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Disease trajectories and medical expenditures of older adults with disabilities: insights from China's long-term care insurance program

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Abstract

Background In China, long-term care (LTC) system has been implemented in recent years to improve the quality of care for older adults. To address healthcare needs of older adults with disabilities, this study investigated the disease trajectory and medical expenditures.

Methods This study included older adults aged 65 and above with disabilities, using data from China's Long-Term Care Insurance (LTCI) program since July 2017. The participants were followed until June 2021. Diagnoses and hospitalization costs were extracted from electronic medical records and the medical insurance system. Disease trajectory networks were constructed by identifying and linking disease pairs with overlapping conditions. Medical expenditures associated with specific diseases were then calculated.

Results The study included 30,003 participants with a mean age of 79.6 ± 11.1 years, 57.0% of whom were female. After a mean follow-up of 21 ± 16 months, 17,428 (58.1%) deaths occurred. The diseases with the highest hazard ratios (HRs) included septic shock (HR 3.59, 95% CI, 3.36–3.84), respiratory failure (HR 3.19, 95% CI, 3.05–3.34), sepsis (HR 2.98, 95% CI, 2.80–3.18), malnutrition (HR 2.38, 95% CI, 2.27–2.48), and decubitus ulcer (HR 2.27, 95% CI, 2.14–2.41). Disease trajectories indicated that mortality was closely associated with malnutrition related diseases (anemia, hypoproteinemia, and malnutrition), pneumonia, and organ failure (respiratory failure and heart failure). Among the top 30 diseases leading to frequent hospitalization, intracerebral hemorrhage (47,882.4 CNY), sepsis (37,978.2 CNY), and respiratory failure (25,921.1 CNY) accounted for the highest total medical costs.

Conclusions The study revealed that malnutrition and infection-related diseases contributed significantly to mortality among older adults with disabilities, with the latter also driving higher medical costs. These findings could inform updates to LTCI policies by emphasizing adequate nutritional support and strengthened infection prevention measures.

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Trial registration chictr.org.cn, ChiCTR2100049973, retrospectively registered.
Keywords Disease trajectory, Medical expenditures, Disability, Long-term care, Nutrition

Background

Globally, the older adult population is expanding rapidly in both number and proportion, and is expected to double within the next three decades [1]. According to the latest census by the National Bureau of Statistics of China in 2021, there are 190.6 million Chinese citizens aged 65 and over, representing 13.5% of the total population [2]. The aging population, coupled with the prevalence of multimorbidity, leads to impairment in activities of daily living (ADLs) among older adults. In 2020, it was estimated that between 108.67 and 108.79 million individuals in China were living with disabilities [3]. This growing disabled population has experienced significant increases in hospitalization rates, mortality, and the burden of care [4, 5].

Since 2000, the World Health Organization has urged nations to reach a global consensus on long-term care (LTC), promoting collaboration to ensure the independence, care, self-fulfillment, and dignity of older adults [6]. In response, countries with significant elderly populations, including the United States, Germany, Japan, and Korea, have established LTC insurance (LTCI) to meet the needs of older people with disabilities [7–10]. In June 2016, China launched an LTCI pilot program in 15 cities to provide formal care for older adults with disabilities, who have been traditionally cared by family members [11]. Given China's rapidly aging population and increasing rates of disabilities, it is essential to comprehensively understand the impact of disability on both mortality and medical expenditures.

Disability is a dynamic process influenced by various factors accumulated throughout individual's life course [12]. Disease trajectory analysis allows us to examine the progression of diseases over time and to elucidate the complex relationships between diseases in the transition from disability to death. It has been proposed as a novel approach to identify pairs of sequentially co-occurring diseases, offering a foundation for discovering causal relationships and patterns of multimorbidity [13]. Such trajectories have been employed in general population and in specific conditions such as depression and cancer [14, 15].

In this study, based on a government led LTCI program in China, we aimed to identify and characterize the diseases trajectories associated with mortality in disabled older adults using a statistical trajectory model. A secondary aim was to investigate the medical expenditures related to specific diseases and analyze medical expenditure trends by age group up to the date of death or the end of follow-up. The significance of this research lies in ensuring that LTC services are tailored to meet the evolving needs of this vulnerable population, while also offering guidance for future LTC research.

Methods

Study population and data source

This investigation was conducted as a prospective observational study, based on the LTCI program in Chengdu, one of China's pilot cities [11]. The program was launched in July 2017 and fully funded by Chengdu Healthcare Security Administration. It provides monetary reimbursements, along with basic care and social support services to participants (eTable 1–3 in Additional file 1) [16].

Applicants for the LTCI program were required to sign an informed consent form and undergo a functional assessment by trained medical professionals, conducted either at their homes or in nursing institutions. The details of functional assessment are displayed in eTable 4 (Additional file 1) and the Method Appendix (Additional file 2). The inclusion criteria of the LTCI program were: severe physical impairment (ADL scores < 40 points) lasting for more than six months, with no response to rehabilitation, and with or without cognitive/perceptual impairment.

In the present study, participants under 65 years of age were excluded, as shown in Fig. 1. Although the study was prospectively conducted, medical history was retrospectively collected from electronic medical records back to December 2013 to identify underlying diseases. Participants were followed until the date of death or June 2021. Ethical approval was granted by the Institutional Ethics Review Committee of West China Hospital (2021 – 687). This study adheres to the STROBE checklist.

Multimorbidities and mortality

Data for every hospitalization, including diagnoses and costs, were systematically extracted from the medical insurance systems. Multimorbidity diagnoses were coded using the 3-digit International Classification of Diseases, 10th revision (ICD-10) [17]. To ensure statistical power, only diseases affecting more than 5% of total cases (i.e., 1,500 cases) were included for analyzing the cause of mortality.

The immediate cause of death is defined as "final disease or condition resulting in death", as recorded on official death certificates and in the national insurance system. These causes of death were also coded in accordance with the ICD-10.

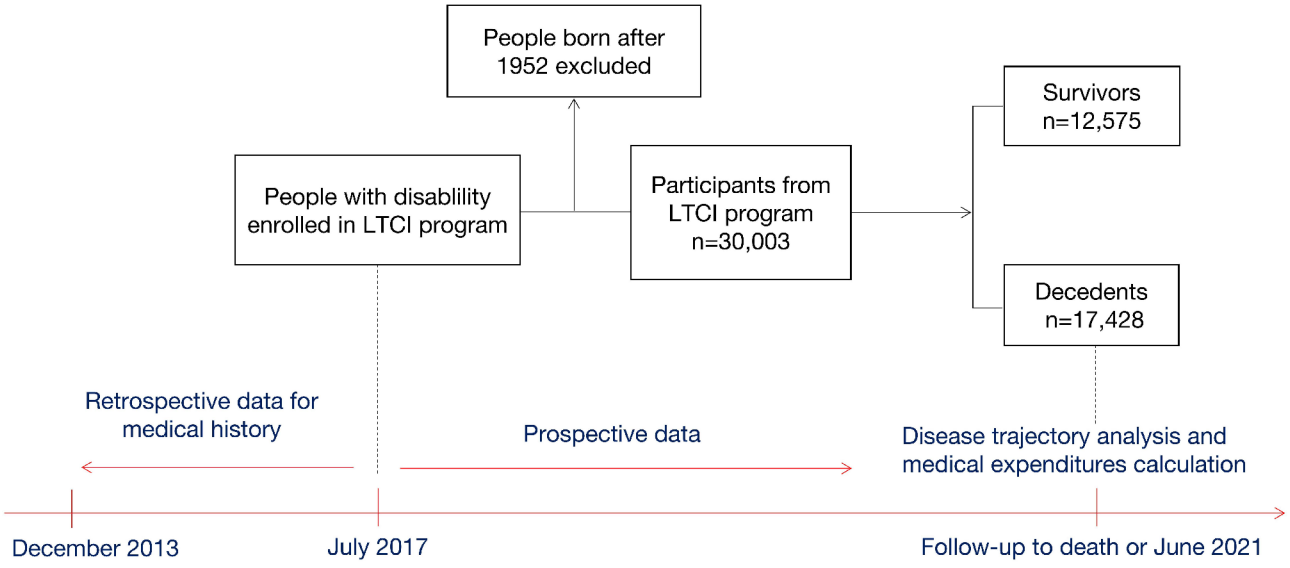

Fig. 1 Protocol of study design. LTCI: long-term care insurance

Disease trajectory analysis

Disease trajectories were constructed by assessing the risk of a subsequent disease (D2, outcome) following a prior disease (D1, exposure), across 1,121 medical conditions. The analysis was conducted in three steps. In the first step, stratified Cox regression was used to perform a phenome-wide association analysis (PheWAS), investigating the risks of 1,121 medical conditions among decedents compared to survivors, displayed by hazard ratios (HRs). In the second step, a binomial test assessed the sequential pattern of D1 → D2, testing whether the probability of D2 being diagnosed after D1 was significantly greater than 50% among patients diagnosed with both D1 and D2. A Bonferroni correction was applied for multiple testing, with the significance threshold set at $p < 0.05$. In the third step, for pairs with a significant D1 → D2 sequential pattern, a nested case–control design with conditional logistic regression was used to assess the association between D1 and D2. An odds ratio (OR) greater than 1 was used to identify significantly associated disease pairs, which were considered for inclusion in disease trajectories. The association of D2 diseases with increased mortality among disabled adults was tested using the same nested case-control design as applied in the D1 → D2 analysis. Disease trajectory networks were constructed by combining disease pairs with overlapping diseases (e.g., D1 → D2 and D2 → D3 were combined into D1 → D2 → D3 if D2 overlapped).

Separate analyses were conducted to investigate whether disease trajectories differed by age, sex, and care facilities. Participants were categorized into subgroups based on age (≥ 85 years or between 65 and 84 years); sex (females or males); and care facility (household or nursing institutions).

Medical expenditure analysis

This study focused on acute hospitalization-related medical expenditures. Locally estimated scatterplot smoothing (LOESS) was used to assess hospitalization costs by age group. For deceased individuals, medical expenses during hospitalizations were calculated from December 2013 to the date of death. For survivors, medical expenses were assessed up until June 2021.

Statistical analysis

All statistical analyses were performed using R software (version 4.1.0, Free Software Foundation, Inc., Boston, MA). Continuous variables were described as mean ± standard deviation and compared using Student's t-test. Categorical variables were described as percentages (%) and compared using the chi-square test. The flowchart and detailed explanation for the disease trajectory analysis are illustrated in eFigure 1 (Additional file S2). Statistical significance was defined as a two-tailed P-value of < 0.05.

Results

We identified 30,003 disabled older adults from LTCI participants recruited between July 2017 and June 2021. During this period, 17,428 (58.1%) deaths occurred. The decedents were more likely to be female (59.2% vs. 54.0%, $p < 0.001$) and older (81. 5 ± 9.9 vs. 76.9 ± 12.0, $p < 0.001$). They also exhibited a higher prevalence of multimorbidities and lower ADL scores than survivors (13.3 ± 12.8 vs. 16.6 ± 13.1, $p < 0.001$). Detailed information is presented in Table 1.

Among the 1,121 medical conditions identified in the cohort, 52 were associated with an increased risk of mortality, with each condition affecting ≥ 1,500 cases. In total,

Table 1 Baseline characteristics of the participants

Characteristics	Total cohort (*n* = 30003)	Survivors (*n* = 12575)	Decedents (*n* = 17428)	*P* value
Demographics				
Sex (Women, %)	17,113 (57.0)	6796 (54.0)	10,317 (59.2)	< 0.001
Age, mean (SD), years	79.6 (11.1)	76.9 (12.0)	81.5 (9.9)	< 0.001
Education (Middle school or above, %)	11,916 (39.7)	5741 (45.7)	6175 (35.4)	< 0.001
Marriage (In marriage, %)	15,997 (53.3)	7403 (58.9)	8594 (49.3)	< 0.001
Care-mode				< 0.001
Household (n, %)	21,060 (70.2)	9111 (72.5)	11,949 (68.6)	
Nursing institution (n, %)	8943 (29.8)	3464 (27.5)	5479 (31.4)	
Multimorbidities				
Hypertension (n, %)	17,632 (58.8)	7801 (62.0)	9831 (56.4)	< 0.001
Coronary artery disease (n, %)	5526 (18.4)	1619 (12.9)	3907 (22.4)	< 0.001
Heart failure (n, %)	5807 (19.4)	2795 (22.2)	3012 (17.3)	< 0.001
Chronic obstructive pulmonary disease (n, %)	5502 (18.3)	1888 (15.0)	3614 (20.7)	< 0.001
Cerebral vascular disease (n, %)	16,353 (54.5)	7208 (57.3)	9145 (52.5)	< 0.001
Diabetes (n, %)	8091 (27.0)	3375 (26.8)	4716 (27.1)	0.68
Cancers (n, %)	1838 (6.1)	532 (4.2)	1306 (7.5)	< 0.001
Chronic kidney disease (n, %)	3723 (12.4)	1261 (10.0)	2462 (14.1)	< 0.001
Physical activity				
ADL scores, mean (SD)	14.7 (13.0)	16.6 (13.1)	13.3 (12.8)	< 0.001
Cognitive function (n, %)				< 0.001
Robust	3163 (10.5)	1626 (12.9)	1537 (8.8)	
Mild impaired	14,132 (47.1)	6226 (49.5)	7906 (45.4)	
Moderate impaired	9674 (32.2)	3381 (26.9)	6293 (36.1)	
Severe impaired	3034 (10.1)	1342 (10.7)	1692 (9.7)	
Perception (n, %)				< 0.001
Robust	2831 (9.4)	1395 (11.1)	1436 (8.2)	
Mild impaired	14,606 (48.7)	6598 (52.5)	8008 (45.9)	
Moderate impaired	11,191 (37.3)	4173 (33.2)	7018 (40.3)	
Severe impaired	1375 (4.6)	409 (3.3)	966 (5.5)	

ADL: activity of daily living. P-values were calculated using chi-square tests for categorical variables (sex, education, marriage status, care mode, multimorbidities, cognitive function, and perception categories) and student's t-tests for continuous variables (age and ADL scores)

45 medical conditions were significantly associated with a higher risk of mortality (eTable 5 in Additional file 1). The diseases with the highest HRs included septic shock (HR 3.59, 95% CI, 3.36–3.84), respiratory failure (HR 3.19, 95% CI, 3.05–3.34), sepsis (HR 2.98, 95% CI, 2.80–3.18), malnutrition (HR 2.38, 95% CI, 2.27–2.48), and decubitus ulcer (HR 2.27, 95% CI, 2.14–2.41) (Fig. 2).

Disease trajectories leading to mortality

In step 1, 2,070 disease pairs were identified among the 1,121 medical conditions. From these,55 pairs with at least 1,500 cases each were selected for further investigation. Subsequently, 48 significant D1→ D2→ death pairs were identified (eTable 6 in Additional file 1; eFigure 1 in Additional file 2).

An overview of the disease trajectories is presented in Fig. 3. These trajectories predominantly involved conditions such as hypertension and diabetes mellitus, followed by dementia, cerebral infarction, chronic obstructive pulmonary disease (COPD), and coronary artery disease. Mortality was closely associated with anemia, malnutrition, hypoproteinemia, electrolyte disorders, arrhythmia, heart failure, sequelae of cerebrovascular disease, pneumonia, respiratory failure, peptic ulcer, functional bowel disease, and gastrointestinal hemorrhage. The color of each circle represents the HRs of the medical condition when comparing decedents with survivors. The size of each circle represents the frequency of the condition in hospitalization visits. Among the conditions leading to death, the most frequent conditions were malnutrition related diseases (4.2%, anemia, hypoproteinemia, and malnutrition), pneumonia (3.1%), and organ failure (3.1%, respiratory failure and heart failure). The color of the arrows represents the ORs for the sequential associations between pairs of medical conditions. The disease pairs with the highest ORs were COPD → respiratory failure (OR 2.35), cerebral infarction → sequelae of cerebrovascular disease (OR 2.26), and coronary artery disease → heart failure (OR 1.95). In summary, the leading causes of death among disabled older adults were identified as organ failure, malnutrition, and infections.

Subgroup analysis

The subgroup analysis conducted using PheWAS identified consistent high-risk medical conditions across different subgroups, as detailed in eTables 7–12 in Additional file 1.

Both age groups displayed common causes of death (e.g., organ failure and malnutrition) but followed different progression pathways (eFigure 2 in Additional file 2). For individuals over 85 years, additional causes of death included urinary tract infections, respiratory disorders post tracheotomy, pulmonary heart diseases, and

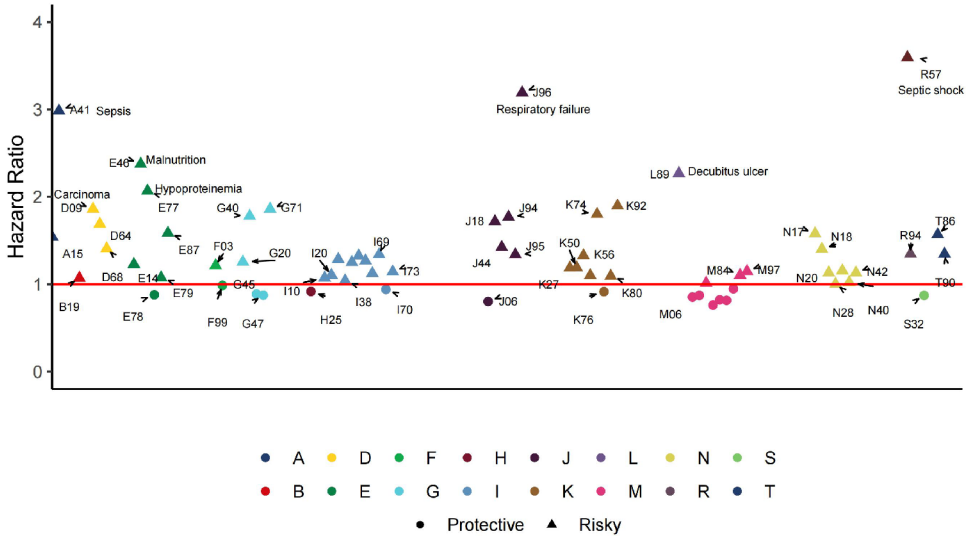

Fig. 2 Hazard ratio of high-risk medical conditions related to mortality. The X-axis shows the disease categories according to ICD-10 codes A-N and S-Y. The Y-axis shows the hazard ratio

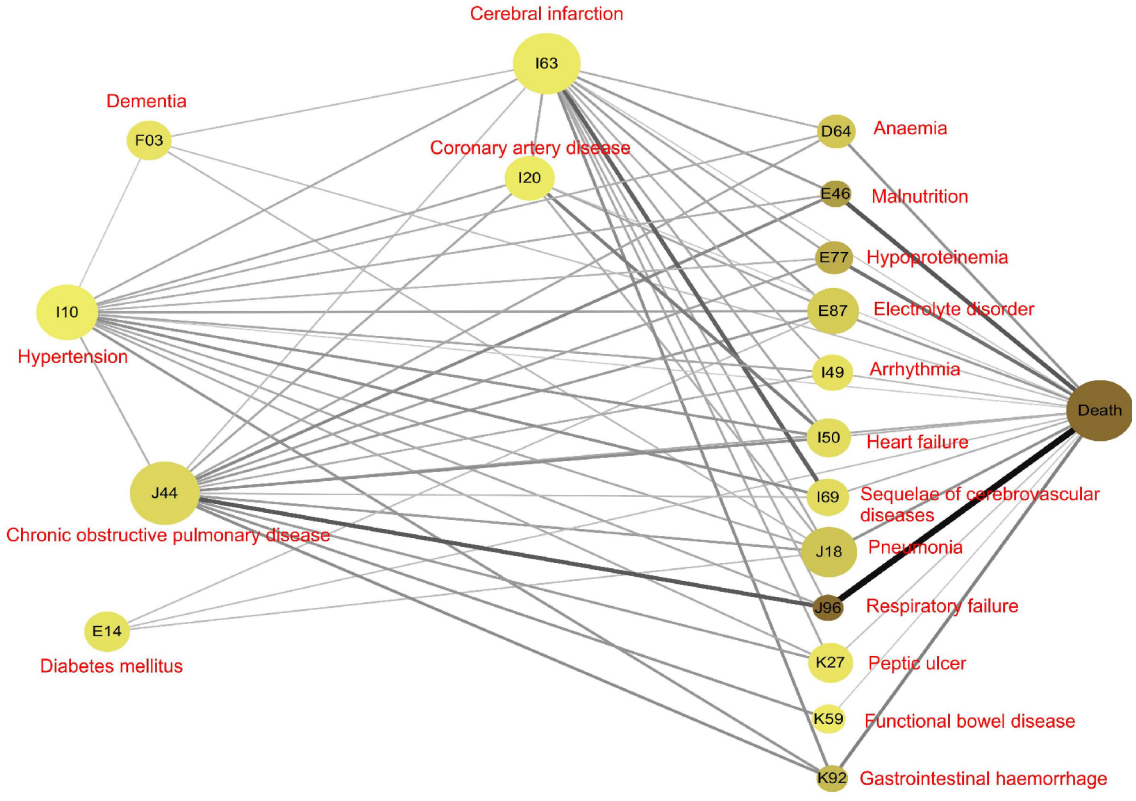

Fig. 3 Disease trajectories leading to mortality among older disabled individuals. The color of the circle represents the hazard ratios of this medical condition when comparing decedents to survivors. The size of the circle represents the frequency of this medical condition. The color of the arrows indicates the odds ratios of the sequential association between the two medical conditions

functional bowel disease (eTables 13 and 14 in Additional file 2).

When analyzing disease trajectories by sex, males exhibited more complex disease progressions (eTables 15 and 16 in Additional file 1; eFigure 3 in Additional file 2). Key conditions associated with disease progression in males included primary hypertension, dementia, and gastrointestinal hemorrhage.

Regarding care facilities, individuals residing in nursing institutions (29.8%) exhibited more complex disease trajectories. Conditions such as dementia and pneumonia were significant contributors to disease trajectories in this group. Additional causes of death included peptic ulcer, functional intestinal disorders, gastrointestinal hemorrhage, and urinary system disorders, compared to those living in household settings, (eTables 17 and 18 in Additional file 1; eFigure 4 in Additional file 2). The increased complexity in nursing institutions is likely due to the generally poorer health status of these individuals.

Medical expenditures

The median medical expenditures by age group are shown in Fig. 4. Overall, costs tended to decrease with advancing age, except for a marked increase near the time of death among decedents.

As shown in Table 2, the most frequent causes of hospitalization were COPD (59,663 visits), cerebral infarction (36,340 visits), pneumonia (25,743 visits), angina pectoris (20,865 visits), dementia (17,909 visits), among others. In summary, the leading reasons for hospital admission included cardiovascular and cerebrovascular diseases, infection-related diseases, fractures, underlying chronic diseases, and carcinoma. Among the top 30 conditions leading to hospitalization, intracerebral hemorrhage

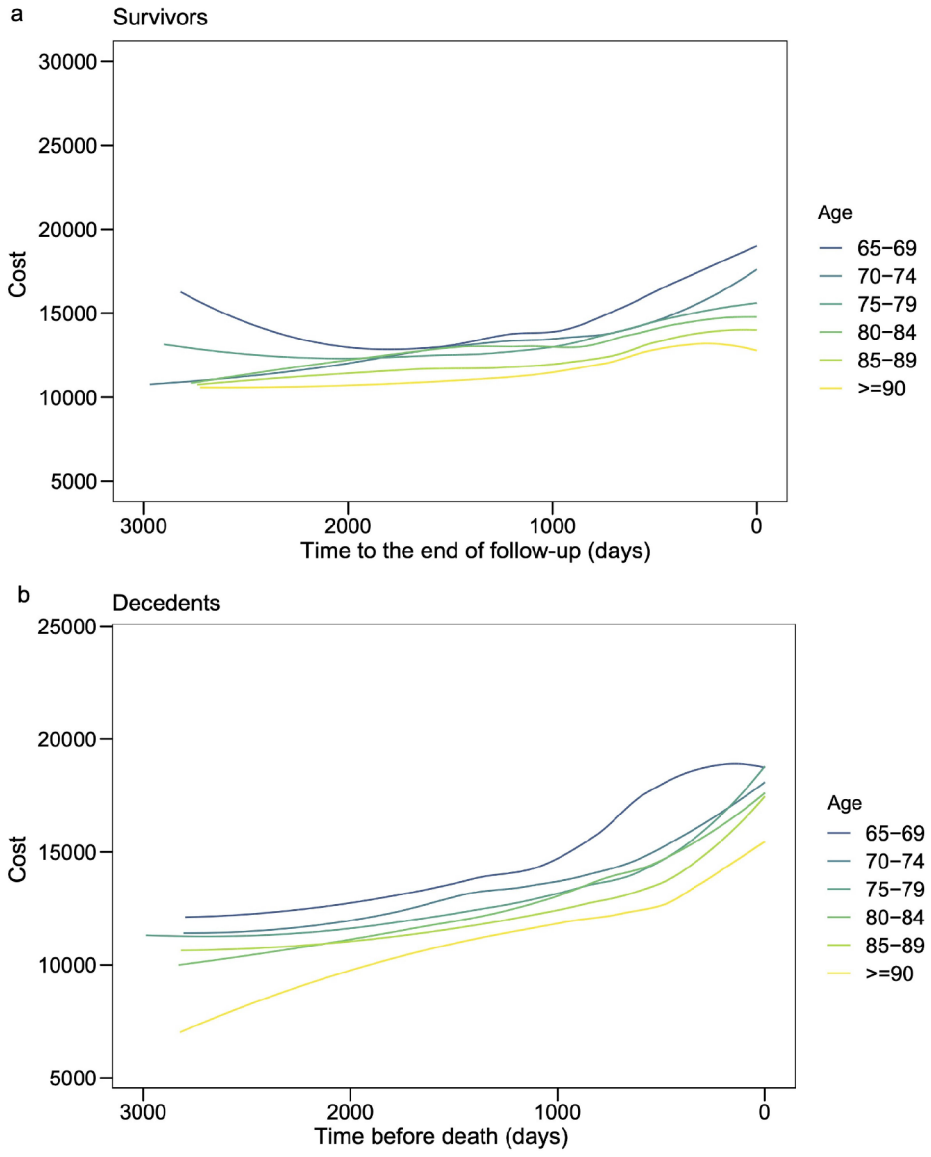

Fig. 4 Median medical expenditures by age group before death or at the end of follow-up. **a** (survivors), **b** (decedents)

Table 2 Highest total cost among diseases of the top frequent 30 hospitalization visits

ICD-10	Disease	Total cost (CNY)	Cost per day (CNY)	Hospitalization visits
I61	Intracerebral hemorrhage	47882.4	1706.5	5167
A41	Sepsis	37978.2	2236.6	1357
J96	Respiratory failure	25921.1	1506.8	1411
M84	Fracture	23869.6	1379.3	8902
G40	Epilepsy	19195.9	1020.2	1696
D09	Carcinoma	18782.8	1376.4	6175
G81	Hemiplegia	18302.0	595.2	1353
N18	Chronic kidney disease	17849.6	1017.6	5380
F99	Mental disorder	17533.8	367.2	4055
J18	Pneumonia	17333.9	960.0	25,743
N17	Acute kidney failure	16407.5	1016.3	2655
I63	Cerebral infarction	16198.5	859.0	36,340
I49	Cardiac arrhythmias	15188.3	1298.4	2271
D64	Anemia	14382.6	1284.8	1164
F03	Dementia	14264.5	317.3	17,909
G20	Parkinson disease	14239.8	867.9	1799
I69	Sequelae of cerebrovascular disease	12991.7	467.8	12,070
I50	Heart failure	12485.1	946.6	2479
I10	Primary hypertension	11962.9	604.3	15,441
I20	Angina pectoris	11808.6	750.0	20,865
M80	Osteoporosis with pathological fracture	11548.6	719.7	5435
E14	Diabetes mellitus	11479.5	615.2	14,824
J44	Chronic obstructive pulmonary disease	11110.5	705.3	59,663
M13	Arthritis	11022.7	743.4	1413
M06	Rheumatoid arthritis	9818.6	633.4	1970
G45	Transient cerebral ischaemic attacks	8944.0	451.0	8843
K27	Peptic ulcer	8440.5	746.3	4002
H25	Senile cataract	7530.6	2237.3	3009
K50	Crohn disease	5544.2	585.3	2472
D68	Coagulation defects	5121.8	276.5	2581

CNY: Chinese Yuan. Costs converted from CNY to US Dollars (USD) using the 2019 average exchange rate (1 USD = 6.9 CNY) reported by the State Administration of Foreign Exchange of China

(47,882.4 CNY), sepsis (37,978.2 CNY), and respiratory failure (25,921.1 CNY) incurred the highest total medical costs.

Discussion

Our study examined disease progression over time and evaluated medical expenditures using longitudinal data from an older population with disabilities. The key findings were as follows: (1) Complications related to malnutrition and infections were the predominant direct causes of death, including anemia, hypoproteinemia, electrolyte disorders, pneumonia, respiratory failure, and urinary infections. (2) Medical expenditures decreased with advancing age. Among the most prevalent diseases, intracerebral hemorrhage, sepsis, and respiratory failure incurred the highest medical costs.

Direct causes of death

Previous studies from developed countries have shown that disability at the end of life follows distinct yet predictable trajectories, including cancer, organ failure, sudden death, advanced dementia, and frailty [18, 19]. Recent research has incorporated chronic kidney disease and cirrhosis into the spectrum of late-life disability trajectories [20]. In China, common non-communicable diseases (NCDs), such as hypertension, diabetes, dementia, COPD, cerebral infarction, and coronary artery disease, can all contribute to disability. However, our study demonstrated that these NCDs do not directly cause death. Instead, malnutrition and infection-related complications were identified as critical pathways leading to mortality in our LTCI cohort.

Malnutrition and disability dynamics

Malnutrition and disability are closely interconnected, with substantial overlap and mutual influence [21]. Physical mobility limitations may prevent older adults from obtaining or preparing food independently. Poor oral health or swallowing disorders further alter eating patterns, exacerbating the risk of malnutrition. This risk is particularly high in those with chronic wasting disease, such as cancer, organ failure, or those undergoing hemodialysis. Sarcopenia, which is closely related to malnutrition, is prevalent among older adults, with a prevalence rate of 41% in LTC facilities [22]. In China, 32.4% of LTC participants were at risk of malnutrition, and 49.7% were diagnosed with sarcopenia [23]. Severe sarcopenia and malnutrition, characterized by low muscle mass and poor physical performance, can exacerbate disability severity in older adults.

Malnutrition and infections

The relationship between malnutrition and infection in LTC settings has been well established [24]. In our analysis, pneumonia and respiratory failure emerged as prominent infection-related causes of death. Older individuals are particularly at high risk of mortality from infections, largely due to their pro-inflammatory status and dysfunctional immune response, collectively referred to as immunosenescence [25].

In LTC settings, malnutrition and hypoproteinemia further weaken the immune system, impairing antibody responses to infections [26]. Sarcopenia is also strongly associated with infection in both acute and LTC settings [27, 28]. Empirical data suggest that older patients with sarcopenia have higher infection rates and poorer prognoses during the COVID-19 pandemic [29]. Additionally,

COVID-19 exacerbates sarcopenia due to increased muscle wasting from systemic inflammation, reduced physical activity, and insufficient nutrient intake. Therapeutic interventions, such as increased protein intake, specific probiotics, and targeted physical therapy, have demonstrated significant efficacy in improving the functional status of older patients recently infected with COVID-19 [30].

Systematic reviews also have demonstrated that targeted nutritional interventions can significantly reduce infection risks in LTC settings [31]. Effective interventions included whey protein (any infection), Black Chokeberry (urinary tract infection), and vitamin D (acute respiratory tract infection, skin and soft tissue infection). Both zinc and dedicated mealplans significantly improved lymphocyte parameters [26]. These nutritional interventions may warrant further rigorous clinical trials.

Medical expenditures

Among decedents, medical expenditures increased rapidly as death approached, consistent with findings from previous studies [32, 33]. Although adults aged 85 years and older have more comorbidities, their frailty often necessitates less invasive interventions, aligning with the growing emphasis on palliative care. This shift in care strategy is reflected in the lower inpatient expenditures among the very elderly.

Our analysis identified sepsis as one of the most costly conditions, second only to intracerebral hemorrhage. In LTC settings, advanced age, multimorbidity, long-term bed rest, and disability increase the susceptibility of older adults to pneumonia or other infection-related diseases. Older adults in LTC settings worldwide have been disproportionately affected by COVID-19, with high infection and mortality rates [34, 35]. In addition, malnutrition and frailty can weaken the immune response to influenza and pneumococcal vaccines, reducing their effectiveness [26]. Although vaccines may not completely prevent pneumonia, they can significantly reduce its severity and hospitalizations [36]. Similarly, COVID-19 vaccinations have been found to decrease infections in nursing homes or alleviate symptoms [37, 38]. Another study showed that vaccinating LTC residents against respiratory syncytial virus disease would be cost-effective, averting significant direct healthcare costs [39]. Vaccinating LTC residents against respiratory diseases, such as influenza, pneumococcal disease, pertussis, and COVID-19, is a simple, cost-effective, and efficient strategy to reduce the infection burden in this vulnerable population [40]. It is imperative for governments to ensure access to these critical preventive measures and conduct health economic assessments to evaluate their impact.

Implications for long-term care system

In high-income countries, the LTC system has been developed over decades, with the public sector covering at least 70% of formal care costs and maintaining 2 to 4.5 nursing home residents per 100 older adults [41]. However, the COVID-19 crisis in nursing homes has led to changes in the provision of LTC in these countries. Smaller-scale, high-quality group models, such as the Green House Project, provide care in small, self-contained, family-style houses with a limited number of residents. Such models could offer a community-based alternative to traditional nursing homes, potentially reducing the risk of infection [42].

In China, our previous research have demonstrated that the implementation of LTCI can significantly reduce overall mortality, alleviate functional deterioration, and decrease hospitalizations related to infections [43, 44]. These findings have driven continual improvements to the LTCI program, including expanding coverage to moderately disabled individuals, enhancing institutional care, and increasing the availability of basic care at home [45]. However, the risk of malnutrition in the LTC population in China may be more common and easily overlooked. Our research highlights the strong association between inadequate nutrition, infections, increased mortality, and higher healthcare costs. Enhancing nutritional assessments, early identification of sarcopenia, and providing targeted nutritional interventions could reduce infection risks and contribute to the sustainability of the LTC system.

Strengths and limitations

This study is the first to apply disease trajectory analysis to an older disabled population using administrative data from the LTCI program in China. This innovative approach allows for a detailed examination of disease progression patterns, providing valuable insights into the health care needs and resource utilization of this vulnerable population. Despite its contributions, this study has several limitations. First, as only diseases with a prevalence of more than 5% were included in the analysis, this approach limits the identification of disease pairs involving rare medical conditions. Second, the medical expenditure extracted from medical insurance system did not include the cost for outpatient care or LTC services, and lacked sub-analyses of different levels of functional impairment. Finally, the study relied on data from a single pilot city in China, which may limit the generalizability of the findings.

Conclusions

This study comprehensively analyzed disease trajectories and medical expenditures among older disabled adults, revealing that malnutrition and infections collectively

account for nearly half of the leading causes of death, with infections incurring the highest medical costs. Future research in the field of LTC should focus on nutritional assessment and interventions, vaccination, and innovative LTC models to prevent infections. The implications of these findings and subsequent recommendations are not only relevant to China but also provide valuable insights for other countries worldwide striving to improve care for their disabled older populations.

Abbreviations

ADL	Activity of daily living
COPD	Chronic obstructive pulmonary disease
COVID-19	2019 novel coronavirus disease
ICD	International Classification of Diseases
LOESS	Locally estimated scatterplot smoothing
LTC	Long-term care
LTCI	Long-term care insurance
PheWAS	Phenome-wide association analysis

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12877-025-05985-8.

Supplementary Material 1

Supplementary Material 2

Author contributions

LZ and HT analyzed the data and wrote the paper. SY, LH, JW acquired and verified the data. BD, AG and QD designed and supervised the study and revised the manuscript. All authors read and approved the final manuscript.

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Data availability

The datasets generated during and/or analyzed during the current study are not publicly available due confidentiality policy of the Chengdu Insurance system but are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

Written informed consent was obtained from all participants. Ethical approval was granted by the institutional ethics review committee of West China Hospital (2021 – 687).

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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