Research Square

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Economic burden of pertussis, its influencing factors, and hospitalization determinants among older adults (≥ 60 years) in Zhejiang, China: A cross-sectional study (2024–2025)

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Research Article

Keywords: Pertussis, Economic burden, Older adults, Influencing factors, Hospitalization

Posted Date: February 9th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-8311185/v1

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Additional Declarations: No competing interests reported.

Version of Record: A version of this preprint was published at BMC Public Health on October 8th, 2026. See the published version at https://doi.org/10.1186/s12889-026-29610-4.

Abstract

Backgroud

Pertussis resurgence is a growing global public health concern. In Zhejiang Province, China, reported pertussis cases surged 38-fold in 2024 compared to 2023, with 632 cases in adults ≥ 60 years—ranking highest nationwide. However, the economic burden of pertussis in this demographic remains unquantified in China, a gap that impedes optimizing prevention strategies for aging populations. We thus conducted a cross-sectional study in Zhejiang Province to assess this burden, identify its influencing factors, and explore hospitalization determinants, providing evidence for targeted pertussis control.

Methods

The research object from three prefecture-level cities (Hangzhou, Jiaxing, Jinhua) in Zhejiang Province, selected via stratified sampling based on gross domestic product (GDP). Data on sociodemographics, clinical features, and expenditures were collected via the China Infectious Disease Surveillance System, hospital information systems (HIS), and structured questionnaires. Economic burden was categorized as direct (medical/non-medical) and indirect (productivity loss). Statistical analyses included gamma distribution fitting (for right-skewed burden data), generalized linear models (GLM) for burden factors, and logistic regression for hospitalization determinants (SPSS 27.0).

Results

195 respondents were enrolled (response rate: 81.3%), the total economic burden was 1,366,260 Renminbi (RMB), with a per-case mean of 7,007 RMB (median: 1,819 RMB, IQR: 653–9,234 RMB). Direct costs accounted for 75.9%, dominated by medical expenses (69.3%), while indirect costs contributed 24.1%. Inpatients had a 13.6-fold higher burden than outpatients (median: 11,026 vs. 811 RMB, $P < 0.001$) .Multivariate GLM identified case type (Inpatients vs. outpatients, OR = 11.97, $P < 0.001$) was the strongest independent predictor of total economic burden, and the hospitalization rate reached 40.5%. Logistic regression revealed high-risk groups for hospitalization: rural residents (OR = 3.08, $P = 0.012$), elderly males (advanced age: OR = 1.15, $P < 0.001$; male: OR = 2.80, $P = 0.015$), and patients with complications (OR = 2.94, $P = 0.045$).Additionally, fever was both increases total economic burden and hospitalization rate (OR = 1.32/4.11, $P < 0.05$), the same with onset-to-diagnosis interval (OR = 1.02/1.04, $P < 0.05$).

Conclusion

Older adults with pertussis in Zhejiang Province face substantial economic burden, characterized by a prominent hospitalization-driven pattern and high hospitalization rate. Targeted interventions—shortening the onset-to-diagnosis interval, optimizing outpatient care for high-risk groups (elderly males, rural residents, febrile cases), reducing complications and unnecessary hospitalizations, and advancing immunization strategy research—may effectively alleviate this burden.

Backgroud

Pertussis, a vaccine-preventable acute respiratory infection, has severe cases often complicated by pneumonia and encephalopathy, imposing substantial disease burden globally[1]. Despite substantial pertussis vaccine coverage, the disease has resurged globally, with a notable elevation in reported cases among adolescents and adults[2, 3]. To elucidate the underlying drivers of this resurgence, characterizing its epidemiological patterns and health burden is paramount, and quantifying its economic burden is equally indispensable—as it serves as a pivotal determinant for prioritizing novel medical interventions amid the current public health landscape[4, 5]. However, existing evidence on the economic burden of pertussis is predominantly confined to infants and young children[6, 7], with scant research

conducted in adolescents and adults—especially older adults, for whom available studies have largely originated from the United States and Europe[8–10].Given the high prevalence of comorbidities in older adults and the relentless global aging demographic shift[11, 12], delineating the economic burden of pertussis in this cohort is crucial for guiding the scaling-up of vaccine implementation and the assessment of its potential integration into national immunization strategies[9, 13]. A systematic review by Kandeil W et al. highlighted that pertussis incidence in older adults is vastly underreported, leading to severe underestimation of its epidemiological and economic burden[14].

In China, pertussis incidence has risen steadily since 2014[15], specially a striking surge was observed in 2024, with over 490,000 reported cases nationwide[16]. Zhejiang Province, an economically developed region in eastern China with rapid population aging, reported 59,917 pertussis cases in 2024, representing a 38-fold increase from 2023 and ranking among the highest nationwide[17]. Notably, pertussis cases (≥ 60 years) also surged significantly (632 cases in 2024), which was markedly higher than other provinces[18]. To date, no data exist on the economic burden of pertussis in older adults in china. To address this gap, we conducted a cross-sectional survey in Zhejiang Province—where economic burden surveys of pertussis have previously been performed among infants and young children[19–21]—to assess the economic burden, identify its influencing factors, and provide evidence-based insights for optimizing pertussis prevention and control strategies among older adults.

Methods

1 Study subject Data on pertussis cases meeting the following criteria were retrieved from the Infectious Disease Surveillance System within the China Disease Prevention and Control Information System: onset date between January 1, 2024 and March 31, 2025, residence in Zhejiang Province, and age at onset ≥ 60 years. In this study, a multi-stage sampling method was adopted to recruit survey respondents. First, based on the per capita gross domestic product (GDP) of 11 cities in Zhejiang Province, these cities were categorized into economically developed, moderately developed, and underdeveloped regions. Subsequently, one prefecture-level city (i.e., Hangzhou, Jiaxing, and Jinhua) with a relatively high incidence of pertussis cases (≥ 60 years) was selected from each region as the survey site, and cases were subsequently enrolled using the random number method. Exclusion criteria: (1) individuals with altered mental status unable to communicate; (2) those unreachable by contact; (3) individuals refusing to participate in the survey. This study protocol was approved by the Ethics Committee of Zhejiang Provincial Center for Disease Control and Prevention (approval number: 2025-033-01). Prior to survey administration, surveyors informed respondents of the study purpose. After obtaining their understanding and full cooperation, written informed consent was signed by the respondents themselves or their legal guardians. Respondents were recruited between April and May 2025, and data collection and collation were conducted from June to September 2025.

Pilot study findings demonstrated that the total disease burden data of pertussis followed a gamma distribution with an estimated shape parameter (κ) of 0.3. To guarantee the coverage probability of the total disease burden, the sample size was calculated using the gamma distribution-based tolerance interval analysis module in PASS 2021 software. Under a 95% confidence level, the lower tolerance interval was required to cover at least 90% of the population data, with the probability of the actual coverage proportion exceeding 90% by more than 5% set as the upper limit-yielding a final required sample size of 189 cases. Accounting for the potential low questionnaire response rate in the elderly population, the sample size was inflated by 20%, resulting in a total planned sample size of ~ 227 cases, with 80 cases planned for each prefecture-level city.

2 Questionnaire survey A self-designed questionnaire (see Additional file 1) was used to conduct the economic burden survey, covering respondents' sociodemographic and clinical characteristics, and various expenses (e.g., medical, self-purchased medications, transport, nutritional and meal expenses, and caregiver service fees) incurred during outpatient/ emergency visits and hospitalization. Trained investigators conducted face-to-face case interviews with the

respondents. For those with unclear medical expense information, additional inquiries were made through the hospital information system (HIS) of the treating institutions. Questionnaires were collected and verified on-site.

3 Economic burden estimation The economic burden was categorized into direct and indirect components, analyzed from a societal perspective. Direct economic burden was further divided into direct medical and direct non-medical burdens: direct medical burden included total medical costs incurred by patients in healthcare institutions due to pertussis (e.g., outpatient registration, hospitalization, examinations, diagnostic and therapeutic services, nursing care, and medications) plus self-purchased medication expenses; direct non-medical burden included costs associated with supportive activities for patients and their families during illness period (e.g., transportation, nutritional and meal, and caregiver service). Indirect economic burden represented time loss costs due to pertussis, productivity loss was estimated using the method of human capital approach: based on the per capita GDP of surveyed prefecture-level cities (from the *2024 Zhejiang Statistical Yearbook*), daily productivity loss cost per city was calculated after a 3% discount. Indirect costs were not calculated for non-working or retired individuals. For employed outpatients and their hospital companions, indirect costs were computed based on 0.5 person-days; for employed inpatients, their hospital companions, and visitors, the costs were calculated at 1.0, 1.0, and 0.5 person-days respectively. The economic burden was quantified in Renminbi (RMB) for monetization.

4 Statistical analysis Data were collected and a database established using EpiData 3.1; collation and statistical analyses were done with Excel 2010 and SPSS 27.0.Sociodemographic and clinical characteristics were described as frequencies (n), proportions (%), or rates (%). Continuous, right-skewed, non-negative economic burden data were summarized as mean, median (interquartile range, IQR). Intergroup comparisons used the Wilcoxon rank-sum test (two groups) or Kruskal-Wallis H test (multiple groups). Correlation between two quantitative variables was assessed via Kendall's tau coefficient.A generalized linear model (GLM) with gamma distribution and log link function was used for multivariate analysis to identify factors associated with economic burden. Outliers were Winsorized at the 99th percentile; collinearity among independent variables was checked with variance inflation factors (VIFs). For hospitalization rate determinants, intergroup comparisons employed Pearson's Chi-square (χ^2) test; multivariate analysis for independent predictors used a logistic regression model .All tests were two-tailed at a = 0.05.

Result

1 Base information

1.1 Sociodemographic characteristics Overall, 195 respondents were enrolled (effective response rate: 81.3%, 195/240). Regarding demographic sociological characteristics distribution by subgroups, survey area: Hangzhou (29.8%), Jiaxing (33.3%), and Jinhua (36.9%); Residence type:rural (41.5%) and urban (58.5%); Age group: 60–69 years (55.4%), 70–79 years (31.3%), and ≥ 80 years (13.3%). Sex: males (41.5%) and females (58.5%); Education level: illiterate (19.5%), primary education (31.8%), lower secondary school (27.2%), and upper secondary school or above (21.5%); Medical insurance: resident (48.7%), employee (50.2%), and uninsured (0.1%); Underlying diseases: yes (61.5%) and no (38.5%). (Table 1).

Table 1
Basic information and economic burden

Variable	Group	n (%)	Direct economic burden (RMB)		Indirect economic burden (RMB)		Total economic burden (RMB)	
			Total cost (%)	Cost per case	Total cost (%)	Cost per case	Total cost (%)	Cost per case
Survey area	Hangzhou	58 (29.8)	161211 (15.5)	2779	57747(17.5)	996	218958(16.0)	3775
	jiaxing	65 (33.3)	380144 (36.7)	5848	155164(47.1)	2387	535308(39.2)	8235
	Jinhua	72 (36.9)	495204 (47.8)	6878	116790(35.4)	1622	611994(44.8)	8500
Residence type	Rural	81 (41.5)	645750 (62.3)	7972	201460(61.1)	2487	847210(62.0)	10459
	Urban	114 (58.5)	390809 (37.7)	3428	128241(38.9)	1125	519050(38.0)	4553
Age group	60–69 years	108 (55.4)	309629 (29.9)	2867	111874(33.9)	1036	421503(30.8)	3903
	70–79 years	61 (31.3)	451629 (43.6)	7404	107043(32.5)	1755	558672(40.9)	9159
	≥ 80 years	26 (13.3)	275301 (26.5)	10589	110784(33.6)	4261	386085(28.3)	14849
Sex	Male	81 (41.5)	594029 (57.3)	7334	168476(51.1)	2080	762505(55.8)	9414
	Female	114 (58.5)	442530 (42.7)	3882	161225(48.9)	1414	613755(44.2)	5384
Education level	Illiteracy	38 (19.5)	222591 (21.5)	5858	107211(32.5)	2821	329802(24.1)	8679
	Primary	62 (31.8)	312395 (30.1)	5039	106483(32.3)	1717	418878(30.7)	6756
	Lower secondary	53 (27.2)	221792 (21.4)	4185	76773(23.3)	1449	298565(21.9)	5633
	Upper secondary or above	42 (21.5)	279781 (27.0)	6661	39234(11.9)	934	319015(23.3)	7596
Medical insurance	Resident	95 (48.7)	440920 (42.6)	4641	174662(53.0)	1839	615581(45.1)	6480
	Employee	98 (50.2)	594304 (57.3)	6064	154347(46.8)	1575	748652(54.8)	7639
	Uninsured	2 (0.1)	1335 (0.1)	668	692(0.2)	346	2027(0.1)	1014
Underlying disease	Yes	120 (61.5)	835963 (80.6)	6966	255131(77.4)	2126	1091094(79.8)	9092

Variable	Group	n (%)	Direct economic burden (RMB)		Indirect economic burden (RMB)		Total economic burden (RMB)	
			Total cost (%)	Cost per case	Total cost (%)	Cost per case	Total cost (%)	Cost per case
	No	75 (38.5)	200596 (19.4)	2675	74570(22.6)	994	275166(20.2)	3669
Case type	Inpatient	79 (40.5)	946706 (91.3)	11984	301135(91.3)	3812	1247841(91.3)	15795
	Outpatient	116 (59.5)	89853 (8.7)	775	28566(8.7)	246	118419(8.7)	1021
Onset-to-diagnosis interval	1–6 days	60 (30.8)	221023 (21.3)	3684	74053(22.5)	1234	295076(21.6)	4918
	7–13 days	70 (35.9)	319197 (30.8)	4560	101617(30.8)	1451	420814(30.8)	6012
	≥ 14 days	65 (33.3)	496339 (47.9)	7636	154031(46.7)	2370	650370(47.6)	10006
Fever	Yes	47 (24.1)	478117 (46.1)	10173	105634(32.0)	2248	583751(42.7)	12420
	No	148 (75.9)	558442 (53.9)	3773	224067(68.0)	1514	782509(57.3)	5287
Cough	Yes	195 (100.0)	1036559 (100.0)	5395	329701(100.0)	1691	1366260(100.0)	7083
	No	0 (0.0)	0 (0.0)	0	0(0.0)	0	0(0.0)	0
Coinfection	Yes	13 (6.7)	122707 (11.8)	9439	59196(18.0)	4554	181902(13.3)	13992
	No	182 (93.3)	913852 (88.2)	5021	270505(82.0)	1486	1184358(86.7)	6507
Complication	Yes	37 (19.0)	265100 (25.6)	7165	112587(34.1)	3043	377687(27.6)	10208
	No	158 (81.0)	771459 (74.4)	4883	217114(65.9)	1374	988573(72.4)	6257
Total		195 (100.0)	1036559 (75.9)	5319	329701(24.1)	1691	1366260(100.0)	7007

1.2 Clinical characteristics Regarding hospitalization status: inpatients (40.5%) and outpatients (59.5%). The median onset-to-diagnosis interval was 6 (10–17) days, with 30.8% of cases diagnosed within 1–6 days, 35.9% within 7–13 days, and 33.3% at ≥ 14 days. For clinical manifestations: cough (100.0%), fever (24.1%), and coinfection occurred in 13 cases (6.67%), including 6 cases of Mycoplasma pneumoniae, 5 of Influenza virus, 2 of Respiratory syncytial virus, 2 of Adenovirus, and 1 each of Parainfluenza virus, Haemophilus influenzae, Streptococcus pneumoniae, and SARS-CoV-2; Complications occurred in 37 cases (18.97%), consisting of 23 cases of pneumonia (11.79%), 14 of bronchitis (7.18%), and 3 of emphysema (1.54%). (Table 1).

2 Economic burden

2.1 Composition of economic burden Total economic burden amounted to 1,366,260 RMB (7,007 RMB/case), comprising direct (75.9%, 5,316 RMB/case) and indirect (24.1%, 1,691 RMB/case) components. Direct burden included direct medical cost (69.3%, 4,857 RMB/case) and direct non-medical cost (6.5%, 459 RMB/case). Regarding the total economic burden distribution by subgroups, case type: inpatients (91.3%) and outpatients (8.7%); Survey area: Hangzhou (16.0%), Jinhua (44.8%) and Jiaxing (39.2%). Residence type: rural (62.0%) and urban (38.0%); Age group: 60–69 years (30.8%), 70–79 years (40.9%), and ≥ 80 years (28.3%); Sex: males (55.8%) and females (44.2%); Education level: illiterate (24.1%), primary school (30.7%), lower secondary school (21.9%), and upper secondary school or above (23.3%); Medical insurance:resident (54.8%), employee (45.1%), and uninsured (0.1%); Clinical characteristics: presence of underlying diseases (79.8%), fever (42.7%), cough (100.0%), coinfection (13.3%), and complications (27.6%). (Table 1).

2.2 Median economic burden and intergroup comparisons The median (IQR) total economic burden was 1,819 (653–9,234) RMB, with direct and indirect economic burdens being 1,300 (447–6,854) RMB and 358 (119–2,137) RMB, respectively. Regarding the total and direct economic burden,Statistically significant differences were observed across different case types, survey areas, residence types, age groups, sex, onset-to-diagnosis interval, presence of underlying diseases, fever, coinfection and complications (all $P < 0.05$). Regarding indirect economic burden, significant differences were noted across different case types, residence types, age groups, educational levels, onset-to-diagnosis interval, presence of underlying diseases, fever, coinfection and complications (all $P < 0.05$). (Table 2).

Table 2
Median economic burden and intergroup comparisons

Variable	Group	Direct economic burden		Indirect economic burden		Total economic burden	
		Median (IQR)	*P*	Median (IQR)	*P*	Median (IQR)	*P*
Survey area	Hangzhou	828 (395–1739)	0.008	227 (0–682)	0.053	1119 (601–2262)	0.017
	Jinhua	2781 (651–7585)		537 (179–2137)	0.048	3374 (892–9747)	0.003
	Jiaxing	2100 (319–8640)		356 (118–3670)	0.026	2188 (578–11706)	0.093
Residence type	Rural	4336 (812–9265)	< 0.001	1662 (227–3917)	< 0.001	6975 (1105–13139)	< 0.001
	Urban	880 (349–5054)		227 (0–951)		1133 (504–6431)	
Age group	60–69 years	926 (387–2476)	< 0.001	232 (0–1033)	< 0.001	1158 (597–2755)	< 0.001
	70–79 years	2351 (432–8590)		455 (119–2077)		4141 (639–9291)	
	≥ 80 years	7759 (4670–14849)		2908 (1691–5101)		11602 (6213–23734)	
Sex	Male	4198 (543–9032)	0.017	537 (59–3027)	0.296	5766 (735–11940)	0.030
	Female	978 (426–5402)		358 (119–1781)		1312 (591–7070)	
Education level	Illiteracy	2157 (428–8454)	0.528	909 (179–3866)	0.005	4303 (637–11905)	0.353
	Primary	2092 (500–7743)		455 (179–2406)		2554 (709–10067)	
	Lower secondary	1067 (451–5956)		358 (119–2032)		1819 (681–8287)	
	Upper secondary or above	993 (340–4233)		179 (0–739)		1300 (430–6339)	
Medical insurance	Resident	1394 (462–6854)	0.772	455 (179–2506)	0.103	2141 (665–9349)	0.894
	Employee	1330 (431–7157)		237 (0–2018)		1632 (613–9405)	
	Uninsured	–(n = 2)		–(n = 2)		–(n = 2)	
Underlying disease	Yes	3409 (502–8529)	< 0.001	506 (179–2938)	0.007	5239 (750–11412)	< 0.001
	No	791 (343–2188)		237 (0–716)		1148 (589–2351)	

Variable	Group	Direct economic burden		Indirect economic burden		Total economic burden	
		Median (IQR)	*P*	Median (IQR)	*P*	Median (IQR)	*P*
Case type	Inpatient	8448 (5899–12953)	< 0.001	2848 (1781–4654)	< 0.001	11098 (8187–18141)	< 0.001
	Outpatient	547 (278–982)		179 (0–358)		811 (438–1318)	
Onset-to-diagnosis interval	1–6 days	802 (235–5457)	0.031	227 (0–1248)	0.002	1095 (378–6956)	0.001
	7–13 days	978 (488–6334)		297 (164–2069)		1222 (689–8380)	
	≥ 14 days	4697 (880–9169)		1137 (179–3132)		6252 (1239–11592)	
Fever	Yes	6349 (1067–12509)	< 0.001	1074 (227–4117)	0.017	8424 (1300–13754)	< 0.001
	No	928 (373–5274)		237 (119–1872)		1264 (574–7155)	
Coinfection	Yes	7636 (4662–10231)	< 0.001	2255 (1602–3145)	0.004	9061 (6916–11940)	< 0.001
	No	1070 (424–6398)		356 (119–2018)		1392 (619–8968)	
Complication	Yes	6017 (766–8935)	0.011	1424 (90–3759)	0.049	8369 (1059–11206)	0.008
	No	1080 (418–6020)		297 (119–1969)		1367 (603–8366)	

2.3 Multivariate analysis Variables with statistically significant intergroup differences were included in GLM, and the results indicated the following associations, regarding total economic burden: case type [OR = 11.97, 95% CI: 9.08–15.78, *P* < 0.001], onset-to-diagnosis interval [OR = 1.02, 95%CI: 1.01–1.03, *P* = 0.001], and fever [OR = 1.32, 95%CI: 1.04–1.68, *P* = 0.023] were independently associated with the outcome; Regarding direct economic burden, case type [OR = 11.29, 95% CI: 8.41–15.15, *P* < 0.001], onset-to-diagnosis interval [OR = 1.02, 95% CI: 1.01–1.03, *P* = 0.003], and fever [OR = 1.40, 95% CI: 1.08–1.81, *P* = 0.011] remained significantly correlated; Regarding indirect economic burden, case type [OR = 10.56, 95% CI: 7.92–14.07, *P* < 0.001] and complications [OR = 1.42, 95% CI: 1.05–1.92, *P* = -0.025] were identified as associated factors. (Table 3). An additional variable assignments file shows this in more detail (see Additional file 2).

Table 3
Multivariate analysis of economic burden

Variable	Group	Direct economic burden		Indirect economic burden		Total economic burden	
		P	OR (95%CI)	*P*	OR (95%CI)	*P*	OR (95%CI)
Case type	Inpatient	< 0.001	11.29 (8.41–15.15)	< 0.001	10.56 (7.92–14.07)	< 0.001	11.97 (9.08–15.78)
	Outpatient	reference		reference		reference	
Survey area	Jiaxing	0.183	0.83 (0.63–1.09)	–	–	0.080	0.79 (0.61–1.03)
	Jinhua	0.716	0.95 (0.73–1.24)	–	–	0.308	0.88 (0.68–1.13)
	Hangzhou	reference				reference	
Residence type	Rural	0.873	1.02 (0.80–1.30)	0.641	0.94 (0.74–1.20)	0.509	1.08 (0.86–1.35)
	Urban	reference				reference	
Age		0.052	1.01 (1.00–1.03)	0.885	1.00 (0.98–1.01)	0.066	1.01 (1.00–1.03)
Sex	Female	0.391	0.91 (0.73–1.13)	–	–	0.332	0.90 (0.73–1.11)
	Male	reference				reference	
Education level		–	–	0.539	1.04 (0.92–1.17)	–	–
Underlying disease	Yes	0.873	1.02 (0.81–1.28)	0.748	0.96 (0.76–1.22)	0.966	1.01 (0.81–1.24)
	No	reference		reference		reference	
Onset-to-diagnosis interval		0.003	1.02 (1.01–1.03)	0.051	1.01 (1.00–1.02)	0.001	1.02 (1.01–1.03)
Fever	Yes	0.011	1.40 (1.08–1.81)	0.841	0.97 (0.75–1.27)	0.023	1.32 (1.04–1.68)
	No	reference		reference		reference	
Coinfection	Yes	0.659	0.91 (0.59–1.40)	0.872	0.96 (0.62–1.51)	0.870	0.97 (0.64–1.47)
	No	reference		reference		reference	
Complication	Yes	0.066	1.30 (0.98–1.71)	0.025	1.42 (1.05–1.92)	0.081	1.26 (0.97–1.64)
	No	reference		reference		reference	

*Age and onset-to-diagnosis interval were included in the logistic regression according as quantitative variables, and education level as ordered multi-categorical.

3 Case type

3.1 Comparison for the total economic burden The median (IQR) total economic burden was 11,026 (8,131–18,568) RMB in inpatient and 811 (438–1,318) RMB in outpatient. Regarding inpatient, the median (IQR) hospitalization duration was 9 (7–12) days, which correlated positively with the total economic burden (Kendall's τ = 0.73, 95% CI: 0.68–0.77, $P < 0.001$), and those admitted to tertiary medical institutions than secondary ones ($P = 0.020$); Regarding outpatient, there was a statistically significant difference in different survey areas ($P = 0.039$), and the median (IQR) of Onset-to-diagnosis interval was 9 (4–14) days, which correlated positively with the total economic burden (Kendall's τ = 0.23, 95% CI: 0.11–0.34, $P < 0.001$). (Table 4).

Table 4
Comparison for the total economic burden in different case types

Variable	Group	Inpatient (n = 79)			Outpatient (n = 116)		
		n (%)	Median (IQR)	*P*	n(%)	Median (IQR)	*P*
Survey area	Hangzhou	10 (12.7)	15145 (10366–19825)	0.203	48 (41.4)	903 (521–1367)	0.039
	Jiaxing	32 (40.5)	11706 (8509–20497)		33 (28.4)	589 (299–1110)	
	Jinhua	37 (46.8)	9234 (7653–17063)		35 (30.2)	890 (479–1548)	
Residence type	Rural	48 (60.8)	10516 (8424–18141)		33 (28.4)	970 (556–1500)	0.157
	Urban	31 (39.2)	10516 (7094–20320)	0.880	83 (71.6)	773 (388–1230)	
Age group	60–69 years	26 (32.9)	10785 (8994–17531)	0.586	82 (70.7)	870 (495–1367)	0.455
	70–79 years	31 (39.2)	9234 (7032–17433)		30 (25.9)	629 (386–1185)	
	≥ 80 years	22 (27.9)	12293 (7844–24386)		4 (3.4)	674 (450–2324)	
Sex	Male	43 (54.4)	11724 (8350–23700)	0.485	38 (32.8)	681 (362–1076)	0.229
	Female	36 (45.6)	10784 (7426–16848)		78 (67.2)	870 (453–1338)	
Education level	Illiteracy	19 (24.1)	11870 (8943–23670)	0.472	19 (16.4)	653 (404–1547)	0.965
	Primary	29 (36.7)	10516 (7478–15431)		33 (28.4)	731 (502–1122)	
	Lower secondary	19 (24.1)	9349 (8035–16331)		34 (29.3)	812 (526–1476)	
	Upper secondary or above	12 (15.1)	15617 (8073–27570)		30 (25.9)	930 (375–1344)	
Medical insurance	Resident	40 (50.6)	10491 (8227–13551)	0.281	55 (47.4)	817 (459–1362)	0.738
	Employee	39 (49.4)	12010 (8150–		59 (50.9)	805 (414–1300)	

Variable	Group	Inpatient (n = 79)			Outpatient (n = 116)		
		n (%)	Median (IQR)	*P*	n(%)	Median (IQR)	*P*
			23713)				
	Uninsured	0 (0.0)	–		2 (1.7)	–	
Underlying disease	Yes	62 (78.5)	11076 (8121–18238)	0.886	58 (50.0)	729 (433–1386)	0.795
	No	17 (21.5)	11314 (9073–17518)		58 (50.0)	852 (444–1300)	
Onset-to-diagnosis interval	1–6 days	20 (25.3)	10807 (8132–17352)	0.728	40 (34.5)	558 (263–1096)	0.007
	7–13 days	23 (29.1)	11687 (8368–23820)		47 (40.5)	890 (536–1230)	
	≥ 14 days	36 (45.6)	10807 (8369–23820)		29 (25.0)	1109 (614–2130)	
Fever	Yes	30 (38.0)	12228 (8702–21890)	0.127	17 (14.7)	1119 (731–1392)	0.117
	No	49 (62.0)	10076 (7125–17270)		99 (85.3)	727 (428–1301)	
Coinfection	Yes	12 (15.2)	10079 (7402–11975)	0.486	1 (0.9)	2187 (2187–2187)	0.165
	No	67 (84.8)	11516 (8187–18529)		115 (99.1)	805 (435–1301)	
Complication	Yes	22 (27.8)	10784 (9056–21888)	0.505	15 (12.9)	919 (379–1379)	0.579
	No	57 (72.2)	11687 (7653–17380)		101 (87.1)	773 (441–1300)	
Healthcare institution level	Tertiary	42 (53.2)	13287 (9019–23701)	0.020	–	–	–
	Secondary	36 (45.5)	9632 (6794–13028)				
	Primary	1 (1.3)	4141 (4141–4141)	–			
Days of hospitalization	1–6 days	16 (20.3)	6281 (4351–9210)	< 0.001	–	–	–

Variable	Group	Inpatient (n = 79)			Outpatient (n = 116)		
		n (%)	Median (IQR)	*P*	n(%)	Median (IQR)	*P*
	7–13 days	46 (58.2)	10491 (8403–13505)				
	≥ 14 days	17 (21.5)	26867 (22493–34559)				

3.2 Analysis of factors associated with hospitalization Intergroup comparisons revealed statistically significant differences in hospitalization rates across survey area, residence type, age group, sex, onset-to-diagnosis interval, underlying disease, fever, coinfection, and complications (all $P < 0.05$). Variables with statistically significant intergroup comparisons were included in a logistic regression model (variable assignments were detailed in Table 3) for multivariate analysis. The results showed that survey area (OR for Jiaxing vs. Hangzhou = 4.47, 95% CI: 1.48–13.48, $P = 0.008$), fever (OR = 4.11, 95% CI: 1.62–10.45, $P = 0.003$), residence type (OR = 3.08, 95% CI: 1.27–7.44, $P = 0.012$), complications (OR = 2.94, 95% CI: 1.02–8.47, $P = 0.045$), sex (OR = 2.80, 95% CI: 1.22–6.44, $P = 0.015$), age (OR = 1.15, 95% CI: 1.08–1.22, $P < 0.001$) and onset-to-diagnosis interval (OR = 1.04, 95%CI: 1.00–1.09, $P = 0.039$) were significantly associated with hospitalization rate. (Table 5).

Table 5
Analysis of factors associated with hospitalization

Variable	Group	Intergroup comparison			Multivariate analysis	
		Inpatient [n (%)]	Outpatient [n (%)]	*P*	*P*	OR (95% CI)
Survey area	Hangzhou	10 (12.7)	48 (41.4)	< 0.001	reference	
	Jiaxing	32 (40.5)	33 (28.4)		0.008	4.47 (1.48–13.48)
	Jinhua	37 (46.8)	35 (30.2)		0.139	2.33 (0.76–7.18)
Fever	Yes	30 (38.0)	17 (14.7)	< 0.001	0.003	4.11 (1.62–10.45)
	No	49 (62.0)	99 (85.3)		reference	
Residence type	Rural	48 (60.8)	33 (28.4)	< 0.001	0.012	3.08 (1.27–7.44)
	Urban	31 (39.2)	83 (71.6)		reference	
Complication	Yes	22 (27.8)	15 (12.9)	0.009	0.045	2.94 (1.02–8.47)
	No	57 (72.2)	101 (87.1)		reference	
Sex	Male	43 (54.4)	38 (32.8)	0.003	0.015	2.80 (1.22–6.44)
	Female	36 (45.6)	78 (67.2)		reference	
Age	60–69 years	26 (32.9)	82 (70.7)	< 0.001	< 0.001	1.15 (1.08–1.22)
	70–79 years	31 (39.2)	30 (25.9)			
	≥ 80 years	22 (27.9)	4 (3.4)			
Onset-to-diagnosis interval*	1–6 days	20 (25.3)	40 (34.5)	0.011	0.039	1.04 (1.00–1.09)
	7–13 days	23 (29.1)	47 (40.5)			
	≥ 14 days	36 (45.6)	29 (25.0)			
Coinfection	Yes	12 (15.2)	1 (0.9)	< 0.001	0.057	17.12 (0.92–319.84)

*Age and onset-to-diagnosis interval were included in the logistic regression according as quantitative variables

Variable	Group	Intergroup comparison			Multivariate analysis	
		Inpatient [n (%)]	Outpatient [n (%)]	*P*	*P*	OR (95% CI)
	No	67 (84.8)	115 (99.1)			
Underlying disease	Yes	62 (78.5)	58 (50.0)	< 0.001	0.066	2.24 (0.95–5.30)
	No	17 (21.5)	58 (50.0)			
Education level	Illiteracy	19 (24.1)	19 (16.4)	0.145		
	Primary	29 (36.7)	33 (28.4)			
	Lower secondary	19 (24.1)	34 (29.3)			
	Upper secondary or above	12 (15.1)	30 (25.9)			
Medical insurance	Resident	40 (50.6)	55 (47.4)	0.744		
	Employee	39 (49.4)	59 (50.9)			
	Uninsured	0 (0.0)	2 (1.7)	–		

*Age and onset-to-diagnosis interval were included in the logistic regression according as quantitative variables

Discussion

To the best of our knowledge, this was the first study to systematically assess the economic burden of pertussis cases (≥ 60 years) in China. We conducted a cross-sectional survey with a multi-stage sampling method to recruit survey respondents in Zhejiang Province to comprehensively evaluate the economic burden of this population with a societal perspective.

First, the results showed that the mean total economic burden per pertussis case (≥ 60 years) reached 7,007 RMB, with a median of 1,819 (653–9,234) RMB, exceeding that of herpes zoster[22] and influenza-like cases[23] in China. Direct economic burden accounted for 75.9% of the total, predominantly attributed to healthcare institution-related expenses (69.3% of the total burden), including diagnostic examinations, treatment, and nursing care. Notably, the median medical cost (1,299 RMB) was comparable to that of children aged 0–4 years and higher than that of children aged 5–15 years in Hangzhou, Zhejiang Province. In addition, indirect economic burden accounted for 24.1% of the total, primarily stemming from the income loss of caregivers and visitors due to the prolonged disease course, which was higher than that of herpes zoster patients (≥ 50 years old)[22] and the whole population with pertussis[20].

Then, results from the generalized linear model indicated that case type (inpatient vs. non-inpatient) was the strongest independent predictor of total economic burden, direct economic burden, and indirect economic burden, respectively. Specifically, hospitalization of outpatients would increase their total economic burden by 11.97-fold. Therefore, reducing unnecessary hospitalizations represents the most effective strategy to alleviate the economic burden of

elderly pertussis cases. Notably, for inpatient cases, a higher level of healthcare institution attended was associated with longer hospital stays and consequently heavier economic burden, which consistent with the conclusions of most relevant studies[24, 25].

Furthermore, our study found that the hospitalization rate of pertussis cases (≥ 60 years) reached 40.5%, which was comparable to the 40.9% hospitalization rate of pediatric pertussis cases at Shenzhen Children's Hospital during 2015–2018[2]. However, it was significantly higher than those reported by the Children's Hospital Affiliated to Zhejiang University School of Medicine in 2022 (4.5%)[21] and Anhui Children's Hospital in 2024 (7.1%)[26]. These differences may be attributed to temporal variations in pertussis incidence and regional disparities in PCR diagnostic capacity[27, 28]. Additionally, the hospitalization rate of elderly pertussis cases reported in Zhejiang Province in 2024 was only 20.47%[18], we hypothesized that this discrepancy may be associated with incomplete reporting of hospitalization information for some cases in Zhejiang Province's pertussis surveillance system in the early stage.

International studies consistently underscore the elevated pertussis hospitalization burden among older adults. For example, a 2012 Australian study documented an 11.5% hospitalization rate among pertussis patients aged ≥ 65 years—significantly higher than the 2.4% in the 45–64 years group—with hospitalization risk correlating positively with age[29]. In Germany, individuals aged ≥ 60 years accounted for 59.2%[30] of adult pertussis inpatients, confirming the elderly as a dominant subgroup of adult pertussis hospitalizations. Similarly, a British study showed elderly pertussis cases have a 2–3-fold higher hospitalization risk than the general population, making them the second most at-risk group for pertussis-related hospitalization after infants and toddlers[31].

Logistic regression analysis was performed with the hospitalization status of middle-aged and elderly pertussis cases as the dependent variable. Results identified rural residents, elderly males, and patients with complications as high-risk groups for pertussis-related hospitalization.Australian and US studies indicate that poor medical accessibility, delayed healthcare-seeking, and low health literacy were key drivers of elevated hospitalization risk in rural residents[32–34]. German and Korean research demonstrates that elderly males had a significantly higher pertussis hospitalization risk than women, primarily linked to underlying respiratory conditions, smoking history, and comorbid COPD[30, 34, 35]. Additionally, patients with complications (predominantly pneumonia and bronchitis) often experienced compromised immunity and organ dysfunction, further increasing their need for hospitalization[36, 37].

Fever was not a typical manifestation of pertussis, yet most studies confirm it was an independent risk factor for severe pertussis and significantly linked to increased hospitalization risk (3.11-fold higher). This aligns with observations that febrile elderly pertussis cases often had co-infections, making them more prone to pneumonia and intensive care needs[35, 38–40]. Regarding the onset-to-diagnosis interval: each 1-day delay increased the total economic burden by 2% and the hospitalization rate by 4%, likely due to symptom progression and complications from delayed treatment[41].

Currently, pertussis remains an underrecognized condition in older adults. Notably, European studies[8, 42, 43] have demonstrated that Bordetella pertussis (the causative agent of pertussis) continues to circulate among the elderly, indicating current vaccination strategies are insufficient to mitigate disease burden across all age groups. Thus, enhanced pertussis surveillance in older adults and lifelong adult booster vaccination are necessary to control the overall pertussis burden[44]. To date, developed countries such as the US and UK have implemented booster immunization with reduced-dose pertussis vaccines for adults[44–46]. However, in China, no licensed pertussis vaccine is currently available for adolescents and adults aged ≥ 7 years[16]. Furthermore, a 2019 expert assessment noted that pertussis burden in the Asia-Pacific region was comparable to that in Europe and North America, identifying older adults as a high-risk group for infection. Available evidence supports that individual-level tetanus-diphtheria-acellular

pertussis (Tdap) vaccination and improved vaccination coverage among older adults can yield substantial benefits for healthy aging in the Asia-Pacific population[13].

Limitations

Although strict data quality control was carried out during the research process with multi-stage sampling, there were some limitations. First, the economic burden of this study was a retrospective survey, and there may be a recall bias regarding indirect economic burden; Second, owing to the inherent nature of the cross-sectional design, it can only identify statistical associations among variables rather than establish definitive causal relationships, subsequent multicenter cohort studies with long-term follow-up are needed to clarify the causal links between relevant risk factors and pertussis-related burden; Finally, this study was restricted to Zhejiang Province. To fully evaluate the economic burden of pertussis in elderly cases nationwide, the investigation scope among older adults should be expanded.

Conclusions

Our findings revealed that the economic burden of pertussis patients aged ≥ 60 years in Zhejiang Province was characterized by a high total burden with a prominent hospitalization-driven pattern. Meanwhile, the hospitalization rate of elderly pertussis cases in Zhejiang Province remains elevated. Both onset-to-diagnosis interval, and fever were identified as independent risk factors for hospitalization and increased economic burden. Additionally, rural residents, elderly males, and patients with complications are at an elevated risk of hospitalization.Targeted interventions may effectively alleviate the economic burden of pertussis in this population: First, strengthen health education and promotion on pertussis for older adults and primary healthcare institutions to shorten the onset-to-diagnosis interval; Second, optimize outpatient management for high-risk groups including elderly males, rural residents, and febrile cases, and deliver standardized symptomatic treatment for pertussis to minimize complications and the need for hospitalization; Third, enhance research on the efficacy and safety of pertussis vaccines in older adults, explore the cost-effectiveness of booster vaccination, and provide evidence to inform future pertussis booster immunization strategies in China, thereby alleviating the pertussis disease burden in this population.

Abbreviations

GDP gross domestic product

HIS hospital information systems

RMB Renminbi

IQR interquartile range

GLM generalized linear models

VIFs variance inflation factors

Declarations

Supplementary Information

The online version contains supplementary material available at ...

Acknowledgments

Thanks to the centers for disease control and prevention in Hangzhou, Jiaxing and Jinhua City, Zhejiang Province for conducting on-site investigations and organizing staff.

Author' contributions

Hui Wu: Conceptualization, Data curation, Methodology, Writing-orginal draft. Yang Zhou: Conceptualization, Methodology, Writing-orginal draft. Yao Zhu: Methodology, Resources. Hanqing He: Conceptualization, Funding acquisition, Writing-review and editing.

Funding

This research was supported by Chinese Preventive Medicine Association Scientific Research Support Project for Young and Middle-aged Talents in Infectious Disease Prevention and Control (CPMA2024CRBFK□, and "Pioneer" and "Leading Goose" R&D Program of Zhejiang (Project No.2025C01134).

Data Availability

The datasets used in this study are available from the corresponding author (Hanqing He, hanqinghe@cdc.zj.cn) on reasonable request.

Ethical approval and consent to participate

The research received ethical approval from the Ethics Committee of Zhejiang Provincial Center for Disease Control and Prevention (approval number: 2025-033-01) and complied with the Declaration of Helsinki. All respondents provided informed consent prior to participation.

Consent for publication

Not applicable

Competing interests

The authors declare no conflicts of interest.

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