Zhu et al. BMC Public Health (2025) 25:957
https://doi.org/10.1186/s12889-025-22203-7

RESEARCH

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Introduction

Smoking is widely acknowledged as a primary behavioral risk factor in global public health. Over the past seven decades, a plethora of studies [1–4] has elucidated the connections between smoking and a range of chronic conditions, including but not limited to cancer [5], hypertension [6, 7], stroke [8], asthma [9], and myocardial infarction [10]. Undeniably, tobacco smoking emerges as a crucial determinant of health in individuals with chronic diseases. Recent research has underscored the possibility for smokers to prolong their life expectancy by up to a decade through smoking cessation [11]. Moreover, smoking cessation has been recognized as a fundamental element in the management of chronic diseases [12–14]. Wang Z et al [15] screened 13,460 literatures and included 11 studies of chronic obstructive pulmonary disease (COPD) patients. Using systematic review and meta-analysis, they analyzed forced expiratory volume in one second percentage predicted (FEV1% predicted), FEV1/forced

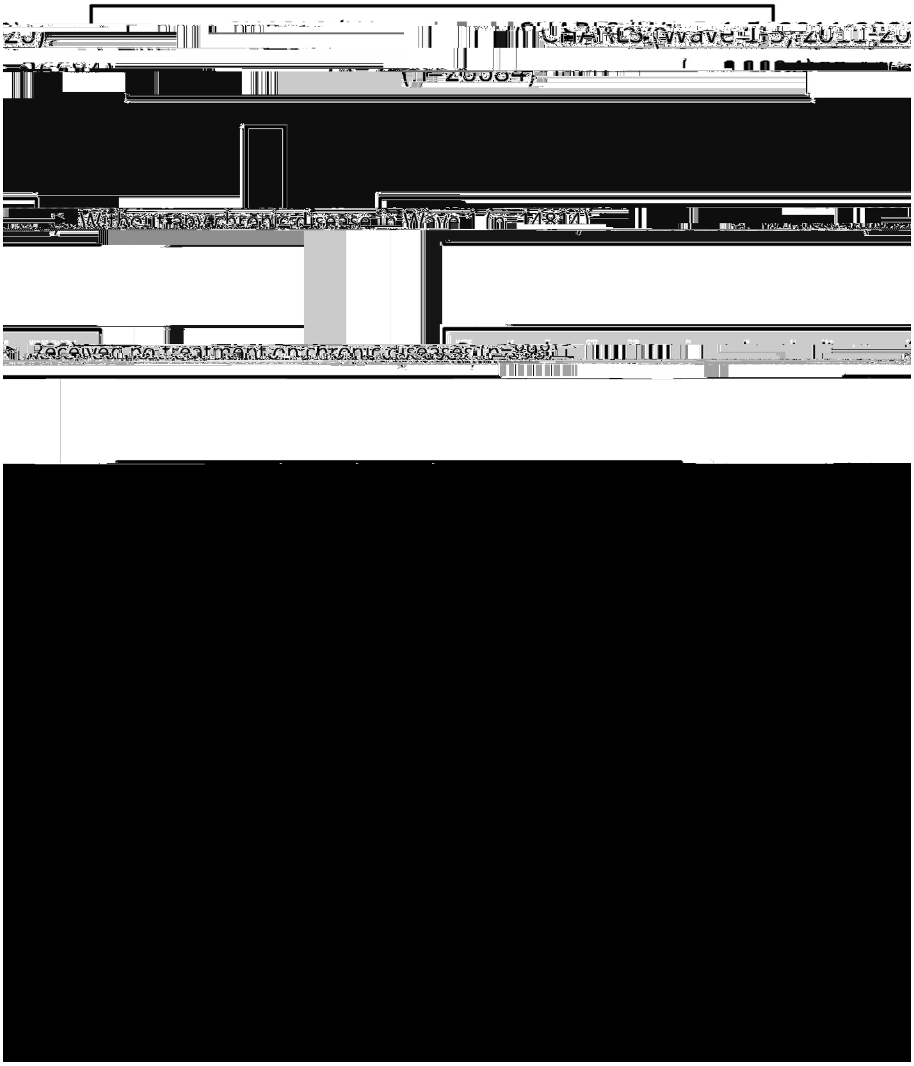

Fig. 1 Flowchart for inclusion and exclusion in our study

0.015, respectively. is analysis suggested that the reduction in EQ-5D-3L scores primarily stemmed from the elevated AD coe cient (Table S-3).

Health status comparisons between all subgroups

As shown in Table 3, almost all parameters in the current smoker and pre-cessation groups displayed similar levels, except for self-rate, EQ-5D-3L, HbA1c, grip strength, and lung function. In blood analyses, compared with the pre-cessation group, the post-cessation group demonstrated a decline in hemoglobin, total cholesterol, LDL cholesterol, and cystatin C, alongside an increase in creatinine, HbA1c, and uric acid. Non-smokers exhibited lower values in hemoglobin, hematocrit, MCV, BUN, creatinine, uric acid, cystatin C, limb strength, and lung function, while a higher level in HbA1c compared to the pre-cessation group.

Regression analysis revealed health bene□ts

Table S-4 presented the results of linear regression analyses examining the relationship between smoking status and all parameters, with all significant outcomes depicted in Fig. 3. A similar trend was observed in Model 1 (M1) and Model 2 (M2), except for several parameters. Notably, the analysis under M2, which accounted for demographic variables, revealed several noteworthy associations. A significant reduction in EQ-5D-3L (β estimate -0.18) and grip strength (β estimate -2.53) was observed. However, a significant positive correlation was found between self-rate and smoking cessation (β estimate 0.20). In the realm of blood analyses, smoking cessation exhibited significant associations with various blood biomarkers after adjusting for demographic factors: 12.03% lower LDL cholesterol, 7.70% lower total cholesterol, 7.26% lower glucose, 5.50% lower cystatin C,

Table 1 Characteristics of included respondents in the study

Variables	Total *N* 9914	Current smoker *N* 3597	Former smoker *N* 509	Non-smoker *N* 5808	*P* value
Age (Mean (SD))	60.62 (9.77)	61.13 (9.82)	64.53 (8.48)	59.95 (9.74)	< 0.001
Gender (%)					< 0.001
Male	4299 (43.36%)				

[a] Those who married but not living with a spouse, separated, divorced, widowed, and never married were considered non-partnered

4.67% lower hemoglobin, 3.39% higher creatinine, 11.40% higher HbA1c, and 12.03% higher uric acid.

Considering cessation duration, trend analysis was performed and several significant associations were identified. With each additional year of smoking cessation, self-rate increases by 0.036, while EQ-5D-3L decreases by 0.031. Additionally, glucose decreases by 2.30%, HbA1c increases by 3.29%, uric acid increases by 3.79%, and walk time decreases by 0.474 (Table 4).

Furthermore, based on the chronic disease classification mentioned above, we divided the respondents into

Table 3 Group comparisons between different smoking status

Variables	Total	Pre (Ref)	Post	Current	Never	*P* value (overall)
Self-rate	*N* = 10,825	*N* = 509	***N*** **= 913**	***N*** **= 3597**	***N*** **= 5806**	< 0.001
	3.25 (0.74)	3.08 (0.73)	**3.27 (1.03)**	**3.23 (0.72)**	**3.28 (0.70)**	
EQ-5D-3L	*N* = 10,331	*N* = 440	***N*** **= 987**	***N*** **= 3361**	***N*** **= 5543**	< 0.001
	0.62 (0.21)	0.74 (0.19)	**0.58 (0.25)**	**0.64 (0.22)**	**0.61 (0.20)**	
Blood analyses						
WBC	*N* = 7796					

trend was shown in the two groups and no distinctive outcomes were observed.

Additionally, significant associations were confirmed between smoking behavior and certain parameters. Current smokers demonstrated a worse health status in comparison to non-smokers, which is suitable for prevailing perceptions (Table S-7).

Discussion

Our discoveries underscored the manifold advantages of abstaining from smoking, consistent with the prevailing scientific consensus regarding the adverse health consequences of tobacco consumption. We successfully quantify the enhancements in health status and blood indicators.

Our findings revealed noteworthy enhancements in specific health markers. e rise in hemoglobin levels can be attributed to the formation of carboxyhemoglobin, a product of the combination of carbon monoxide released from smoke and hemoglobin, leading to tissue hypoxia, heightened erythropoietin secretion, and increased erythropoiesis [33]. Elevated serum cholesterol and LDL levels, previously noted in smokers and considered a risk factor for cardiovascular disease [34], may result from modification of apolipoproteins [35]. Our findings demonstrate an improving trend after smoking cessation. In a prior meta-analysis, smokers were found to have higher HbA1c levels than non-smokers [36], but we found HbA1c increased after cessation, which was similar to other researchers' findings [37, 38]. It was pointed out that the level of HbA1c would not immediately decrease in the short term after cessation. Furthermore,

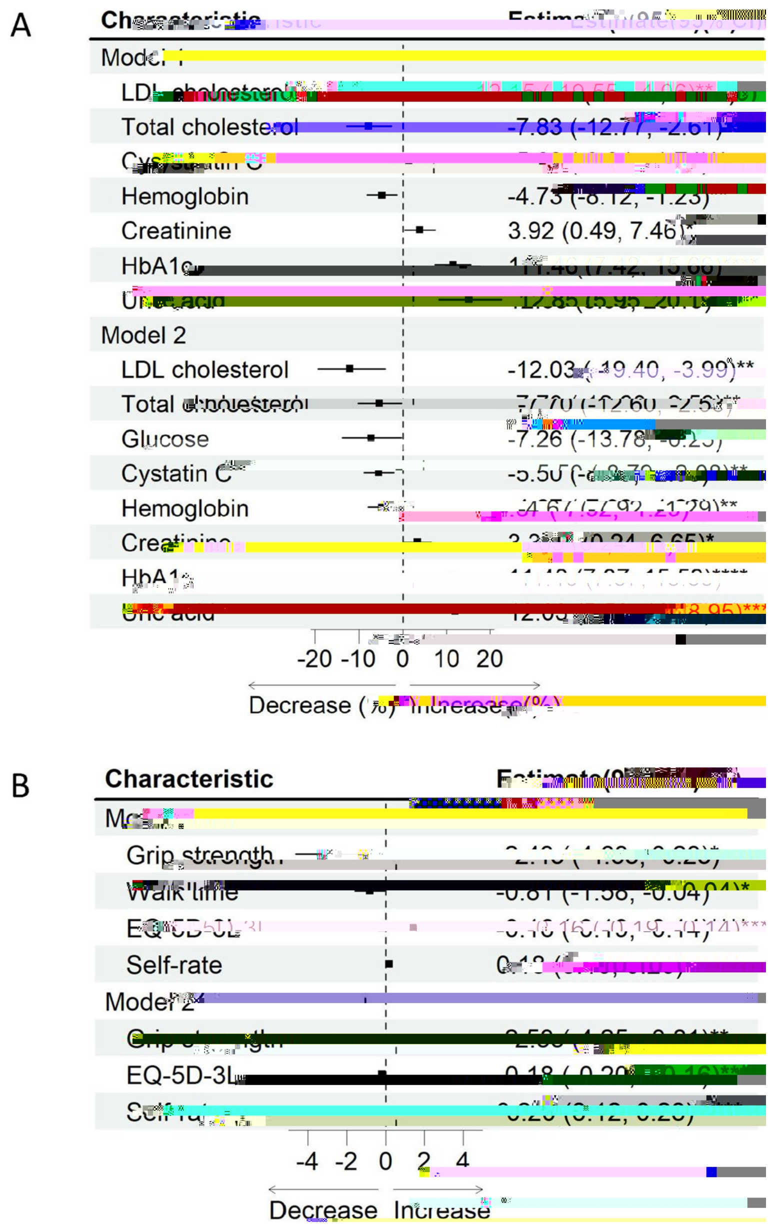

Fig. 3 Forest plot of linear regression. Model 1 was not adjusted. Model 2 was adjusted for demographic factors. Only significant outcomes were plotted. Blood analysis outcomes were natural log-transformed and presented as percentage differences (**A**). Other outcomes were not transformed (**B**). *: $p < 0.05$, **: $p < 0.01$, ***: $p < 0.001$, ****: $p < 0.0001$. Abbreviation: EQ-5D-3L: EuroQoL 5-Dimension 3-Level; LDL: low-density lipoprotein; HbA1c: glycosylated hemoglobin, type A1c

[43, 45, 46] and arthritis patients [47], the benefits are still controversial. Meanwhile, it is worth mentioning that few research focused on older adults as we did. In general, the health status deteriorates as people get old. We must pay attention to the impacts brought about by advanced age.

The regression models provide a nuanced comprehension of the correlation between smoking cessation and health outcomes. Each model was meticulously crafted to sequentially account for potential confounding variables, thus isolating the impact of smoking cessation. M1, which specifically adjusts for smoking cessation status, revealed significant associations that were predominantly consistent across the adjusted models (M2) and the trend analysis, underscoring the robustness of our findings. The consistent results across models, particularly the notable associations observed in blood analyses, underscored the potential advantages of smoking cessation. However, the adverse association with EQ-5D-3L highlights the necessity for supportive interventions to address the immediate challenges quitters face.

The CHARLS dataset serves as a robust foundation for analysis due to its extensive sample size and longitudinal framework. However, it is important to acknowledge limitations such as potential selection bias and the generalizability of our findings to non-Chinese populations. Additionally, there remain other confounders that might not have been controlled for, even though we have corrected for a variety of possible confounding factors. The detailed treatment for chronic diseases was hard to classify. For example, we cannot be sure whether Chinese traditional medicine is suitable for patients. Besides, the use of self-made cigarettes by many individuals in rural areas presented difficulties in quantifying smoking amounts and detailing smoking behaviors. Moreover, the absence of access to medical records in the CHARLS dataset meant that respondents relied on memory to report physician-diagnosed diseases, potentially introducing recall bias. Finally, the cross-sectional nature of the data limits our ability to establish causality. Moving forward, it is imperative to conduct future longitudinal studies with larger sample sizes and extended follow-up periods to validate these findings and explore the temporal dynamics of smoking cessation's effects on health outcomes more comprehensively.

These findings advocate for the integration of smoking cessation interventions into routine care for older adults with chronic diseases, suggesting significant health benefits that warrant further exploration in clinical settings. Future studies should examine the specific effects of smoking cessation on various chronic disease populations and investigate its long-term impacts on healthcare utilization and costs.

Conclusion

The study's findings underscore the significant health benefits of smoking cessation among older Chinese adults with chronic diseases. Despite an initial decline in perceived quality of life, as indicated by EQ-5D-3L, long-term health markers demonstrate substantial improvements. The favorable trends in blood parameters highlight the physiological advantages of abstaining from smoking. These results reinforce the critical need to incorporate smoking cessation assistance into healthcare protocols, especially for elderly individuals dealing with chronic conditions. The study calls for additional

Acknowledgements
The authors would like to acknowledge the China Health and Retirement Longitudinal Study (CHARLS) team for providing the data.

Authors' contributions
Haoyu Zhu and Peng Xu contributed equally to this work. HZ led the design of the study, analysis of the data, and drafting of the manuscript. PX assisted with the design of the study, preparation and analysis of the data, and revision of the manuscript. YW, CZ, DZ, and YL assisted with drafting of the manuscript. XM, MW and HK contributed to the design of the study and revision of the manuscript for important intellectual content.

Funding
The authors declare that no funds, grants, or other support were received during the preparation of this manuscript.
CHARLS was supported by the Behavioral and Social Research division of the National Institute on Aging of the National Institute of Health, the Natural Science Foundation of China, the World Bank, and Peking University.

Data availability
The data used in our study comes from China Health and Retirement Longitudinal Study (CHARLS), a public database. Researchers who want to use these data can visit http://charls.pku.edu.cn/.

Declarations

Ethics approval and consent to participate
The institutional review board at Peking University granted the CHARLS ethical approval. Written informed consent was given by each participate who agreed to take part in the study.

Consent for publication
The present study contains no identifiable individual personal data.

Competing interests
The authors declare no competing interests.

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