ORIGINAL RESEARCH

Leading Causes of In-Hospital Death of Older Patients of Different Age Groups in Shanghai

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Background: Despite great achievements in clinical medicine, the in-hospital mortality of older patients remains high. How to reduce the in-hospital mortality of older inpatients is of great clinical value in clinical practice. This study is to analyze the leading causes of in-hospital death of older inpatents of different ages in Shanghai.

Methods: An observational study was conducted in Shanghai. A total of 3894 older inpatients (≥60 years old) were investigated. According to the age stratification standard of World Health Organization, they were divided into young older patients group (aged 60 to 74), old older patients group (aged 75 to 89) and very old patients group (aged ≥90). Diseases of in-hospital death of older inpatients in different age groups were classified according to the 10th edition of the International Classification of Diseases. Constituent ratio of causes of in-hospital death in each group was analyzed.

Results: The constituent ratio of pulmonary infection had the highest rate of in-hospital death in older patients. The constituent ratio of lung malignant tumors had the highest rate of in-hospital death in young older patients. The constituent ratio of pulmonary infection had the highest rate of in-hospital death in old older patients. The constituent ratio of pulmonary infection had the highest rate of in-hospital death in very old patients.

Conclusion: The leading cause of in-hospital death of young older patients group was lung malignant tumor. The leading cause of in-hospital death of old older patients group and very older patients group was pulmonary infection. Great importance should be attached to the prevention of lung tumor and lung infection in the elderly. Results of this study will provide a basis for health administrative departments to formulate corresponding health-care policies for older patients.

Keywords: causes of in-hospital death, older patients, age stratified analysis, lung malignant tumor, pulmonary infection

Introduction

Despite great achievements in clinical medicine, mortality of older patients remains high. The number of aging population has increased significantly which caused huge disease and economic burden. With the improvement of living standards including nutritional status and dietary structure, people's average life expectancy has been generally prolonged. In the inpatient population, the number of older patients has increased significantly. How to reduce the in-hospital mortality of older inpatients is of great clinical value in clinical practice. Researches on the causes of death of older inpatients have been conducted in several countries.[1–8] They studied the main diseases that lead to the death of older patients in different countries and found that malignant tumors of lung, pneumonia and bronchopneumonia were the leading causes of death of older patients. However, little is known about the cause of death in older inpatients of different age groups.

For older patients of different age groups, due to the different ages of each older patient, their function of immune system, function of main organs and body health status are different. Different age groups of older patients have different clinical

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characteristics and outcomes for the same disease. Therefore, it is necessary to conduct research to identify the main diseases leading to the death of older patients of different age groups.

Human beings have entered an aging society. How to improve the quality of life of the elderly and extend their life span is a very important problem that medical workers need to solve. Identifying the leading cause of in-hospital death of older inpatients of different age groups can improve the treatment level of older patients and reduce the mortality of older patients. It is of great value to conduct research on causes of in-hospital death of older inpatients of different age groups. This study is to analyze the leading cause of in-hospital death of older inpatients of different age groups in the central urban area of Shanghai. Results of the study can strengthen the prevention and treatment of diseases that lead to the death of older patients of different age groups, reduce the mortality rate and improve the quality of life of elderly patients of all age groups. The results will provide a basis for health administrative departments to formulate corresponding medical and health-care policies for older patients.

Methods

A retrospective study was conducted from July 1, 2013 to December 30, 2019 in a university affiliated hospital in the central urban area of Shanghai. A consecutive sample of 3894 older inpatients (aged ≥60) (mean age 80.51 ± 9.31 years old) was investigated by using the medical record management system of the hospital. The subject inclusion and exclusion criteria: older inpatients lived and worked in the central urban area of the mega city for over 60 years were included in this study. Older inpatients lived and worked in the central urban area of Shanghai less than 60 years and older inpatients did not live and work in the central urban area of Shanghai were excluded from the study.

Among these 3894 older inpatients, 2125 were males and 1769 were females. They were divided into young older patients group (aged 60 to 74), old older patients group (aged 75 to 89) and very old patients group (aged ≥90) according to the most recent age stratification for older people as defined by World Health Organization (WHO). Socio-demographic variables of these 3894 older inpatients, young older patients, old older patients and very old patients are shown in Table 1. The constituent ratios of causes of in-hospital death in older inpatients of different ages were analyzed by age stratification. All diseases that cause in-hospital death in older inpatients were classified according to the 10th edition of the International Classification of Diseases (ICD-10). Constituent ratio of death etiology of older inpatients in each age group was statistically analyzed. The causes of in-hospital of older inpatients in three age groups were analyzed.

Statistical Analyses

By using the IBM SPSS Statistics Version 20.0 (IBM Inc., Chicago, USA), statistical analysis of the study data was performed. Continuous variables were analyzed by Student's t-test and expressed as the mean ± standard deviation ($x±s$) or median and interquartile range. Categorical variables were analyzed by chi-square test or Fisher's exact test. p value < 0.05 was considered statistically significant.

The protocol for this research project has been approved by the Ethics Committee of Shanghai Municipal Eighth People's Hospital, and the approval number is 2019–006. It conforms to the provisions of the Declaration of Helsinki in 1975 (as revised in Edinburgh 1983). Informed, written consent was obtained from every patient.

Table 1 Socio-Demographic Variables of Older Inpatients (≥60 Years Old), Young Older Patients (Aged 60 to 74), Old Older Patients (Aged 75 to 89) and Very Old Patients (Aged ≥90) in Central Urban Areas of Shanghai

Item	All Older Patients (Aged ≥60)	Young Older Patients (Aged 60 to 74)	Old Older Patients (Aged 75 to 89)	Very Old Patients (Aged ≥90)
Number of older patients	3894	1071	2223	600
Number of male patients	2125	689	1186	250
Number of female patients	1769	382	1037	350
Average age (years old)	80.51±9.31	67.89±4.65	83.24 ± 3.66	92.92±2.79

Results

In this study, a total of 3894 older inpatients (aged ≥60) were investigated. The average age was 80.51 ± 9.31 years, including 2125 males and 1769 females. The top 5 diseases of death in older inpatients were pulmonary infection, lung malignant tumors, chronic obstructive pulmonary disease, coronary heart disease, and gastric malignant tumors. The constituent ratio of the top 5 diseases was 13.8%, 7.5%, 7.3%, 6.0% and 5.9%, respectively (see Table 2).

The average age of young older patients group was 67.89 ± 4.65 years old, 689 males and 382 females. The top 5 diseases of death in young older patients group were lung malignant tumors, gastric malignant tumors, pancreatic malignant tumors, liver malignant tumors and pulmonary infection. The constituent ratio of the top 5 diseases was 12.2%, 11.3%, 6.9%, 6.8% and 5.2%, respectively (see Table 3).

Table 2 Etiological Analysis of In-Hospital Death of Older Inpatients (≥60 Years Old) in Central Urban Areas of Shanghai

Sort	Causes of Hospital Death	ICD-10	Number of Cases	Percentage (%)
1	Pulmonary infection	J98.414	536	13.76
2	Lung Malignant Tumor	C34.900x001	292	7.50
3	Chronic obstructive pulmonary disease	J44.900	283	7.27
4	Coronary heart disease	I25.103	233	5.98
5	Malignant tumors of the stomach	C16.900	231	5.93
6	Malignant tumors of the pancreas	C25.900	185	4.75
7	Aspiration pneumonia	J69.001	134	3.44
8	Malignant liver tumors	C22.900	133	3.42
9	Cerebral infarction	I63.900	133	3.42
10	Malignant tumors of the colon	C18.900	107	2.75
11	Malignant tumors of the rectum	C20.x00	106	2.72
12	Severe pneumonia	J18.903	91	2.34
13	Malignant breast tumors	C50.900x011	53	1.36
14	Upper gastrointestinal bleeding	K92.208	35	0.90
15	Acute coronary syndrome	I24.901	35	0.90
16	Malignant tumors of the gallbladder	C23.x00	35	0.90
17	Pneumonia	J18.900	34	0.87
18	Intracerebral hemorrhage	I61.900	33	0.85
19	Prostate Malignant Tumor	C61.x00	30	0.77
20	Chronic kidney disease stage 5	N18.001	30	0.77
21	Malignant tumors of the sigmoid colon	C18.700	26	0.67
22	Malignant tumors of the esophagus	C15.900	26	0.67
23	Lacunar cerebral infarction	I63.801	26	0.67
24	Malignant tumor of the bladder	C67.900	22	0.56
25	Malignant ovarian tumors	C56.x00	21	0.54
26	Intestinal obstruction	K56.700	21	0.54
27	Acute attack of chronic bronchitis	J20.900x004	20	0.51
28	Malignant tumor of ascending colon	C18.200	19	0.49
29	Respiratory failure	J96.900	19	0.49
30	Bronchopneumonia	J18.000	18	0.46
31	Malignant tumors of the digestive tract	C26.900x002	17	0.44
32	Malignant tumor of bile duct	C24.002	17	0.44
33	Malignant renal tumors	C64.x00x001	16	0.41
34	Cardiac insufficiency	I50.900x002	14	0.36
35	Gallbladder stones with acute cholecystitis	K80.000	14	0.36
36	Gastrointestinal bleeding	K92.210	13	0.33
37	Septic shock	R57.200	13	0.33

(Continued)

Table 2 (Continued).

Sort	Causes of Hospital Death	ICD-10	Number of Cases	Percentage (%)
38	Malignant tumors of the transverse colon	C18.400	12	0.31
39	Acute myocardial infarction	I21.900	11	0.28
40	Malignant tumor of the upper lobe of the lung	C34.101	11	0.28
41	Multiple cerebral infarction	I63.905	11	0.28
42	Obstructive pneumonia	J18.800x003	10	0.26
43	Malignant tumor of descending colon	C18.600	10	0.26
44	Decompensated phase of liver cirrhosis	K74.607	10	0.26
45	Malignant tumor of the pancreatic head	C25.000	9	0.23
46	Arrhythmias	I49.900	9	0.23
47	Malignant tumor of duodenum	C17.000	9	0.23
48	Community acquired pneumonia, severe	J15.903	9	0.23
49	Malignant brain tumors	C71.900	8	0.21
50	Interstitial lung disease	J84.900	8	0.21
51	Acute non ST segment elevation myocardial infarction	I21.401	8	0.21
52	Cirrhosis	K74.100	8	0.21
53	Malignant tumors of the intestine	C26.000x001	8	0.21
54	Sudden cardiac death	I46.100x001	7	0.18
55	Community acquired pneumonia, non severe	J15.902	7	0.18
56	Large area cerebral infarction	I63.902	7	0.18
57	Fallen pneumonia	J18.200	6	0.15
58	Heart failure	I50.900	6	0.15
59	Atrial fibrillation	I48.x01	6	0.15
60	Malignant tumors of the middle and upper esophagus	C15.801	6	0.15
61	Uremia	N19.x01	6	0.15
62	Acute heart failure	I50.907	6	0.15
63	Acute cholangitis	K83.001	6	0.15
64	Systemic inflammatory response syndrome with infectious causes and organ failure	R65.100	6	0.15
65	Post hepatitis B cirrhosis	K74.600x024	5	0.13
66	Cerebrovascular accident	I64.x01	5	0.13
67	Cerebral contusion	S06.202	5	0.13
68	Urinary tract infection	N39.000	5	0.13
69	Chronic gastritis	K29.500	5	0.13
70	Interstitial pneumonia	J84.900x002	5	0.13
71	Malignant thyroid tumors	C73.x00	5	0.13
72	Hepatic encephalopathy	K72.903	5	0.13
73	Hepatocellular carcinoma	C22.000	5	0.13
74	Severe pulmonary infection	J98.400x024	5	0.13
75	Malignant tumor of the cardia	C16.000	5	0.13
76	Described as sudden cardiac death	I46.100	5	0.13
77	Bronchiectasis with infection	J47.x03	4	0.10
78	Sequela of cerebral infarction	I69.300	4	0.10
79	Acute severe pancreatitis	K85.902	4	0.10
80	Acute pancreatitis	K85.900	4	0.10
81	Acute gastroenteritis	K52.905	4	0.10
82	Acute peritonitis	K65.000	4	0.10
83	Acute biliary pancreatitis, severe	K85.102	4	0.10
84	Respiratory and cardiac arrest	I46.901	4	0.10
85	Rheumatic heart disease	I09.900	4	0.10

(Continued)

Table 2 (Continued).

Sort	Causes of Hospital Death	ICD-10	Number of Cases	Percentage (%)
86	Malignant tumor of the lower lobe of the lung	C34.301	4	0.10
87	Malignant tumor of residual stomach	C16.903	4	0.10
88	Incomplete intestinal obstruction	K56.701	4	0.10
89	Endometrial malignant tumor	C54.100	3	0.08
90	Malignant tumors of the uterus	C55.x00	3	0.08
91	Bronchial Malignant Tumor	C34.901	3	0.08
92	Paroxysmal atrial fibrillation	I48.x00x021	3	0.08
93	Asphyxia caused by inhalation of foreign objects	T17.901	3	0.08
94	Malignant tumor of pancreatic tail	C25.200	3	0.08
95	Malignant tumors with unclear digestive system location	C26.900	3	0.08
96	Cervical Malignant Tumor	C53.900	3	0.08
97	Obstructive jaundice	K83.109	3	0.08
98	Common bile duct stones with cholangitis	K80.302	3	0.08
99	Malignant tumors of the nasopharynx	C11.900	3	0.08
100	Diffuse large B-cell lymphoma	C83.306	3	0.08
101	Chronic obstructive pulmonary disease with acute lower respiratory tract infection	J44.000	3	0.08
102	Subdural hemorrhage	I62.000	3	0.08
103	Subacute myocardial infarction	I21.900x017	3	0.08
104	Shock	R57.900	3	0.08
105	Angina pectoris	I20.900	3	0.08
106	Diabetes nephropathy	E14.200x210 +N08.3*	3	0.08
107	Malignant tumor of renal calices	C65.x02	3	0.08
108	Malignant tumors of the renal pelvis	C65.x00	3	0.08
109	Breast Malignant Tumor, Lateral	C50.804	3	0.08
110	Breast Malignant Tumor, Medial	C50.803	3	0.08
111	Systemic widespread secondary malignant tumors	C80.x03	3	0.08
112	Chronic pulmonary heart disease	I27.900x002	3	0.08
113	Malignant lymphoma of the neck	C85.900A	3	0.08
114	Acute respiratory failure	J96.000	3	0.08
115	Acute cholecystitis	K81.000	3	0.08
116	Acute intestinal infarction	K56.700x011	3	0.08
117	Ampullary tumor	D37.607	3	0.08
118	Ampullary carcinoma	C23.x00A	3	0.08
119	Decompensated period of posthepatitic cirrhosis	K74.605	3	0.08
120	Secondary malignant tumor of abdominal cavity	C79.809	3	0.08
121	Malignant tumor of pulmonary hilum	C34.001	3	0.08
122	Malignant ascites	C78.604	3	0.08
123	Multiple organ dysfunction syndrome (MODS)	R65.301	3	0.08
124	Arteriosclerotic encephalopathy	I67.201	3	0.08
125	Malignant tumors of the common bile duct	C24.003	3	0.08
126	Cholangiocarcinoma	C22.101M81600/3	3	0.08
127	Intracerebral hemorrhage in the cerebral hemisphere, subcortical	I61.000	3	0.08
128	Sudden death	R96.000x001	3	0.08
129	Traumatic subdural hemorrhage	S06.500	3	0.08
130	Renal insufficiency	N19.x00x002	3	0.08
131	Schistosomiasis cirrhosis of liver	K74.622	2	0.05
132	Malignant tumor of thymus	C37.x00	2	0.05

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Table 2 (Continued).

Sort	Causes of Hospital Death	ICD-10	Number of Cases	Percentage (%)
133	Lower gastrointestinal bleeding	K92.209	2	0.05
134	Malignant tumor of gastric antrum	C16.301	2	0.05
135	Gastrointestinal Malignant Tumors	C26.901	2	0.05
136	Malignant tumor of the ureter	C66.x00	2	0.05
137	Pelvic Malignant Tumor	C76.300	2	0.05
138	Sepsis	A41.901	2	0.05
139	Malignant tumors of the cecum	C18.000	2	0.05
140	Chronic colitis	K52.910	2	0.05
141	Paralytic intestinal obstruction	K56.000	2	0.05
142	Acute renal failure, uremic phase	N17.900A	2	0.05
143	Acute biliary pancreatitis, mild	K85.101	2	0.05
144	Malignant tumors in the ileocecal region	C18.001	2	0.05
145	Malignant tumors of the larynx	C32.900	2	0.05
146	Abdominal Malignant Tumor	C76.200	2	0.05
147	Pulmonary embolism	I26.900x001	2	0.05
148	Non Hodgkin's lymphoma	C85.900	2	0.05
149	Common bile duct stones with acute cholangitis	K80.304	2	0.05
150	Congestive heart failure	I50.000	2	0.05
151	Myelodysplastic syndrome	D46.900	2	0.05
152	Malignant melanoma of the foot	C43.707	2	0.05
153	Malignant tumors of the mediastinum	C38.300	2	0.05
154	Decompensation period of liver cirrhosis after autoimmune hepatitis	K74.604	2	0.05
155	Liver cirrhosis after autoimmune hepatitis	K74.600x048	2	0.05
156	Subdural hematoma	I62.001	2	0.05
157	Pancreatic Tumor	D37.706	2	0.05
158	Malignant tumor of pancreatic body	C25.100	2	0.05
159	Malignant tumors of the lumbar spine	C41.203	2	0.05
160	Malignant tumors of the chest	C76.100	2	0.05
161	Heart valve disease	I38.x01	2	0.05
162	Cardiogenic shock	R57.000	2	0.05
163	Small intestinal obstruction	K56.700x013	2	0.05
164	Malignant tumors of the small intestine	C17.900	2	0.05
165	Inhalation pneumonia due to gastric secretions	J69.001A	2	0.05
166	Gastric tumor	D37.101	2	0.05
167	Specifically referring to acute gastritis	K29.100x001	2	0.05
168	Pneumonia caused by food and vomit	J69.000	2	0.05
169	Nephropathy	N28.901	2	0.05
170	Malignant tumors of the kidney (excluding the renal pelvis)	C64.x00	2	0.05
171	Perforation of upper digestive tract	K27.503	2	0.05
172	Malignant tumor of parotid gland	C07.x00	2	0.05
173	Cerebral embolism	I63.402	2	0.05
174	Cerebral hernia	G93.501	2	0.05
175	Sequela of cerebral hemorrhage	I69.100x001	2	0.05
176	Malignant tumors of the face	C76.001	2	0.05
177	Chronic renal failure	N18.900B	2	0.05
178	Intracranial space occupying lesions	R90.000	2	0.05
179	Dilated cardiomyopathy	I42.000	2	0.05
180	Malignant tumors of the oral cavity	C06.900x001	2	0.05
181	Acute left heart failure	I50.101	2	0.05

(Continued)

Table 2 (Continued).

Sort	Causes of Hospital Death	ICD-10	Number of Cases	Percentage (%)
182	Acute inferior right ventricular myocardial infarction	I21.207	2	0.05
183	Acute gastric mucosal lesions	K31.904	2	0.05
184	Acute renal failure	N17.900	2	0.05
185	Acute upper gastrointestinal bleeding	K92.207	2	0.05
186	Acute ST segment elevation myocardial infarction	I21.300x004	2	0.05
187	Basal ganglia hemorrhage	I61.004	2	0.05
188	Intertrochanteric fracture of femur	S72.101	2	0.05
189	Abdominal infection	K65.903	2	0.05
190	Retroperitoneal malignant tumor	C48.000x001	2	0.05
191	Lung Tumor	D38.101	2	0.05
192	Secondary malignant tumor of the lung	C78.000x011	2	0.05
193	Malignant tumor of Vater's ampulla	C24.100	2	0.05
194	Malignant pleural effusion	C78.201	2	0.05
195	Pernicious anemia	D51.001	2	0.05
196	Hypoglycemic encephalopathy	E16.108+G94.8*	2	0.05
197	Hypoglycemic coma encephalopathy	E16.107+G94.8*	2	0.05
198	Common bile duct stones with acute suppurative cholangitis	K80.301	2	0.05
199	Choledocholithiasis	K80.501	2	0.05
200	Gallstone	K80.200x003	2	0.05
201	Malignant pituitary tumors	C75.100	2	0.05
202	Unstable angina pectoris	I20.000	2	0.05
203	Nasal malignant tumor	C30.000	2	0.05
204	Sepsis	A41.900	2	0.05
205	Type 2 diabetes nephropathy	E11.201+N08.3*	2	0.05
206	Type 2 diabetes hypoglycemic coma	E11.002	2	0.05
207	Type 2 diabetes	E11.900	2	0.05
208	Multiple fractures of ribs	S22.400	2	0.05
209	Secondary malignant tumors of the brain	C79.300x002	2	0.05
210	Secondary malignant tumors of the liver	C78.700x011	2	0.05
211	Secondary malignant tumors of the vertebral body	C79.500x006	1	0.03
212	Vertebrobasilar artery insufficiency	G45.002	1	0.03
213	Rupture of aortic dissecting aneurysm	I71.001	1	0.03
214	Aortic valve stenosis	I35.000	1	0.03
215	Aortic valve insufficiency	I35.100	1	0.03
216	Subarachnoid hemorrhage	I60.900	1	0.03
217	Severe anemia	D64.903	1	0.03
218	Bronchial Asthma, Non Critical	J45.903	1	0.03
219	Bronchiectasis with hemoptysis	J47.x01	1	0.03
220	Malignant tumors of the pyloric duct	C16.402	1	0.03
221	Stress ulcer	K27.902	1	0.03
222	Malignant tumors of the vagina	C52.x00	1	0.03
223	Sigmoid colon tumor	D37.409	1	0.03
224	Space occupying lesions of the pancreas	R93.302	1	0.03
225	Adenocarcinoma of the ampulla of the pancreas	C24.100A	1	0.03
226	Malignant tumor of the pancreatic body and tail	C25.801	1	0.03
227	Malignant tumor of the throat	C14.001	1	0.03
228	Malignant tumors of the pharynx	C14.000	1	0.03
229	Circulatory failure	R57.901	1	0.03
230	Schistosomiasis induced cirrhosis	B65.202+K77.0*	1	0.03

(*Continued*)

Table 2 (Continued).

Sort	Causes of Hospital Death	ICD-10	Number of Cases	Percentage (%)
231	Hypovolemic shock	R57.100	1	0.03
232	Pleural effusion	J94.804	1	0.03
233	Malignant tumors of the chest and esophagus	C15.100	1	0.03
234	Cardiorespiratory failure	R09.201	1	0.03
235	Cardiac Malignant Tumor	C38.000	1	0.03
236	Ventricular fibrillation	I49.001	1	0.03
237	Myocardial infarction	I21.900x011	1	0.03
238	Malignant tumor of the lower leg skin	C44.703	1	0.03
239	Cerebellar infarction	I63.904	1	0.03
240	Cerebellar hemorrhage	I61.400x001	1	0.03
241	Digestive organs, other dynamically uncertain or unknown tumors	D37.700	1	0.03
242	Restrictive cardiomyopathy, other	I42.500	1	0.03
243	Lower limb deep vein thrombosis	I80.207	1	0.03
244	Lower limb ulcer	L97.x00	1	0.03
245	Malignant tumors of the lower limbs	C76.500	1	0.03
246	Malignant melanoma of the lower limbs	C43.700x001	1	0.03
247	Malignant tumors of connective tissue and soft tissue in the lower limbs (including the hip)	C49.200	1	0.03
248	Malignant tumor of the lower pharynx	C13.900	1	0.03
249	Gastric carcinoma in situ	D00.200	1	0.03
250	Malignant tumor of gastric body	C16.200	1	0.03
251	Gastric stromal cell tumor	C16.900B	1	0.03
252	Tumors with uncertain or unknown gastric motility	D37.100	1	0.03
253	Malignant tumor of gastric curvature	C16.600	1	0.03
254	Gastric perforation	K31.814	1	0.03
255	Gastrointestinal dysfunction	K92.901	1	0.03
256	Unspecified type of non Hodgkin's lymphoma	C85.700	1	0.03
257	Complete right bundle branch block	I45.102	1	0.03
258	Complete intestinal obstruction	K56.700x003	1	0.03
259	Vulvar malignant tumor	C51.900	1	0.03
260	Mantle cell lymphoma	C83.812M96730/3	1	0.03
261	Scalp laceration	S01.001	1	0.03
262	Malignant tumors of the head	C76.000x002	1	0.03
263	Specific T-cell lymphoma	C84.506	1	0.03
264	Idiopathic acute pancreatitis	K85.000	1	0.03
265	Malignant tumors of the fallopian tubes	C57.000	1	0.03
266	Preoperative chemotherapy for malignant tumors	Z51.101	1	0.03
267	Postoperative biliary tract infection	T81.404	1	0.03
268	Lack of appetite	R63.000	1	0.03
269	Malignant tumors of the middle and lower esophagus	C15.802	1	0.03
270	Duodenal bulb ulcer	K26.900x002	1	0.03
271	Hemorrhagic shock	R57.101	1	0.03
272	Ascending aortic aneurysm	I71.201	1	0.03
273	Malignant tumor of kidney and ureter	C68.801	1	0.03
274	Malignant tumor of the tongue base	C01.x00	1	0.03
275	Malignant tumor of the tongue	C02.900	1	0.03
276	Malignant tumors of upper limb connective tissue and soft tissue	C49.100	1	0.03
277	Bedsore	L89.900	1	0.03
278	Cerebral infarction caused by thrombosis of the anterior cerebral artery	I63.000	1	0.03

(Continued)

Table 2 (Continued).

Sort	Causes of Hospital Death	ICD-10	Number of Cases	Percentage (%)
279	Breast Malignant Tumor, Lower Part	C50.802	1	0.03
280	Breast Malignant Tumor, Upper Part	C50.801	1	0.03
281	Unspecified carcinoma in situ of the breast	D05.900	1	0.03
282	Hypoxic ischemic encephalopathy	G93.102	1	0.03
283	Ischemic cardiomyopathy	I25.500	1	0.03
284	Iron deficiency anemia	D50.900	1	0.03
285	Pancytopenia	D61.903	1	0.03
286	Systemic inflammatory response syndrome	R65.900	1	0.03
287	Thalamic hemorrhage	I61.802	1	0.03
288	Incarcerated inguinal hernia	K41.302	1	0.03
289	Intratracheal foreign body	T17.400	1	0.03
290	Malignant tumor of the spleen	C26.100	1	0.03
291	Malignant skin tumors	C44.900	1	0.03
292	Parkinson's disease dementia	G20.x02+F02.3*	1	0.03
293	Uremic encephalopathy	N18.806+G94.8*	1	0.03
294	Malignant meningeal tumors	C70.000	1	0.03
295	Brain stem injury	S06.901	1	0.03
296	Brainstem hemorrhage	I61.300x002	1	0.03
297	Membranous proliferative glomerulonephritis	N03.503	1	0.03
298	Urinary system tumors	D41.901	1	0.03
299	Disseminated intravascular coagulation	D65.x00x001	1	0.03
300	Portal hypertension	K76.600	1	0.03
301	Chronic obstructive bronchitis complicated with infection	J44.000x001	1	0.03
302	Chronic bronchitis	J42.x00	1	0.03
303	Chronic subdural hematoma	I62.003	1	0.03
304	Chronic heart failure	I50.908	1	0.03
305	Chronic gastric ulcer with bleeding and perforation	K25.600	1	0.03
306	Chronic gastric ulcer with bleeding	K25.400	1	0.03
307	Chronic kidney disease stage 3	N18.803	1	0.03
308	Chronic pyelonephritis	N11.900x001	1	0.03
309	Chronic renal insufficiency	N18.900x005	1	0.03
310	Chronic lymphocytic leukemia	C91.100	1	0.03
311	Chronic cholecystitis	K81.100	1	0.03
312	Intracranial hemorrhage	I62.900	1	0.03
313	Lymphatic, hematopoietic, and related tissue malignancies	C96.900	1	0.03
314	Malignant tumor of the appendix	C18.100	1	0.03
315	Observation of suspicious malignant tumors	Z03.100	1	0.03
316	Open specifically refers to composite body part injuries	T01.800x001	1	0.03
317	Open distal tibiofibular fracture	S82.311	1	0.03
318	Open intra-abdominal organ injury	S36.910	1	0.03
319	Alcoholic cirrhosis	K70.300	1	0.03
320	Malignant tumors of connective tissue and soft tissue	C49.900	1	0.03
321	Malignant tumors of the colon and rectum	C19.x01	1	0.03
322	Malignant tumor of colonic liver curvature	C18.300	1	0.03
323	Malignant lymphoma of colon	C85.900R	1	0.03
324	Strangulated intestinal obstruction	K56.201	1	0.03
325	Traffic hydrocephalus	G91.000	1	0.03
326	Malignant tumor of descending colon and sigmoid colon	C18.801	1	0.03
327	Interstitial emphysema	J98.200	1	0.03

(Continued)

Table 2 (Continued).

Sort	Causes of Hospital Death	ICD-10	Number of Cases	Percentage (%)
328	Hyperthyroid heart disease	E05.903+I43.8*	1	0.03
329	Malignant tumor of buccal mucosa	C06.000	1	0.03
330	Secondary peritonitis	K65.017	1	0.03
331	Spinal Tumors	D48.013	1	0.03
332	Malignant tumors of the spine	C41.200	1	0.03
333	Acute bronchitis	J20.900	1	0.03
334	Acute subdural hemorrhage	I62.002	1	0.03
335	Acute inferior myocardial infarction	I21.103	1	0.03
336	Acute gastric mucosal lesion with bleeding	K25.000A	1	0.03
337	Acute myeloid leukemia	C92.000x004	1	0.03
338	Acute duodenal ulcer with perforation	K26.100	1	0.03
339	Acute pyelonephritis	N10.x02	1	0.03
340	Acute renal insufficiency	N17.900x003	1	0.03
341	Acute anterior septal myocardial infarction	I21.003	1	0.03
342	Acute anterior wall myocardial infarction	I21.001	1	0.03
343	Acute cerebrovascular disease	I67.802	1	0.03
344	Acute necrotizing pancreatitis, severe	K85.818	1	0.03
345	Acute suppurative cholecystitis	K81.002	1	0.03
346	Acute obstructive suppurative cholecystitis	K81.007	1	0.03
347	Acute high wall myocardial infarction	I21.204	1	0.03
348	Acute leukemia	C95.000	1	0.03
349	Acute ST segment elevation type extensive anterior wall myocardial infarction	I21.004	1	0.03
350	Acute abdomen	R10.000	1	0.03
351	Myasthenia	G70.902	1	0.03
352	Amyotrophic lateral sclerosis (ALS)	G12.201	1	0.03
353	Mechanical intestinal obstruction	K56.604	1	0.03
354	Mixed liver cirrhosis	K74.600x022	1	0.03
355	Malignant lymphoma of the ileocecal region	C85.900x014	1	0.03
356	Malignant tumors of the ileum	C17.200	1	0.03
357	Secondary malignant tumors of respiratory organs	C78.306	1	0.03
358	Posterior circulation ischemia	G45.004	1	0.03
359	Secondary malignant tumors of bone and bone marrow	C79.500	1	0.03
360	Hypertensive kidney disease with renal failure	I12.000	1	0.03
361	Hypertension Phase III	I10.x05	1	0.03
362	Hyperkalemia	E87.500	1	0.03
363	Sjogren's syndrome	M35.000	1	0.03
364	Infectious systemic inflammatory response syndrome	R65.000	1	0.03
365	Liver cirrhosis with esophageal variceal rupture and bleeding	K74.615+I98.3*	1	0.03
366	Intrahepatic cholangiocarcinoma	C22.100	1	0.03
367	Malignant lymphoma of the liver	C85.900x011	1	0.03
368	Abdominal pain	R10.402	1	0.03
369	Abdominal cavity tumor	D48.714	1	0.03
370	Malignant lymphoma of abdominal cavity	C85.900X	1	0.03
371	Peritonitis	K65.900	1	0.03
372	Peritoneal mesothelioma	C45.100	1	0.03
373	Retroperitoneal tumor	D48.301	1	0.03
374	Retroperitoneal and secondary malignant tumors of the peritoneum	C78.600	1	0.03
375	Peritoneal Malignant Tumor	C48.200	1	0.03
376	Malignant tumors of the inguinal region	C76.304	1	0.03

(*Continued*)

Table 2 (Continued).

Sort	Causes of Hospital Death	ICD-10	Number of Cases	Percentage (%)
377	Malignant melanoma of the inguinal region	C43.504	1	0.03
378	Abdominal mass	R19.001	1	0.03
379	Malignant tumors of abdominal connective tissue and soft tissue	C49.400	1	0.03
380	Malignant tumor in the middle and lower lobe of the lung	C34.802	1	0.03
381	Malignant tumors in the middle and upper lobes of the lung	C34.801	1	0.03
382	Pulmonary space occupying lesions	R91.x03	1	0.03
383	Acute pulmonary heart disease not mentioned in pulmonary embolism	I26.900	1	0.03
384	Pulmonary artery embolism	I74.800x021	1	0.03
385	Atelectasis of lung	J98.101	1	0.03
386	Hypertrophic cardiomyopathy, other	I42.200	1	0.03
387	Atrioventricular block	I44.303	1	0.03
388	Polymyositis	M33.200	1	0.03
389	Multiple cerebral hemorrhage	I61.600x001	1	0.03
390	Multiple myeloma	C90.000	1	0.03
391	Transient ischemic attack	G45.900x001	1	0.03
392	Sinus tachycardia	R00.001	1	0.03
393	Epileptic status	G41.900	1	0.03
394	Hypoalbuminemia	E77.801	1	0.03
395	Common bile duct stones with chronic cholecystitis	K80.404	1	0.03
396	Gallstone intestinal obstruction	K56.300	1	0.03
397	Gallbladder occupying lesion	R93.204	1	0.03
398	Gallbladder stones with chronic cholecystitis	K80.101	1	0.03
399	Simple chronic anemia	D53.901	1	0.03
400	Metabolic encephalopathy	G93.403	1	0.03
401	Cerebral artery thrombotic infarction	I63.300	1	0.03
402	Cerebral artery embolism, cerebral infarction	I63.400	1	0.03
403	Escherichia coli enteritis	A04.401	1	0.03
404	Traumatic intracranial hemorrhage	S06.804	1	0.03
405	Traumatic acute subdural hemorrhage	S06.501	1	0.03
406	Hemorrhagic cerebral infarction	I63.903	1	0.03
407	Dementia	F03.x00	1	0.03
408	Old myocardial infarction	I25.200	1	0.03
409	Malignant lymphoma of mesentery	C85.900O	1	0.03
410	Mesenteric artery embolism with intestinal necrosis	K55.009	1	0.03
411	Residual gastritis	K29.701	1	0.03
412	Disseminated intravascular coagulation [defibrination syndrome]	D65.x00	1	0.03
413	Malignant melanoma of the nose	C43.302	1	0.03
414	Malignant tumors of the cardia and gastric body	C16.802	1	0.03
415	Malignant tumors of the cardia and fundus of the stomach	C16.801	1	0.03
416	Bladder tumor	D41.401	1	0.03
417	B-cell lymphoma	C85.100x031	1	0.03
418	Third degree atrioventricular block	I44.200	1	0.03
419	Type 2 diabetes ketoacidosis	E11.101	1	0.03

Notes: ICD-10, 10th edition of the International Classification of Diseases; *(Asterisk indicator): 10th edition of the International Classification of Diseases (ICD-10) stipulates that *(Asterisk indicator) is indicate the clinical manifestations of the disease.

The average age of old older patients group was 83.24 ± 3.66 years old, 1186 males and 1037 females. The top 5 diseases of death in old older patients group were pulmonary infection, chronic obstructive pulmonary disease, coronary heart disease, lung malignant tumor and gastric malignant tumors. The constituent ratio of the top 5 diseases was 17.1%, 9.0%, 7.0%, 6.9% and 4.5%, respectively (see Table 4).

Table 3 Etiological Analysis of In-Hospital Death of Young Older Patients Group (Aged 60 to 74) in Central Urban Areas of Shanghai

Sort	Causes of Hospital Death	ICD-10	Number of Cases	Percentage (%)
1	Lung malignant tumor	C34.900x001	131	12.2
2	Gastric malignant tumor	C16.900	121	11.3
3	Pancreatic malignant tumor	C25.900	74	6.9
4	Liver malignant tumor	C22.900	73	6.8
5	Pulmonary infection	J98.414	56	5.2
6	Rectal malignancy	C20.x00	50	4.7
7	Malignant tumor of colon	C18.900	39	3.6
8	Malignant tumor of breast	C50.900	37	3.5
9	Malignant tumor of bronchus or lung	C34.900	31	2.9
10	Malignant tumor of gallbladder	C23.x00	28	2.6

Note: ICD-10, 10th edition of the International Classification of Diseases.

Table 4 Etiological Analysis of In-Hospital Death of Old Older Patients Group (Aged 75 to 89) in Central Urban Areas of Shanghai

Sort	Causes of Hospital Death	ICD-10	Number of Cases	Percentage (%)
1	Pulmonary infection	J98.414	397	17.1
2	Chronic obstructive pulmonary disease	J44.900	201	9.0
3	Coronary heart disease	I25.103	156	7.0
4	Lung malignant tumor	C34.900x001	153	6.9
5	Gastric malignant tumor	C16.900	99	4.5
6	Aspiration pneumonia	J69.001	90	4.0
7	Cerebral infarction	I63.900	85	3.8
8	Malignant tumor of pancreas	C25.900	75	3.4
9	Malignant tumor of colon	C18.900	63	2.8
10	Malignant tumor of liver	C22.900	63	2.8

Note: ICD-10, 10th edition of the International Classification of Diseases.

The average age of very old patients group was 92.92 ± 2.79 years old, 250 males and 350 females. The top 5 diseases of death in very old patients group were pulmonary infection, chronic obstructive pulmonary disease, coronary heart disease, aspiration pneumonia and cerebral infarction. The constituent ratio of the top 5 diseases was 27.0%, 10.7%, 10.0%, 5.0% and 4.3%, respectively (see Table 5).

Table 5 Etiological Analysis of In-Hospital Death of Very Old Patients Group (Aged ≥90) in Central Urban Areas of Shanghai

Sort	Causes of Hospital Death	ICD-10	Number of Cases	Percentage (%)
1	Pulmonary infection	J98.414	162	27.0
2	Chronic obstructive pulmonary disease	J44.900	64	10.7
3	Coronary heart disease	I25.103	60	10.0
4	Aspiration pneumonia	J69.001	30	5.0
5	Cerebral infarction	I63.900	26	4.3
6	Acute upper gastrointestinal bleeding	K92.207	11	1.8
7	Acute attack of chronic bronchitis	J20.900x004	11	1.8
8	Malignant tumor of stomach	C16.900	11	1.8
9	Malignant tumor of pancreas	C25.900	11	1.8
10	Pulmonary malignant tumor	C34.900x001	7	1.2

Note: ICD-10, 10th edition of the International Classification of Diseases.

Discussion

Human beings have entered an aging society. How to improve the quality of life of the elderly and extend their life span is a very important problem that medical workers need to solve. Different age groups of older patients have different health status and immune function. Identifying the leading cause of in-hospital death of older patients of different age groups can improve the treatment level of older patients. It is of great significance in reducing the mortality of older patients.

Central urban areas of Shanghai are densely populated among which the elderly population accounts for a high proportion and most of them are concentrated. These older patients have high retirement income, good economic conditions and pay more attention to their own health care in their daily life. And there are more large general hospitals in the central urban area of Shanghai, which makes it convenient for the elderly to go to large general hospitals with advanced medical equipment and well-known medical experts. They can have regular physical examination at ordinary times to find diseases in time. If the elderly are sick, they can get timely diagnosis and treatment. But, there is serious air pollution caused by automobile exhaust in the central urban area of super large city. Therefore, older people in the central urban area are more likely to suffer from lung diseases such as malignant tumor and pulmonary infection. The disease spectrum of older people in the central urban area has unique characteristics which is different from that of small and medium-sized cities.

In addition to the long-term lung injury of older patients caused by air pollution, smoking is also the leading cause of lung injury in older male patients in central urban area of mega city. China has high rates of lung cancer due to smoking. According to "China Smoking Hazards Report 2020", the number of smokers in China exceeds 300 million. The smoking rate among people aged 15 and above is 26.6%, with a high male smoking rate of 50.5% in China. The smoking rate among teenagers is 6.0%, and the attempted smoking rate is 19.9%. Eighty percent of adolescent smokers will continue to smoke in adulthood and find it difficult to quit. According to report statistics, tobacco causes over 1 million deaths in China every year, with over 100,000 deaths due to exposure to second-hand smoke. In the study of Xu et al, it was found that smoking and environmental pollution combine to account for the elevated rates of lung cancer mortality in Shenyang, a mega city in northeast China.[9]

In the study of Wang et al, it was found that NO2 in the air was significantly associated with the risk of lung cancer, followed by SO2. Air pollutants have the strongest lag effect on the incidence and mortality of lung cancer within 2–3 years.[10] Air pollution and smoking are the main reasons for older male patients to suffer from lung infection, lung tumor and chronic obstructive pulmonary disease. Therefore, young male citizens should be encouraged not to develop the unhealthy habit of smoking. Middle aged and elderly male citizens who have formed smoking habits should quit smoking in time. Quitting smoking can significantly reduce the risk of male citizens suffering from lung malignant tumor and pulmonary infection so as to reduce the mortality in older male patients.

In this study, it was found that pulmonary infection is the leading cause of death in old older patients with a constituent ratio of 15.3%, which is significantly higher than other diseases leading to death. Chronic obstructive pulmonary disease was the second cause, and lung malignant tumor was the fourth cause of death in old older patients. Pulmonary infection and chronic obstructive pulmonary disease have increased significantly in recent years. The increase in the number of smokers and the younger age of smokers are the main reasons. Prevention of pulmonary infection is more important than treatment. We should attach great importance to the prevention and treatment of pulmonary infection, especially for old older patients with long-term smoking history, advocate old older patients to quit smoking or minimize smoking.

Older patients are prone to lung infections due to their weakened immune system. Therefore, older patients should engage in physical exercise, enhance their immunity, pay attention to warmth, prevent coldness, and prevent lung infections. For older patients who are bedridden for a long time, it is easy to cause lung infections if the sputum in the lungs cannot be eliminated in a timely manner. It is necessary to strengthen the care of elderly patients, often turning over and patting their backs to help them expel phlegm. When eating, older patients should be careful to avoid choking and coughing to prevent food from entering the lungs which may cause lung infections.

Older patients should pay more attention to a balanced diet, eat more fresh fruits and vegetables, quit smoking and drinking, and avoid long-term exposure to dusty environments to prevent lung infections. If older patients experience uncomfortable symptoms such as coughing and fever, timely treatment should be given to avoid delaying the condition and leading to severe pneumonia, which may cause death in older patients.

Chronic obstructive pulmonary disease (COPD) is the result of the gradual onset of long-term inflammation of chronic bronchitis. This disease has a long course and cannot heal repeatedly which seriously affects the quality of life of older patients. The recurrence of chronic bronchitis should be controlled in the middle age of patients. At the same time, patients in this age group should change the bad living habits of smoking, avoiding the inhalation of second-hand smoke. The recurrence of chronic bronchitis should be controlled in the middle age of patients. It is also very important to control air pollution in the central urban area in Shanghai.

In this study, lung malignant tumor was the fourth cause of death in old older patients group which may be related to air pollution and smoking. Therefore, controlling air pollution and quitting smoking are of great importance for old older patients. We should also pay attention to the prevention and treatment of lung cancer.

In this study, the average age of hospitalized patients in very old patients group was 92.92 ± 2.79 years old, and pulmonary infection was found to be the top 1 cause of death in very old patients group, which was the same as that in old older patients group. More attention should be paid to the prevention of pulmonary infection for very old patients.

In this study, it was found chronic obstructive pulmonary disease was the second cause of death in old older patients and in very old patients group. Therefore, we should take timely and effective treatment measures to treat older patients with pulmonary infection and chronic obstructive pulmonary disease. Clinicians should attach great importance to prevent chronic obstructive pulmonary disease from developing into cor pulmonale and pulmonary encephalopathy which can result in the death of very old patients.

In this study, it was found that aspiration pneumonia is the fourth major cause of in-hospital death of very old patients group. This is because very old patients belong to the older patients in the super older group. Their nervous system function decreases significantly, resulting in insensitive swallowing reflex. It is easy for very old patients to inhale food into the trachea by mistake when eating food and resulting in aspiration pneumonia. The symptoms of aspiration pneumonia are very serious and the very old patient may have high fever, severe cough, and even bacteremia which can result in the death. Therefore, very old patients should pay great attention to avoid mistakenly inhaling food into the respiratory tract when eating. It is a better solution to placing a gastric tube in the patient's esophagus and injecting food into the patient's stomach through the gastric tube which can greatly avoid the occurrence of aspiration pneumonia in very old patients. It can improve the quality of life and prolong the life of very old patients. We found this is a very effective measure to prevent aspiration pneumonia in very old patients and may be popularized in daily clinical work of other regions.

Doctors usually decide whether to perform this invasive operation on very old patients after fully evaluating the potential benefits and damages of placing a gastric tube based on the actual situation of very old patients. Placing a gastric tube is mainly used in very old patients with senile dementia who are unable to swallow normally and patients who are unable to eat orally and critically ill individuals. Patients with upper gastrointestinal bleeding, nasopharyngeal cancer, acute inflammation, and heart failure are not suitable for inserting a gastric tube, which can easily worsen the disease. Inserting a gastric tube requires guidance from a doctor to avoid damage to the throat and stomach.

Gee et al conducted continuous autopsy on 3000 older inpatients and found bronchopneumonia and malignant tumors of digestive system and lung were the most common diseases leading to death of these older inpatients.[4] They believed that there is an increased frequency of multiple pathological processes in a given subject and interactions play an important role in morbidity and mortality with the advancing age of older inpatients. Brandt et al conducted a prospective study on the diseases leading to the death of older inpatients and evaluated the direct causes of death of all older inpatients in the Netherlands. It was found most older inpatients died of pneumonia.[5] They concluded that many older patients spent unconscious or conscious with one or more burdensome symptoms in the last days of life which suggests the potential for improvement of symptom management. The above two findings are the same as our findings. In our study, we found lung infection and lung malignant tumor and COPD are the top three leading causes of death of older inpatients. For old older patients group and very old patients group, pulmonary infection was the leading cause of death.

In the study of Goldberg et al, they studied the causes of the death of older patients in geriatric nursing homes in the United States and found the diseases leading to the death of older patients in geriatric nursing homes are Alzheimer's/dementia, cardiac/cerebrovascular and pulmonary.[6] This research result is different from ours since the geriatric nursing home in the United States is not a formal general hospital. There are less medical experts in various clinical disciplines and advanced medical equipment. Compared with the large-scale general hospital in our study, there is an obvious gap in

the treatment level of various elderly diseases and medical equipment. In geriatric nursing homes in the United States, the nursing of older patients is conducted by nurses who cannot meet the medical needs of older patients since they have less clinical experience compared with doctors and nurses in large general hospitals and unable to treat older patients in time.

Abdel-Karim et al studied the causes of death of older patients receiving hospice care in San Antonio, Texas, USA and found pneumonia was the main cause of death of older patients receiving hospice care.[7] The results of this study are the same as that of ours because the general condition of older patients who need hospice care is poor and these older patients usually suffered from cancer and other severe diseases with low immunity and mal-nutritional status. So, they are prone to severe lung infections such as pneumonia which can lead to death of these older patients.

In the study of Braggion et al, they conducted research on the diseases that led to the death of 19,392 older patients (≥65 years old) who were hospitalized in the elderly nursing home for a long time in the Veneto region of northeastern Italy. It was found that respiratory diseases and infections were the main causes of death of older patients hospitalized in the elderly nursing home.[8] The results of this study are similar to our results because the older patients hospitalized for a long time in the elderly nursing home were in a state of low immune function and usually suffered from various complications. These older patients were prone to respiratory diseases and infections. Ferorelli et al found that the main causes of death of older patients in Italy are cardiovascular diseases and tumors, infectious diseases and parasitic diseases are the third leading causes of death, and the main reason is the high incidence of nosocomial infection in European hospitals.[11] Among them, pulmonary infection was the main cause of death in older patients. In the study of Guido et al, they conducted a research on the main causes of death of older patients with COVID-19 (mean age 79.6 ± 0.9 years old). After multivariate analysis, it was showed that older patients with COPD were one of the most common risk factors for mortality of older patients with COVID-19.[12] COPD is a chronic disease in the elderly caused by lung infection and inflammation. The results of the study of Guido et al demonstrated that chronic lung infection in the elderly may become one of the main risk factors for mortality of old patients with COVID-19.

Klima et al have studied the causes of death of older patients in the Czech Republic and found that infection and heart disease were the main causes of death of older patients, of which pulmonary infection is the main cause of death of older patients. They especially emphasize the importance of autopsy in identifying the causes of death of older patients.[13] This result is similar to that of our study.

In the study of Bordin et al, they analyzed the main causes of death of extreme-aged hospitalized people (aged 97–106 years) in Italy retrospectively and found that pneumonia was the main cause of death of extreme-aged hospitalized people and clinicians significantly underestimated pneumonia on death in extreme-aged hospitalized people.[14] The results of this study are similar to our results. In our study, it was found that pulmonary infection was the leading cause of death of very old patients group. This is because very old patients are in a state of hypoimmunity and the defense ability of respiratory tract is low. Once very old patients have pulmonary infection, it is difficult to control due to low immunity and are easy to lead to acute heart failure and acute renal failure which can further lead to multiple organ dysfunction syndrome (MODS) and death of very old patients.

Lung is an internal organ that directly contacts the external environment and is easy to be infected. The risk of pulmonary infection in very old patients is higher than that in young people, especially those very old patients with cardiovascular diseases, diabetes, cancer, and those who are in bed for a long time. If pulmonary infection of very old patients is not controlled timely and effectively, it can develop into severe pneumonia, leading to respiratory failure and death. Very old patients with pneumonia have a high probability of serious complications which is the main reason for the high mortality. If pulmonary infection is not controlled timely and effectively, it can develop into severe pneumonia and lead to respiratory failure and death. So, timely medical treatment should be taken immediately to control pulmonary infection in very old patients. The main treatment of pneumonia is anti-infection. Since the extensive use of antibiotics in recent years, bacteria have developed considerable drug resistance. Pneumococcal vaccination for the elderly can obtain immunity against pulmonary infection which has been considered as an important measure adopted by many developed countries.

Although vaccination against pneumonia is the most effective way to prevent pneumonia of older patients, the vaccination rate of pneumonia vaccine for the older people is relatively low in many countries. The older people have low awareness of pneumonia and have no awareness of the prevention of pneumonia. Older people should be actively vaccinated against pneumonia to prevent pneumonia to protect their health.

In the study of Berzlanovich et al, they studied the causes of death of older inpatients in Vienna, Austria. They found respiratory diseases were the second most common cause of death of older inpatients while urogenital and metabolic diseases are not common.[15] This research result is similar to that of ours because Vienna is the capital and the most populous city in Austria. It is the main cultural center in Europe with dense population, which is similar to that of the central urban area in our study. Brook et al studied the causes of death of 1226 older psychiatric patients in the Netherlands and found respiratory diseases are the main cause of death.[16] This result is similar to ours. Older psychiatric patients usually have low immunity and poor self-care ability and are prone to pulmonary infection. Although with different ICD-10 code, pulmonary infection, pneumonia, and severe pneumonia are difficult to distinguish in clinic. But they all belong to respiratory diseases. If these three diseases were combined and counted in ICD-10 code of respiratory diseases, it may increase the proportion of respiratory diseases in the study of inpatient deaths in older patients.

In the study of Ang et al, they found that the most common causes of death of non-hospitalized older people in Singapore after discharge are malignant tumors and cerebrovascular diseases.[17] The result of this study is different from that of our study. This is because the object of this study is the non-hospitalized older people who were not treated in large general hospital or geriatric nursing homes, so it is impossible to make early diagnosis of tumor and carry timely treatment for the diseases leading to death of older patients. Therefore, malignant tumors and cerebrovascular diseases became the main causes of death for the non-hospitalized elderly in Singapore.

The above clinical studies were carried out in economically developed countries in Europe and Asia. They analyzed the causes of death of elderly patients in economically developed countries. Their research results were similar to ours. Pulmonary infection and cardiovascular disease are the main causes of death of older inpatients. This is because our research is carried out in the central urban area of mega city. The current economic development level and people's living standard are the same as those of developed countries. However, compared with the developing countries, the main causes of death of older patients are significantly different and require further research. In the study of Alam et al, they studied the causes of death of older patients (≥60 years old) in a developing country and found that infectious diseases accounted for 18% and non-communicable diseases accounted for 66%. The main non-communicable diseases were circulatory diseases, tumors, respiratory diseases and digestive disease.[18] The results of this study were different from ours. This may be mainly because this study was conducted in an economically underdeveloped region with relatively backward medical conditions and relatively poor sanitary conditions. Therefore, infectious diseases account for a high proportion of the causes of death of older patients.

In the study of Olubuyide et al, they conducted a ten-year study on the main causes of the death of older patients (≥60 years old) in a tropical African country (Nigeria) and found that the leading cause of death in older patients is cancer, heart disease and infectious diseases.[19] This research result is different from ours. This is mainly because Nigeria is an underdeveloped country in Africa. The proportion of total national health expenditure in gross domestic product (GDP) is low, and the health-care system is imperfect. Therefore, cancer, heart disease and infectious diseases are the main causes of death in older patients. This may be due to the differences in economic development and the level of health-care system among different countries.

In the study of Huang et al, it was found that hypochloremia is mildly common in patients with coronary artery disease and is associated with increased short- and long-term mortality.[20] In clinical practice, hypochloremia is generally not given enough attention by clinical doctors. This study found that hypochloremia increased short- and long-term mortality of patients. This is an important clinical research result with significant clinical value. Clinicians should attach great importance to the treatment of hypochloremia to avoid patients dying due to hypochloremia.

We analyzed the results of our study with other studies from other countries mentioned above and found some valuable results. It was found that lung malignant tumor and pulmonary infection including pneumonia were the leading cause of death of older patients, as shown in Table 6.

There are some limitations in this study. This study is a single-center study with a relatively small number of older patients and a relatively short observation time. More patients of multiple centers and longer observation time will be conducted in the future.

Table 6 Comparison of Leading Causes of In-Hospital Death of Older Patients Between the Results in Our Study and Other Studies in Other Countries

Study	Reference List Number in this Paper	Studies in Different Countries	Age of the Older Patients	Leading Causes of In-Hospital Death of Older Inpatients
In the study of Gong Y, et al	In this study	Shanghai, China	≥60 years old	Lung malignant tumor for young older patients (aged 60 to 74) Pulmonary infection for old older patients (aged 75 to 89) Pulmonary infection for very old patients (aged≥90)
In the study of Gee, et al	4th reference	Geneva, Switzerland		Bronchopneumonia and malignant tumors of digestive system and lung
In the study of Brandt, et al	5th reference	Amsterdam, The Netherlands		Pneumonia, renal failure or dehydration
In the study of Goldberg, et al	6th reference	The United States		Alzheimer's/dementia, cardiac/cerebrovascular and pulmonary
In the study of Abdel-Karim, et al	7th reference	San Antonio, Texas, USA		Pneumonia
In the study of Braggion, et al	8th reference	Veneto region of northeastern Italy	≥65 years old	Respiratory diseases and infections
In the study of Ferorelli, et al	11th reference	Italy		Cardiovascular diseases and tumors, infectious diseases and parasitic diseases are the third leading causes of death
In the study of Guido, et al	12th reference	Italy	Mean age 79.6±0.9 years old	Chronic lung infection
In the study of Klima et al	13th reference	Czech Republic		Pulmonary infection
In the study of Bordin, et al	14th reference	Italy	Aged 97–106 years	Pneumonia
In the study of Berzlanovich, et al	15th reference	Vienna, Austria		Respiratory diseases were the second most common cause of death of older inpatients
In the study of Brook, et al	16th reference	Netherlands		Respiratory diseases
In the study of Ang, et al	17th reference	Singapore		Malignant tumors and cerebrovascular diseases
In the study of Alam, et al	18th reference	Bangladesh	≥60 years old	Circulatory diseases, tumors, respiratory diseases and digestive disease
In the study of Olubuyide et al	19th reference	African country (Nigeria)	≥60 years old	Cancer, heart disease and infectious diseases

Conclusions

Lung malignant tumor was found to be the leading cause of in-hospital death of young older patients, and pulmonary infection was the leading cause of in-hospital death of old older patients and very old patients in central urban area of Shanghai. Great importance should be attached to the prevention of lung tumor and lung infection in the elderly. Results of this study will provide a basis for health administrative departments to formulate corresponding health-care policies for older patients. This study is a single-center study with a relatively small number of patients. Studies with more patients of multiple centers will be conducted in the future.

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Disclosure

The authors report no conflicts of interest in this work.

References

1. Aronow WS. Clinical causes of death of 2372 older persons in a nursing home during 15-year follow-up. *J Am Med Dir Assoc*. 2000;1(3):95–96.
2. Cordeiro P, Martins M. Hospital mortality in older patients in the Brazilian unified health system, Southeast region. *Rev Saude Publica*. 2018;69. doi:10.11606/S1518-8787.2018052000146
3. Adebusoye LA, Owolabi M, Ogunniyi A. Predictors of mortality among older patients in the medical wards of a tertiary hospital in Nigeria. *Aging Clin Exp Res*. 2019;31(4):539–547. doi:10.1007/s40520-018-0997-7
4. Gee WM. Causes of death in a hospitalized geriatric population: an autopsy study of 3000 patients. *Virchows Arch a Pathol Anat Histopathol*. 1993;423(5):343–349. doi:10.1007/BF01607146
5. Brandt HE, Ooms ME, Deliens L, et al. The last two days of life of nursing home patients--a nationwide study on causes of death and burdensome symptoms in the Netherlands. *Palliat Med*. 2006;20(5):533–540. doi:10.1191/0269216306pm1164oa
6. Goldberg TH, Botero A. Causes of death in older nursing home residents. *J Am Med Dir Assoc*. 2008;9(8):565–567. doi:10.1016/j.jamda.2008.04.011
7. Abdel-Karim IA, Sammel RB, Prange MA. Causes of death at autopsy in an inpatient hospice program. *J Palliat Med*. 2007;10(4):894–898. doi:10.1089/jpm.2006.0240
8. Braggion M, Pellizzari M, Basso C, et al. Overall mortality and causes of death in newly admitted nursing home residents. *Aging Clin Exp Res*. 2020;32(2):275–280. doi:10.1007/s40520-019-01441-x
9. Xu ZY, Blot WJ, Xiao HP, et al. Smoking, air pollution, and the high rates of lung cancer in Shenyang, China. *J Natl Cancer Inst*. 1989;81 (23):1800–1806. doi:10.1093/jnci/81.23.1800
10. Wang W, Meng L, Hu Z, et al. The association between outdoor air pollution and lung cancer risk in seven eastern metropolises of China: trends in 2006–2014 and sex differences. *Front Oncol*. 2022;12:939564. doi:10.3389/fonc.2022.939564
11. Ferorelli D, Donno F, De Giorgio G, et al. Study of determinants in deaths occurring in an Italian teaching hospital during a year. *Clin Ter*. 2020;171 (3):e245–252. doi:10.7417/CT.2020.2222
12. Iaccarino G, Grassi G, Borghi C, et al. Age and multimorbidity predict death among covid-19 patients: results of the sars-ras study of the Italian society of hypertension. *Hypertension*. 2020;76(2):366–372. doi:10.1161/HYPERTENSIONAHA.120.15324
13. Klima MP, Povysil C, Teasdale TA. Causes of death in geriatric patients: a cross-cultural study. *J Gerontol a Biol Sci Med Sci*. 1997;52(4):M247– 253. doi:10.1093/gerona/52A.4.M247
14. Bordin P, Da Col PG, Peruzzo P, et al. Causes of death and clinical diagnostic errors in extreme aged hospitalized people: a retrospective clinical-necropsy survey. *J Gerontol a Biol Sci Med Sci*. 1999;54(11):M554–559. doi:10.1093/gerona/54.11.M554
15. Berzlanovich AM, Missliwetz J, Sim E, et al. Unexpected out-of-hospital deaths in persons aged 85 years or older: an autopsy study of 1886 patients. *Am J Med*. 2003;114(5):365–369. doi:10.1016/S0002-9343(03)00049-4
16. Brook OH. Mortality in the long-stay population of Dutch mental hospitals. *Acta Psychiatr Scand*. 1985;71(6):626–635. doi:10.1111/j.1600-0447.1985.tb02558.x
17. Ang YH, Wong SF, Chan KM. Predictive factors of post-discharge mortality in the hospitalised older. *Singapore Med J*. 2000;41(3):98–102.
18. Alam N, Chowdhury HR, Bhuiyan MA, et al. Causes of death of adults and older and healthcare-seeking before death in rural Bangladesh. *J Health Popul Nutr*. 2010;28(5):520–528. doi:10.3329/jhpn.v28i5.6161
19. Olubuyide IO, Solanke TF. The causes of death in an older African population. *J Trop Med Hyg*. 1990;93(4):270–274.
20. Huang H, Mai Z, Chen L, et al. Prevalence and mortality of hypochloremia among patients with coronary artery disease: a cohort study. *Risk Manag Healthc Policy*. 2021;14:3137–3145. doi:10.2147/RMHP.S306125