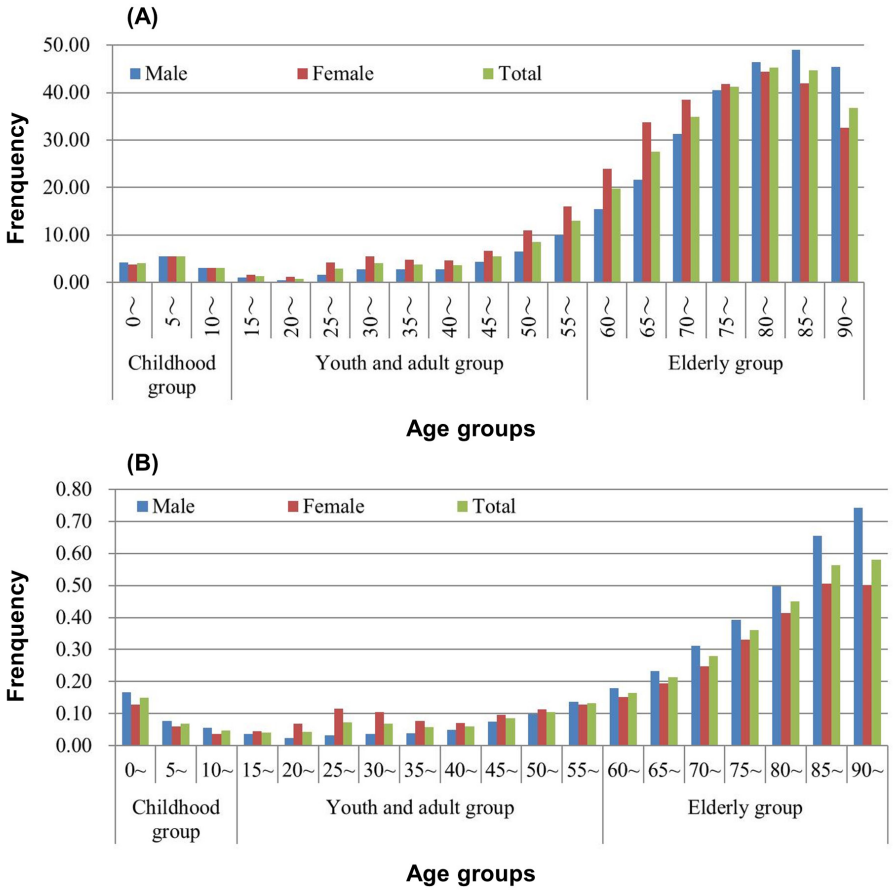

Figure 2. Shanghai per capita outpatient and emergency visits & hospitalization by 5 year intervals and gender in 2015 (Unit: Frequency). **(A),** Outpatient and emergency visits; **(B),** Hospitalization.

elderly group was 3.0 and 3.5 times higher than the children, youth and adult groups.

Figure 3 illustrates the age distribution pyramid of Shanghai permanent residents and medical expenses. It is notable that as age increases, the population shrinks, while the medical expense is distinctly increasing in general. Comparing with the permanent residents structure, the elderly population as 19.5% of total population, and accounted for 52.2% of total outpatient and emergency visits, and 45.3% discharged patients, which indicated that the elderly group consumes more medical resources. Moreover, the expenditure by age

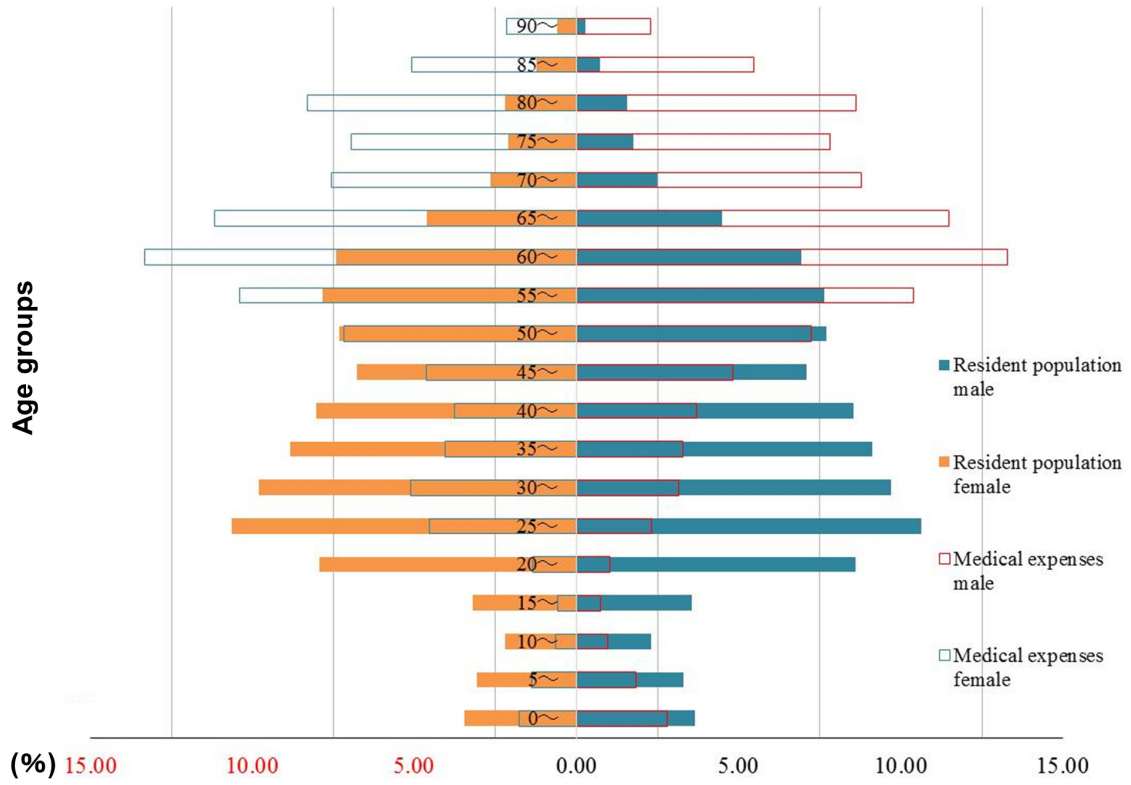

Figure 3. The age distribution pyramid of Shanghai permanent residents and medical expenses by 5 year intervals in 2015 (Unit: %).

distribution pattern had a similar tendency as services utilization by age, but a relatively higher concentration. The elderly population as 19.5% total population accounted for 63.2% of outpatient and emergency expenses, and 52.8% hospitalization expenses.

3.3. *Permanent resident lifetime expected medical costs*

3.3.1. *Outpatient and emergency*

In the life table lifetime outpatient and emergency expenses, the per capita expenses and per capita expenses of deaths were growing as age increased, in general. The tendency of per capita expenses was relatively smooth, while the tendency of per capita expenses of deaths showed a slight fluctuation. The group aged 0-1 had zero death expenses, this could be due to that most infant deaths happened in hospitalization, and in 2015 there were no infant deaths during outpatient and emergency visits.

From the results, it is worth noting that the per capita lifetime expected outpatient and emergency cost and the per capita lifetime expected outpatient and emergency cost of survivors declined as age was increasing, and the later slightly exceeded the former. It indicated that for the older group, there was less lifetime expected medical expenditure that an individual can consume. Table 1 presents the simulated results of lifetime expected outpatient and emergency costs. The per capita lifetime expected outpatient and emergency cost from birth was 81,042 purchasing power parity (PPP) Dollar, when people survived to age 60, per capita lifetime expected outpatient and emergency cost of the group aged 60-64 was 62,776 PPP Dollar.

Figure 4A shows the age group distribution of per capita medical expenses and lifetime expected costs in outpatient and emergency, and Figure 4B shows the proportion of per capita lifetime expected cost of survivors in per capita lifetime expenses. In outpatient and emergency, as age increases, the per capita expenses of both overall population and deaths roughly increased, whilst the per capita expected cost of both overall population and the survivors declined, however the per capita outpatient and emergency expenses distinctly fell in the group aged 90 and over. The proportion of per capita lifetime expected cost of survivors in per capita lifetime expected cost in group aged 60-64 was 77.5%, illustrated that when people reached the age 60-64, one individual's expenses from now to death accounted for 77.5% of this person's whole lifetime outpatient and emergency expenses, which meant that almost eighty percent of outpatient and emergency expenditures was used in the elderly period after 60.

3.3.2. *Hospitalization*

From Table 2 we can draw the conclusion that compared with outpatient and emergency, the per capita

Table 1. Simulated results of lifetime expected outpatient and emergency cost

Age groups	Survivors	Deaths	Survivor person-years*	Survivor person years in total**	Per capita outpatient & emergency expenses (PPP Dollar***)	Per capita outpatient & emergency expenses of deaths (PPP Dollar)	Outpatient & emergency medical expenses in total (PPP Dollar)	Per capita lifetime expected outpatient& emergency cost (PPP Dollar)	Per capita lifetime expected outpatient& emergency cost of survivors (PPP Dollar)
0~	100,000	483	99,604	8,292,764	303	0	30,204,233	81,042	81,042
1~	99,517	185	397,699	8,193,160	303	620	120,599,540	80,740	81,130
5~	99,332	89	496,440	7,795,461	427	28	212,186,402	79,534	80,068
10~	99,243	98	495,974	7,299,021	262	43	129,752,788	77,412	78,002
15~	99,146	125	495,417	6,803,048	94	257	46,341,050	76,114	76,770
20~	99,021	100	494,854	6,307,630	57	290	28,301,234	75,651	76,399
25~	98,920	117	494,309	5,812,777	214	592	105,949,935	75,368	76,190
30~	98,803	158	493,621	5,318,468	325	512	160,656,994	74,308	75,208
35~	98,645	214	492,691	4,824,847	303	638	149,507,743	72,702	73,699
40~	98,431	340	491,303	4,332,156	296	804	145,219,772	71,207	72,339
45~	98,090	591	488,974	3,840,853	431	629	210,854,524	69,755	71,109
50~	97,499	1,003	484,989	3,351,879	674	565	326,795,392	67,646	69,375
55~	96,496	1,741	478,128	2,866,890	1,020	782	487,691,300	64,378	66,702
60~	94,755	2,468	467,605	2,388,762	1,477	737	690,570,762	59,501	62,776
65~	92,287	3,873	451,754	1,921,157	1,991	777	899,255,698	52,595	56,958
70~	88,414	6,623	425,515	1,469,403	2,495	778	1,061,707,239	43,603	49,258
75~	81,791	11,839	379,359	1,043,888	2,961	826	1,123,335,405	32,986	40,210
80~	69,952	17,472	306,079	664,530	3,365	920	1,029,998,095	21,753	30,867
85~	52,480	22,289	206,677	358,450	3,520	938	727,499,516	11,453	21,424
90~	30,191	30,191	151,773	151,773	2,752	867	417,753,490	4,178	13,837

* Survivor person-yearsrefers to the person-years of people who are alive in this age group. ** Survivor person years in total refers to the total person-years of people who are alive in this age group to death. *** PPP Dollar to Chinese RMB currency in 2015 comes from Organisation for Economic Co-operation and Development database (*17*). PPP, purchasing power parity.

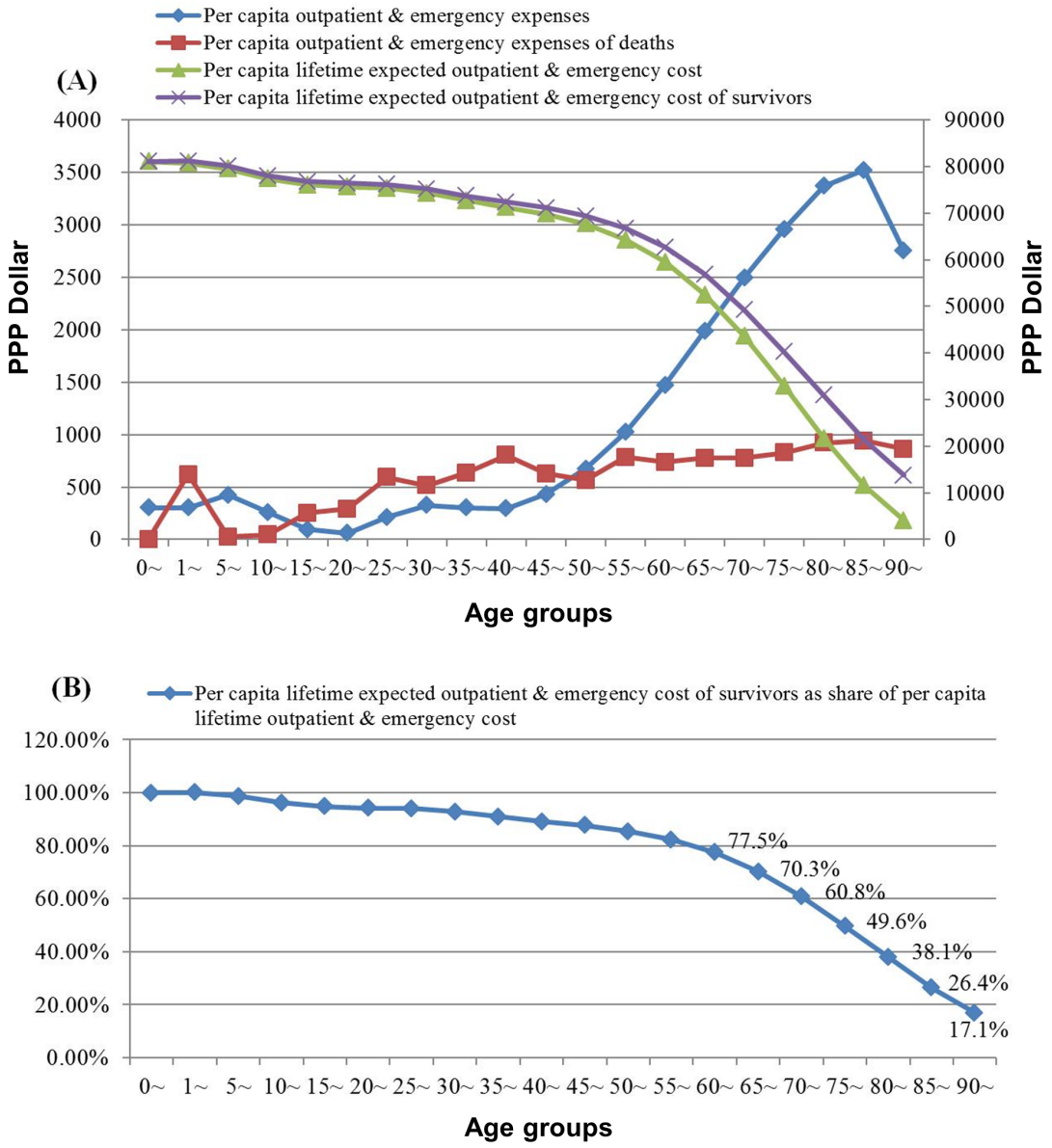

Figure 4.Per capita medical expenses and lifetime expected cost by age groups in outpatient and emergency(Unit: PPP Dollar) (A), and the proportion of per capita lifetime expected cost of survivors in per capita lifetime expenses in outpatient and emergency by 5 year intervals (Unit: %) (B). PPP, purchasing power parity.

hospitalization expenditure of deaths was higher, and not only far exceeded the per capita outpatient and emergency expenditure of deaths, but also exceeded per capita hospitalization expenditures. The per capita lifetime expected hospitalization cost from birth was 58,540 PPP Dollar, and accounted for 72.2% of the per capita lifetime expected outpatient and emergency cost from birth (81,042 PPP Dollar).The highest per capita expenditure of deaths appeared in the group aged 1-4, which was 45,095 PPP Dollar. It is noteworthy that, although the per capita hospitalization expenditure was increasing, the per capita hospitalization expenditure of deaths distinctly dropped with ascending age, and the relatively higher value emerged before the group aged 55-60, almost exceeding 20,000 PPP Dollar per capita.

Figure 5A refers to the age group distribution of per capita medical expenses and lifetime expected cost by age groups in hospitalization, and Figure 5B presents the proportion of per capita lifetime expected cost of survivors in per capita lifetime expenses for hospitalization. As age increases, the change of per capita hospitalization expenses of deaths was sharper than that in outpatient and emergency expenses, with 3 peaks appearing at groups aged 1-4 (45,095 PPP Dollar), 25-29 (37,270 PPP Dollar), and 35-59 (28,958 PPP Dollar). Meanwhile, the per capita hospitalization expenses escalated mildly, and the per capita lifetime expected hospitalization cost of both overall population and the survivors dropped smoothly, and at group aged 90 and over, the per capita lifetime expected hospitalization cost of survivors edged up. The share of the per capita lifetime expected hospitalization

Table 2. Simulated results of lifetime expected hospitalization cost*

Age groups	Survivors	Deaths	Survivor person-years	Survivor person years in total	Per capita hospitalization expenses (PPP Dollar)	Per capita hospitalization expenses of deaths (PPP Dollar)	Hospitalization expenses in total (PPP Dollar)	Per capita lifetime expected hospitalization cost (PPP Dollar)	Per capita lifetime expected hospitalization cost of survivors (PPP Dollar)
0~	100,000	483	99,604	8,292,764	489	6,289	48,738,149	58,540	58,510
1~	99,517	185	397,699	8,193,160	489	45,095	194,601,807	58,053	58,251
5~	99,332	89	496,440	7,795,461	191	30,286	94,669,190	56,106	56,456
10~	99,243	98	495,974	7,299,021	177	29,470	87,824,948	55,160	55,551
15~	99,146	125	495,417	6,803,048	150	26,540	74,418,630	54,282	54,716
20~	99,021	100	494,854	6,307,630	124	25,782	61,321,289	53,537	54,041
25~	98,920	117	494,309	5,812,777	195	37,270	96,543,334	52,924	53,457
30~	98,803	158	493,621	5,318,468	211	23,759	104,243,782	51,959	52,550
35~	98,645	214	492,691	4,824,847	208	28,958	102,648,328	50,916	51,553
40~	98,431	340	491,303	4,332,156	264	19,963	129,660,882	49,890	50,616
45~	98,090	591	488,974	3,840,853	414	20,455	202,499,334	48,593	49,416
50~	97,499	1,003	484,989	3,351,879	520	20,056	252,114,726	46,568	47,556
55~	96,496	1,741	478,128	2,866,890	654	21,075	312,544,335	44,047	45,266
60~	94,755	2,468	467,605	2,388,762	837	19,807	391,411,163	40,922	42,671
65~	92,287	3,873	451,754	1,921,157	1,111	19,256	501,759,108	37,007	39,292
70~	88,414	6,623	425,515	1,469,403	1,438	17,840	612,064,070	31,990	34,845
75~	81,791	11,839	379,359	1,043,888	1,816	15,999	688,954,453	25,869	29,312
80~	69,952	17,472	306,079	664,530	2,266	14,962	693,578,081	18,980	23,395
85~	52,480	22,289	206,677	358,450	3,180	15,722	657,238,874	12,044	16,273
90~	30,191	30,191	151,773	151,773	3,605	15,947	547,154,403	5,472	18,123

*PPP Dollar to Chinese RMB currency in 2015 comes from Organisation for Economic Co-operation and Development database (17). PPP, purchasing power parity.

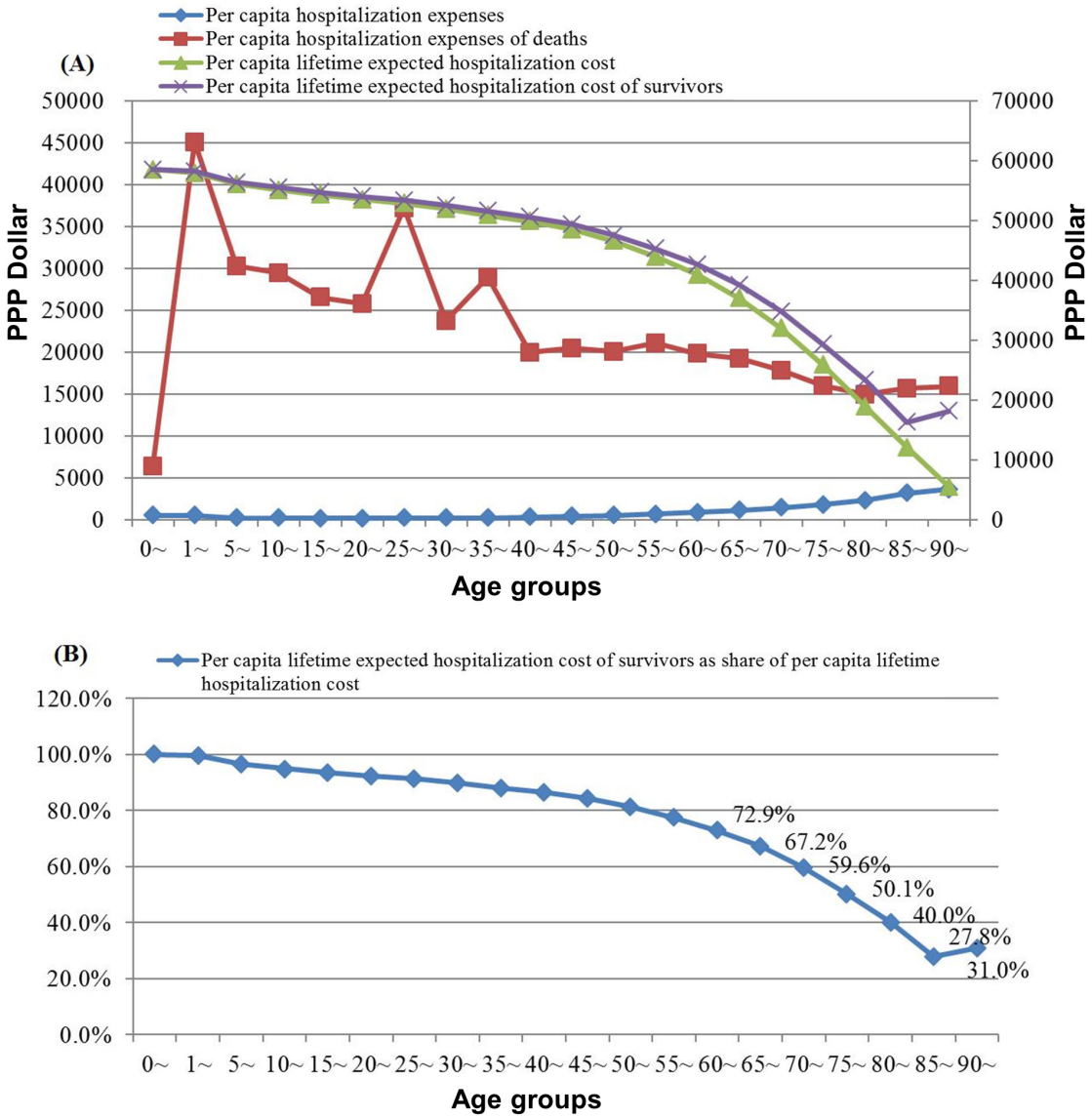

Figure 5. Per capita medical expenses and lifetime expected cost by age groups in hospitalization(Unit: PPP Dollar) (A), and the proportion of per capita lifetime expected cost of survivors in per capita lifetime expenses in hospitalization by 5 year intervals (Unit: %) (B). PPP, purchasing power parity.

cost of survivors in the per capital lifetime expected hospitalization cost was 72.9% in the group aged 60-64, which was 4.6 points lower than outpatient and emergency. It showed for people that lived to be in 60-64, the hospitalization expenses from now to death accounted for 72.9% of this individual's whole life hospitalization expenses. From groups aged 60-64 to 70-74, the proportions of hospitalization expenses from now to death in whole lifetime was below that of outpatient and emergency in the same age groups, whilst from age groups 75-79, to 90 and over, the proportions of hospitalization expenses from now to death in whole lifetime exceeded the proportions of outpatient and emergency in the same age groups. Generally, in the more advanced elderly group, the proportion of expenses in hospitalization tend to be higher than that in outpatient and emergency.

3.3.3. *Total medical expense*

Table 3 combines the outpatient and emergency, and hospitalization expenditures, and shows the results of simulated total lifetime expected cost. The per capita total medical expenses went up with increasing age, and was below the per capita total medical expenses of deaths. The per capita lifetime expected hospitalization cost from birth was 139,551 PPP Dollar, when people who survived to age 60, per capita lifetime expected cost of the group aged 60-64 was 105,447 PPP Dollar. However, since the hospitalization expenses were much higher than outpatient and emergency expenses, the per capita total medical expenses of deaths was mainly affected by per capita hospitalization expenses of deaths, presenting similar fluctuant features as hospitalization. After eliminating the deaths, the per capita total expected

Table 3. Simulated results of total lifetime expected cost*

Age groups	Survivors	Deaths	Survivor person-years	Survivor person years in total	Per capita total medical expenses (PPP Dollar)	Per capita total medical expenses of deaths (PPP Dollar)	Total medical expenses (PPP Dollar)	Per capita total lifetime expected cost (PPP Dollar)	Per capita total lifetime expected cost of survivors (PPP Dollar)
0~	100,000	483	99,604	8,292,764	793	6,289	78,942,383	139,582	139,551
1~	99,517	185	397,699	8,193,160	793	45,715	315,201,347	138,792	139,381
5~	99,332	89	496,440	7,795,461	618	30,314	306,855,592	135,640	136,525
10~	99,243	98	495,974	7,299,021	439	29,513	217,577,736	132,572	133,553
15~	99,146	125	495,417	6,803,048	244	26,797	120,759,680	130,396	131,485
20~	99,021	100	494,854	6,307,630	181	26,072	89,622,523	129,188	130,439
25~	98,920	117	494,309	5,812,777	410	37,862	202,493,269	128,292	129,647
30~	98,803	158	493,621	5,318,468	537	24,271	264,900,776	126,267	127,758
35~	98,645	214	492,691	4,824,847	512	29,595	252,156,071	123,618	125,251
40~	98,431	340	491,303	4,332,156	559	20,767	274,880,654	121,097	122,955
45~	98,090	591	488,974	3,840,853	845	21,084	413,353,859	118,348	120,525
50~	97,499	1,003	484,989	3,351,879	1,194	20,621	578,910,118	114,214	116,932
55~	96,496	1,741	478,128	2,866,890	1,674	21,857	800,235,635	108,425	111,968
60~	94,755	2,468	467,605	2,388,762	2,314	20,544	1,081,981,925	100,423	105,447
65~	92,287	3,873	451,754	1,921,157	3,101	20,032	1,401,014,805	89,603	96,251
70~	88,414	6,623	425,515	1,469,403	3,934	18,618	1,673,771,309	75,593	84,104
75~	81,791	11,839	379,359	1,043,888	4,777	16,825	1,812,289,858	58,855	69,522
80~	69,952	17,472	306,079	664,530	5,631	15,882	1,723,576,177	40,732	54,262
85~	52,480	22,289	206,677	358,450	6,700	16,660	1,384,738,390	23,496	37,697
90~	30,191	30,191	151,773	151,773	6,358	16,814	964,907,894	9,649	31,960

* PPP Dollar to Chinese RMB currency in 2015 comes from Organisation for Economic Co-operation and Development database (*17*). PPP, purchasing power parity.

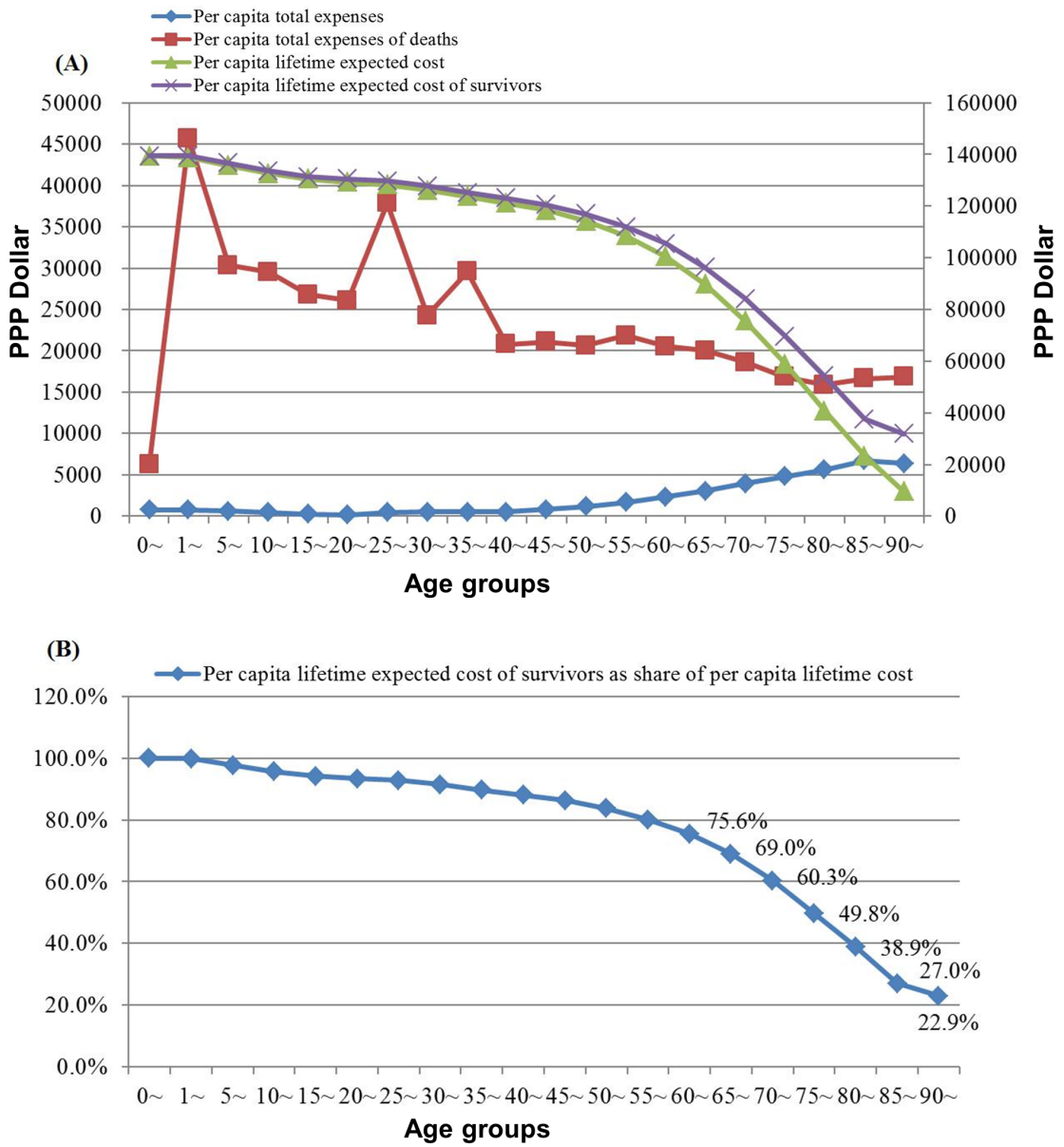

Figure 6. Per capita total medical expenses and total lifetime expected cost by age groups (Unit: PPP Dollar) (A), and the proportion of per capita total lifetime expected cost of survivors in per capita total lifetime expenses by 5 year intervals (Unit: %) (B).

cost of survivors wasa bit over the per capita total expected cost in the same age group.

Figure 6A is the age group distribution of per capita total medical expenses and total lifetime expected cost, and Figure 6B refers to the share of per capita total lifetime expected cost of survivors in per capita total lifetime expenses. The change of Figure 6A presented the approximated characteristics of Figure 5A, as age was trending up, the per capita total medical expenses of deaths increased, with 3 peaks appearing at groups aged 1-4 (45,715 PPP Dollar), 25-29 (37,862 PPP Dollar), and 35-59 (29,595 PPP Dollar). Meanwhile the per capita total expenses grew, and the per capita lifetime expected total cost of both overall population and the survivors fell. The proportions of per capita total lifetime expected cost of survivors in per capita total medical expenses were 75.6% and 38.9%, in groups aged 60-64 and 80-84, respectively. The share of the group aged 90 and over reached 22.9%, which meant for people who live to 90, the total medical expenditure from now to death accounted for approximately twenty percent of their total lifetime medical expenditure.

4. Discussion

4.1. *Shanghai elderly people had higher shares of expected medical expenses in lifetime medical expenses*

According to the above results, the elderly population as 19.5% of the total population in Shanghai, not only

utilized a large portion of medical resources (52.2% of total outpatient and emergency visits, and 45.3% discharged patients), but also accounted for more than half of the medical expenses (63.2% of outpatient and emergency expenses, 52.8% hospitalization expenses). In addition, the expenses in elderly age accounted for a major portion (approximately eighty percent, Figure 6) of lifetime medical expenses, which indicated that the medical expenses are more concentrated in the aged phase, and reflected that the elderly population consumed a larger proportion of medical resources compared with other groups of the population. In comparison with other countries, it can be concluded that although the studies found similar results, the gap between elderly people and other age groups in medical expenses was less significant.

For example, the study by Alemayehu (2004) in Michigan (*16*), US showed that the expenses of population aged 65 and over accounted for 1/2 of lifetime medical expenses in this region. The analysis from Shanghai data revealed that in the group aged 60-64, the proportions of per capita expected cost in per capita lifetime cost in outpatient and emergency, and hospitalization accounted for 77.5% (Figure 4B) and 72.9% (Figure 5B), respectively. Excluding the confounding factors such as study times, it can still be concluded that the medical expenses in the elderly population of Shanghai far exceeded the corresponding rates of Michigan, US.

4.2. *The medical expenses of elderly aged 80 and over was expected to flow to hospitalization, while the expenses of elderly aged 60-79 was expected to flow to outpatient and emergency*

Our results illustrated that the proportion of per capita lifetime expected cost of survivors in per capita lifetime expenses of the advanced elderly (population aged 80 and over) accounted for 38.9% (Figure 6B) of their lifetime expenses, including 38.1% (Figure 4B) in outpatient and emergency, and 40.0% (Figure 5B) in hospitalization, which was slightly higher than in outpatient and emergency. Moreover, the three advanced age groups, aged 80-84, 85-89, and 90 and over, all have higher expected hospitalization costs in lifetime expenses (40.0%, 27.8%, 31.0%, respectively, Figure 5B), compared with expected outpatient and emergency costs in lifetime expenses (38.1%, 26.4%, 17.1%, respectively, Figure 4B), while the other elderly group aged from 60 to 79 represented the opposite. It is indicated that the expected medical cost in advanced elderly groups (aged 80 and over) was mainly concentrated in hospitalization, while the expected medical cost in the relatively younger elderly people (aged 60-79) largely flew to outpatient and emergency. This conclusion is also close to the actual situation in Shanghai.

There is room for saving medical expenses in the elderly people in Shanghai, especially in the hospitalization expenditure of the advanced elderly population. International experience suggested that elderly care and rehabilitation has a momentous function in replacing hospitalization, furthermore would bring benefits to the health of elderly people in the future (*15,16*).

Our study has some limitations: first of all, the hypothesis in this study is assuming that the technology, pricing and other factors are stable, and the prevalence, incidents, development process and costs of disease do not change with time. Therefore, the life table model cannot reflect the impact of health technology development, the outbreak of new disease, perishing of old disease, and inflation. Secondly, nursing care plays an important role in the lives of the elderly, however the nursing care expenditures were not included in this study. In Shanghai, currently most of nursing care expenses has been paid out-of-pocket, which applies difficulty for data collection of our full sample size study. Further research could investigate the role of nursing care in the age distribution of expenditures, as well as how these expenses play out over the lifetime with medical expenses.

5. Conclusion

The findings of our study extend the knowledge of age-specific medical expenses, and show a striking share of elderly people's medical resource utilization and expenses. Although the lifetime expenses studies have been well-documented, we have known little about it, for two reasons: first, most of the studies were conducted in developed countries, and may not be applied in developing counties; second, the vast majority of studies were based on sampling, which may bring selection bias. This study is an exploration of lifetime expenses simulation in a relatively more developed region of China, which has a large population base with rapidly aging people. Besides, our study covered all the emergency, outpatient, hospitalization and medical expenses data in Shanghai in 2015, which can fully represent the characteristics of medical spending concentration in the Shanghai population.

We found that the elderly population as 19.5% of total population in Shanghai, accounted for 63.2% of outpatient and emergency expenses (52.2% of total outpatient and emergency visits) and 52.8% of hospitalization expenses (45.3% discharged patients). When surviving to age 60, 75.6% of lifetime medical expenses were expected to be spent at age 60 and over (Figure 6B), with 77.5% in emergency and outpatient (Figure 4B), and 72.9% in hospitalization (Figure 5B). The groups aged 80 and over, have higher expected hospitalization costs in lifetime expenses (40.0% in ages 80-84, 27.8% in ages 85-89, and 31.0% in age 90

and over, Figure 5B) than outpatient and emergency cost in lifetime expenses (38.1% in ages 80-84, 26.4% in ages 85-89, and 17.1% in age 90 and over, Figure 4B). Among the advanced elderly (population aged 80 and over), their expected medical expenses were more concentrated in hospitalization. In addition, our results have implications for forecasting the expected medical expenses. We suggested addressing the elderly population for saving medical resources and expenses, especially in hospitalization expenditures of the advanced elderly population.

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