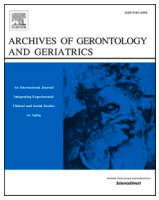
Archives of Gerontology and Geriatrics 103 (2022) 104797

Contents lists available at ScienceDirect

Archives of Gerontology and Geriatrics

journal homepage: www.elsevier.com/locate/archger



Too depressed to breathe: The longitudinal association between depressive symptoms and lung function among general middle-aged and older adults

Lizhi Guo [a,b,c,d,1], Li Yang [a,b,c,1], Liwei Rao [a,b,c], Fengping Luo [e], Ningcan Gao [f], Xiaohua Jia [g], Bin Yu [b,h,*]

[a] School of Education, Tianjin University, Tianjin, China
[b] Institute of Applied Psychology, Tianjin University, Tianjin, China
[c] Laboratory of Suicidology, Tianjin Municipal Education Commission, Tianjin, China
[d] Institute of Biomedical Engineering, Shenzhen Bay Laboratory, Shenzhen, China
[e] Department of Psychology, Wuhan University, Wuhan, China
[f] School of Psychological Science, University of Bristol, Bristol, UK
[g] Key Laboratory of Molecular Imaging of Chinese Academy of Sciences, Institute of Automation, Chinese Academy of Sciences, Beijing, China
[h] Academy of Medical Engineering and Translational Medicine, Tianjin University, Tianjin, China

ARTICLE INFO

Keywords:
Depressive symptoms
Lung function
Peak expiratory flow (PEF)
General middle-aged and older adults

ABSTRACT

Objective Most previous studies focusing on the association between depressive symptoms and lung function were conducted in patients with chronic lung diseases. This study aims to investigate the association of depressive symptoms with lung function among general Chinese middle-aged and older adults.

Participants This study used data from the China Health and Retirement Longitudinal Study (CHARLS). Analyses were conducted with data from three waves (2011, 2013, and 2015) and restricted to those respondents aged 45 and older. Finally, 9487 individuals [mean age (SD) = 58.47 (9.19); female, 53.1%] were included in analysis.

Methods Depressive symptoms were measured by the Chinese version of 10-item Center for Epidemiological Studies Depression Scale (CESD-10). Lung function was assessed by peak expiratory flow (PEF). Two-level linear mixed growth models were used to evaluate the longitudinal association between depressive symptoms and PEF.

Results Depressive symptoms were significantly associated with PEF among general middle-aged and older adults ($b = -1.85$, $p < 0.001$) after adjusting for multiple confounding factors. A significant interaction between depressive symptoms and gender was found ($b = 1.29$, $p < 0.001$). The association between depressive symptoms and PEF was greater for men ($b = -2.36$, $p < 0.001$) than for women ($b = -1.46$, $p < 0.001$).

Conclusions This longitudinal study found that increased depressive symptoms were associated with reduced PEF in middle-aged and older adults in China. Compared with women, men with a higher level of depressive symptoms experienced a greater decrement in PEF. Our findings suggest that it is possible to reduce the effects of PEF by improving psychological health among general middle-aged and older populations.

1. Introduction

Lung function is a significant predictor of health and an essential marker of physical functioning for older adults (Rocha et al., 2021; Singh-Manoux et al., 2011). Previous studies have demonstrated that lung function impairment was strongly linked with a higher number of comorbidities (Agustí et al., 2017), cognition impairment (Qiao et al., 2020; Singh-Manoux et al., 2011), disability (David Mannino et al., 2003), and premature all-cause mortality (Mannino & Davis, 2006; Smith et al., 2013). Therefore, recognizing the potential influencing factors that might affect lung function could help in enhancing healthy aging, mitigating disease development, and ensuring timely intervention.

Among the various influencing factors (such as aging, smoking, and

Abbreviations: PEF, peak expiratory flow; CHARLS, the China Health and Retirement Longitudinal Study.

* Corresponding author at: Institute of Applied Psychology, Tianjin University, Tianjin, China.
E-mail address: yubin@tju.edu.cn (B. Yu).

[1] These authors contributed equally to this work.

https://doi.org/10.1016/j.archger.2022.104797
Received 20 July 2022; Received in revised form 22 August 2022; Accepted 25 August 2022
Available online 28 August 2022

genetic predisposition) that might affect lung function, depression has been receiving more and more attention. As a leading cause of disability worldwide and a significant contributor to the overall global burden of disease, the prevalence of depression has been sharply increasing over the past decades. Globally, more than 264 million people suffer from depression (James et al., 2018). In patients with chronic lung diseases, accumulated evidence has indicated that symptoms of depression are inversely related to lung function, as well as a lower adherence to treatment, poorer quality of life, and a higher probability of death (Atlantis et al., 2013; Riekert et al., 2007; Smith et al., 2006). Moreover, two studies conducted in America and Germany both reported that depressive symptoms and lung function were inversely correlated among patients with cystic fibrosis (Goldbeck et al., 2010; Riekert et al., 2007). A systematic review included 16 prospective cohort studies and 28,759 individuals demonstrated that depressive symptoms increased the risk of adverse outcomes among patients with chronic obstructive pulmonary disease (COPD) (Atlantis et al., 2013).

A few studies have examined the association between depressive symptoms and lung function among general older populations and the results were mixed. Using data from a community-based cohort, Park et al. (2018) found no statistically significant relationship between Beck Depression Inventory (BDI) score and lung function among adults aged 40–69 years. However, another study conducted with healthy older adults from Singapore has found a significant association between depressive symptoms and pulmonary function (Lu et al., 2013). However, the studies on depressive symptoms and lung function among healthy older adults have, to date, been confined to cross-sectional samples. Increasing clinical evidence shows that depression might exacerbate the deterioration of lung function among patients with chronic lung diseases such as COPD and so on (Huang et al., 2021;; Viniol & Vogelmeier, 2018). Thus, it is rational to clarify whether changes in pulmonary function over time are associated with baseline depression levels among older populations without lung diseases.

To fill this knowledge gap, we used data from China Health and Retirement Longitudinal Study (CHARLS) to examine the impact of depressive symptoms on lung function over four years among general middle-aged and older Chinese adults. Given previous evidence indicating gender differences in the association between depression and health (Naqvi et al., 2005; Salk et al., 2017), we also explored the interaction of gender and depressive symptoms on PEF for our sample.

2. Methods

2.1. Participants

Data were obtained from the CHARLS, a nationally representative longitudinal survey of the middle-aged and elderly population (45+) in China. In the current study, participants were from three waves of the CHARLS (2011, 2013, and 2015) and restricted to those aged 45 and above ($n = 16{,}931$) at the baseline (2011). Participants were excluded if they had any missing values on the baseline measure of depressive symptoms ($n = 1549$) or control variables ($n = 4505$). Participants with chronic lung diseases ($n = 1338$) such as asthma, chronic bronchitis, COPD, or emphysema were also excluded. The remaining 9487 participants [mean age (SD) = 58.47 (9.19); female, 53.1%] who completed at least one assessment of peak expiratory flow (2011, 2013, and 2015) were included in the analyses.

2.2. Measures

2.2.1. Depressive symptoms

Depressive symptoms were measured at baseline by the Chinese version of the 10-item Center for Epidemiological Studies Depression Scale (CESD-10), which had high validity and reliability in the Chinese population (Boey, 1999; Chen & Mui, 2014). Respondents were asked how frequently in the last week they: were bothered by things that usually do not bother them; had trouble concentrating; felt depressed; felt that everything they did was an effort; felt hopeful about the future; felt fearful; were sleepless; felt happy; felt lonely, and were inability to 'get going' (Lei et al., 2014). The four-point response included rarely, some days (1–2 days), occasionally (3–4 days), and most of the time (5–7 days). The sum of the scores ranged from 0 to 30, with higher scores indicating a higher level of depressive symptoms.

3. Lung function

Lung function was assessed by peak expiratory flow (PEF). PEF, defined as the maximum flow during expiration with maximal force starting from maximal lung inflation, has been considered as a robust lung function indicator. In COPD patients, it demonstrated an even better prognostic value for mortality than other pulmonary function measures (Hansen et al., 2001). In people free from lung disease, PEF has also been suggested to be a predictor of general health (Cook et al., 1991). A higher value of PEF referred to a better lung function. In CHARLS, PEF was measured by trained technicians using a peak flow meter (Everpure ™, Shanghai, China) with a disposable mouthpiece in units of L/min. The same type of instruments was used for all 3-waves. Participants were instructed to stand up, take a deep breath, place the lips around the mouthpiece and blow as hard and fast as possible. Investigators recorded the readings indicated by the pointer and reset the meter for another two measurements. The time interval between each measurement was set as 30 s using a stopwatch and the highest value of the three tests was used in the present study.

4. Covariates

Data on all covariates were obtained at baseline by trained interviewers via standard questionnaires. Age, gender, and education were self-reported. Education was dichotomized as lower than secondary school and secondary or above. Household expenditure was expressed as the natural log of the annual household consumption. Chronic diseases including hypertension, diabetes, and heart diseases, were obtained by asking respondents if a physician had ever told them that they had the condition and were dichotomized as yes or no. Body mass index (BMI) was defined as weight in kilograms divided by height squared in meters. Marital status was dichotomized as married or not. Healthy behaviors including smoking and drinking were collected by asking respondents whether they were current smokers and if they had consumed alcohol in the past 12 months. We coded the linear time variable in yearly intervals (0, 1, 2, …, $N = t$), and the baseline measurement occasion was coded as 0.

5. Statistical analysis

Characteristics of key variables were described using means and standard deviations for continuous data and percentages for categorical data. We used t-tests and chi-square tests to examine the differences between included and excluded participants. Linear mixed models were fitted to test whether changes in PEF over time were reflected in baseline depressive symptoms levels. The 2-level linear growth model had three measurements of PEF (level 1) nested within individuals (level 2). We specified the intercept(s) (baseline value of PEF) and slope(s) (annual rate of change in the value of PEF) as random. Random intercept(s) and random slope(s) were allowed to co-vary (unstructured covariance). Analysis was conducted by using the mixed procedure with maximum likelihood estimation in Stata version 14.0.

Three models were fitted. Model 1 was established by simply adding the depressive symptoms and time variable into the equation. Further adjustment was performed by including all the confounding variables (age, gender, BMI, education, household expenditure, marital status, chronic diseases, and healthy behaviors) in Model 2. In Model 3, the interaction term between time and depression was adjusted. Given po-

tential differences between women and men, the two-way interaction (depressive symptoms × gender) and three-way interaction (depressive symptoms × gender × time) were conducted based on Model 2 and Model 3, respectively. To avoid potential confounding effects of age and cardiovascular diseases, two sensitivity analyses were performed in participants stratified by age (<65 years vs. ≥65 years) or free of cardiovascular diseases including hypertension, heart attack, coronary heart disease, angina, congestive heart failure, and other heart problems. The regression coefficients were reported with standard errors. All statistical tests were two-tailed, and statistical significance was set as a p-value < 0.05.

6. Results

A total number of 9487 participants were included in the final analysis [mean age (SD) = 58.47 (9.19); female, 53.1%]. Descriptive statistics on key variables were presented in Table 1. Compared to those who were excluded ($n = 7444$), participants who were included in the analysis were younger and had a lower level of depressive symptoms at baseline and a higher level of PEF for all three waves (all $ps < 0.001$). Included participants were more likely to be women and less likely to be diagnosed with chronic diseases including hypertension and heart diseases (all $ps < 0.001$).

Table 2 presented results from the two-level growth models assessing trajectories of PEF. In the crude model (Model 1), time and depressive symptoms were significantly associated with PEF among Chinese middle-aged and older adults [time ($b = 3.52$, $p < 0.001$); depressive symptoms ($b = -4.03$, $p < 0.001$)]. These associations remained significant when adjusted for multiple confounding factors [time ($b = 3.72$, $p < 0.001$), depressive symptoms ($b = -1.85$, $p < 0.001$)] (Model 2). On average, the value of PEF increased by 3.72 units for Chinese middle-aged and older adults over time. One unit increment in the score of baseline depressive symptoms was accompanied by a 1.85 unit decrement in the value of PEF.

The results of the interaction analysis were shown in Table 3. A significant interaction between depressive symptoms and gender was found ($b = 1.29$, $p < 0.001$). We then examined the effect of depressive symptoms on PEF by gender and found that the association was greater for men ($b = -2.36$, $p < 0.001$) than for women ($b = -1.46$, $p < 0.001$). The three-way interaction between depressive symptoms, time, and gender was insignificant ($b = -0.17$, $p = 0.112$).

The first sensitivity analysis showed the association between depressive symptoms and PEF is independent of age [<65 ($n = 7198$): $b = -1.98$, $p < 0.001$; ≥65 ($n = 2289$): $b = -2.22$, $p < 0.001$]. No significant interaction between depressive symptoms and time was found in either subgroup of age. Another sensitivity analysis indicated that depressive symptoms remained significantly associated with PEF even after participants with cardiovascular diseases were excluded ($n = 6588$; $b = -1.92$, $p < 0.001$).

Table 1
Characteristics of respondents on key variables.

Characteristics	Included (n = 9487)	Excluded (n = 7444)	p-value
Age, M (SD), y	58.47 (9.19)	59.92 (10.42)	<0.001
Gender, (female,%)	53.1	48.8	<0.001
Education level, (Less than lower secondary education, %)	89.0	86.0	<0.001
Household expenditure, yuan	24,257.94 (112,516.42)	26,245.80 (40,837.82)	0.24
BMI, M (SD), kg/m^2	24.26 (34.42)	23.91 (41.47)	0.63
Hypertension,%	25.4	27.8	<0.001
Diabetes,%	6.1	6.4	0.42
Heart disease,%	10.5	14.7	<0.001
Smoking,%	30.5	27.9	<0.001
Drinking,%	33.1	33.6	0.55
Unmarried,%	11.7	14.7	<0.001
Depressive symptoms, M (SD)	8.17 (6.22)	8.80 (6.49)	<0.001
PEF in 2011, M (SD)	303.73 (124.01)	263.05 (125.87)	<0.001
PEF in 2013, M (SD)	303.92 (126.30)	276.29 (131.50)	<0.001
PEF in 2015, M (SD)	318.63 (119.85)	287.64 (129.02)	<0.001

M, mean; SD, standard deviation; BMI, body mass index; PEF, peak expiratory flow.

7. Discussion

Using nationally representative, longitudinal data in China, we found that baseline depressive symptoms were significantly associated with reduced PEF among general Chinese middle-aged and older adults. The association remained strong after all confounding variables had been taken into account. Further analysis showed that the association between depressive symptoms and PEF was greater for men than women. To the best of our knowledge, this is the first longitudinal study to explore the change trajectories between depressive symptoms and PEF among general middle-aged and older adults.

In the present study, an overall increment in PEF was observed during a 4-year follow-up, which seemed not reasonable for a relatively older population. Several reasons might be responsible for this general increasing trend of PEF. First of all, starting in 2013, China conducted a series of clean air actions that markedly improved air quality (Xue et al., 2019). This air pollution mitigation might improve the lung function of adults in China (Xue et al., 2021). Another explanation might be that with the rapid economic development from 2011 to 2015 in China, a healthy community lifestyle with more social and physical activities had been popular among citizens, which could explain the overall increment in PEF (Xia et al., 2021).

Consistent with most previous studies conducted on patients with chronic lung disease, we found that depressive symptoms were negatively associated with lung function. Moreover, our findings confirmed the results from cross-sectional studies conducted in healthy populations. For example, the study by Lu et al. (2013) demonstrated that depressive symptoms were associated with progressive increases in pulmonary obstruction among general Singapore older adults. Using data from Chinese college students, Guo et al. (2020) also found that depression severity was independently correlated with lung function decline.

The mechanisms underlying the association between depression and lung function remain unclear. However, there are several possible explanations to consider. A population-based meta-analysis showed that patients with depression had elevated oxidative stress levels (Black et al., 2015). Oxidative stress may induce lipid peroxidation, protein oxidation, and DNA damage, which, in turn, may result in abnormalities in cell structures, eventually leading to cell death (Valko et al., 2007). The large surface area for gas exchange makes the respiratory system particularly susceptible to oxidative stress-mediated injury, which would subsequently exacerbate pulmonary dysfunction (Santus et al., 2014). Alternatively, proinflammatory cytokines may play a role in the link. Using data from the Singapore Longitudinal Ageing Study (SLAS), Lu et al., found serum IL-6 and CRP partially mediated the association between depressive symptoms and lung function (Lu et al., 2013). Previous studies showed that a higher level of depression is significantly associated with raised inflammatory markers (e.g. C-reactive protein, CRP; interleukin-6, IL-6) (Valkanova et al., 2013). Overexpression of IL-6 may lead to emphysema-like airspace enlargement, peribronchiolar collections of mononuclear cells, thickening of airway walls, subepithelial fibrosis, and airway hyperresponsiveness (Kuhn et al., 2000). Finally, an increased level of depression might lead to reduced physical activity, increased cigarette consumption, and a longer sedentary lifestyle, which are all considered as risk factors for lung function decline.

A significant gender difference was found in the association between

Table 2
Regression coefficients from two-level growth models for depressive symptoms and PEF ($n = 9487$).

	Model 1 [a]			Model 2 [b]			Model 3 [c]		
	b	SE	*p*	b	SE	*p*	b	SE	*p*
Intercept	334.30	1.89	<0.001	559.53	13.28	<0.001	560.92	13.30	<0.001
Time (in years)	3.52	0.32	<0.001	3.72	0.32	<0.001	2.98	0.52	<0.001
depressive symptoms	− 4.03	0.18	<0.001	− 1.85	0.14	<0.001	− 2.01	0.17	<0.001
Individual-level change rate									
Time × **D**epressive symptoms							0.09	0.05	0.076
Individual-level controls									
Age (in years)				− 4.25	0.11	<0.001	− 4.25	0.11	<0.001
gender				− 107.53	2.33	<0.001	− 107.55	2.33	<0.001
BMI				0.03	0.03	0.239	0.03	0.03	0.237
Education (ref. less secondary)				29.14	2.93	<0.001	29.08	2.93	<0.001
Household expenditure [d]				13.35	2.35	<0.001	13.33	2.35	<0.001
Married (ref. not married)				6.18	2.91	0.034	6.19	2.91	0.034
Hypertension (ref. no)				0.02	2.08	0.991	0.02	2.08	0.994
Diabetes (ref. no)				6.34	3.71	0.088	6.35	3.71	0.087
Heart disease (ref. no)				0.01	2.93	0.996	0.01	2.93	0.996
Smoking (ref. no)				− 12.47	2.33	<0.001	− 12.46	2.33	<0.001
Drinking (ref. no)				2.51	2.12	0.238	2.50	2.13	0.241

*$p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$. BMI, body mass index.
[a] : Crude model.
[b] : Adjusted for age, gender, BMI, education, household expenditure, marital status, chronic diseases (hypertension, diabetes, and heart disease), and healthy behaviors (smoking and drinking).
[c] : [b] + Time × Depressive symptoms.
[d] : Household expenditure is expressed as the natural log of the annual household expenditure.

Table 3
Interaction analysis between depressive symptoms, gender, and time ($n = 9487$).

	Depressive symptoms*gender			Depressive symptoms*gender*time		
	b	SE	*p*	b	SE	*p*
Intercept	566.15	13.35	<0.001	566.88	13.40	<0.001
Time (in years)	3.71	0.32	<0.001	3.36	0.74	<0.001
Depressive symptoms	− 2.61	0.22	<0.001	− 3.00	0.27	<0.001
Depressive symptoms*gender	1.29	0.29	<0.001	1.58	0.34	<0.001
Depressive symptoms*gender*time	–	–	–	−0.17	0.11	0.112

depressive symptoms and PEF. A higher level of baseline depressive symptoms was linked with a greater decrement of PEF for men than women. One possible reason for this gender difference might be sex hormones, which have been shown to modulate a large variety of mechanisms involved in the immune response. For example, estrogen, a major sex hormone, has been proven to have substantial immune-modulatory effects (Tanriverdi et al., 2003). One of these effects is the partially attenuating of inflammatory responses (Nilsson, 2007), which may prevent women from an inflammatory hyper-responsiveness induced by depression.

Strengths of our study included the large sample size and the fact that CHARLS was designed to be representative of the community-dwelling Chinese middle-aged and older population. The limitations of this study were as follows. Firstly, although PEF has turned out to be an indicator of general robustness in extensive surveys and clinical settings (Roberts & Mapel, 2012), it is a relatively crude measure of pulmonary function compared to formal spirometry such as forced expiratory volume in 1 s (FEV1) and forced vital capacity (FVC). Secondly, although many covariates have been considered, we could not rule out the possibility that residual and unmeasured factors might have contributed to the association observed. Finally, compared to those excluded, included participants had a lower level of depressive symptoms and a higher level of PEF. This might lead to an underestimate of the true association between depressive symptoms and PEF.

8. Conclusions and implications

In conclusion, we found that increased depressive symptoms were associated with reduced PEF in general middle-aged and older adults in China. Compared with women, men with a higher level of depressive symptoms experienced greater decrement in PEF. Our findings suggest that it is possible to reduce the effects of PEF on health by improving psychological health among general middle-aged and older populations.

Authors' contribution

Lizhi Guo and Li Yang made substantial contributions to the design of the work, drafted the manuscript as well as analyzed and interpreted data of the work. Liwei Rao, Fengping Luo, Ningcan Gao and Xiaohua Jia edited and revised the manuscript critically for important intellectual content. Bin Yu contributed to the study design, data analysis and critical revision of the article for important intellectual content. All authors gave final approval of the version to be published.

Declaration of Competing Interest

None.

Data availability statement

The data that support the findings of this study are available from the author upon reasonable request.

Funding sources

This work was supported by the National Social Science Foundation, China (Grant No. 18BSH118).

Acknowledgments

None.

Reference

Agustí, A., Noell, G., Brugada, J., & Faner, R. (2017). Lung function in early adulthood and health in later life: A transgenerational cohort analysis. *The Lancet Respiratory Medicine, 5*(12), 935–945. https://doi.org/10.1016/S2213-2600(17)30434-4

Atlantis, E., Fahey, P., Cochrane, B., & Smith, S. (2013). Bidirectional associations between clinically relevant depression or anxiety and COPD: A systematic review and meta-analysis. *Chest, 144*(3), 766–777. https://doi.org/10.1378/chest.12-1911

Black, C. N., Bot, M., Scheffer, P. G., Cuijpers, P., & Penninx, B. W. J. H. (2015). Is depression associated with increased oxidative stress? A systematic review and meta-analysis. *Psychoneuroendocrinology, 51*, 164–175. https://doi.org/10.1016/j.psyneuen.2014.09.025

Boey, K. W. (1999). Cross-validation of a short form of the CES-D in Chinese elderly. *International Journal of Geriatric Psychiatry, 14*(8), 608–617. https://doi.org/10.1002/(SICI)1099-1166(199908

Chen, H., & Mui, A. C. (2014). Factorial validity of the center for epidemiologic studies depression scale short form in older population in China. *International psychogeriatrics, 26*(1), 49–57. https://doi.org/10.1017/s1041610213001701

Cook, N. R., Evans, D. A., Scherr, P. A., Speizer, F. E., Taylor, J. O., & Hennekens, C. H. (1991). Peak expiratory flow rate and 5-year mortality in an elderly population. *American Journal of Epidemiology, 133*(8), 784–794. https://doi.org/10.1093/oxfordjournals.aje.a115957

Goldbeck, L., Besier, T., Hinz, A., Singer, S., & Quittner, A. L. (2010). Prevalence of symptoms of anxiety and depression in German patients with cystic fibrosis. *Chest, 138*(4), 929–936. https://doi.org/10.1378/chest.09-2940

Guo, L., Cao, J., Cheng, P., Shi, D., Cao, B., Yang, G., et al. (2020). Moderate-to-severe depression adversely affects lung function in Chinese college students. *Frontiers in Psychology*, (652), 11. https://doi.org/10.3389/fpsyg.2020.00652

Hansen, E. F., Vestbo, J., Phanareth, K., Kok-Jensen, A., & Dirksen, A. (2001). Peak flow as predictor of overall mortality in asthma and chronic obstructive pulmonary disease. *American Journal of Respiratory and Critical Care Medicine, 163*(3), 690–693. https://doi.org/10.1164/ajrccm.163.3.2006120

Huang, J., Bian, Y., Zhao, Y., Jin, Z., Liu, L., & Li, G. (2021). The impact of depression and anxiety on chronic obstructive pulmonary disease acute exacerbations: A prospective cohort study. *Journal of Affective Disorders, 281*, 147–152. https://doi.org/10.1016/j.jad.2020.12.030

James, S. L., Abate, D., Abate, K. H., Abay, S. M., Abbafati, C., Abbasi, N., et al. (2018). Global, regional, and national incidence, prevalence, and years lived with disability for 354 diseases and injuries for 195 countries and territories, 1990–2017: A systematic analysis for the Global Burden of Disease Study 2017. *The Lancet, 392*(10159), 1789–1858. https://doi.org/10.1016/S0140-6736(18)32279-7

Kuhn, C., Homer, R. J., Zhu, Z., Ward, N., Flavell, R. A., Geba, G. P., et al. (2000). Airway hyperresponsiveness and airway obstruction in transgenic mice. *American Journal of Respiratory Cell and Molecular Biology, 22*(3), 289–295. https://doi.org/10.1165/ajrcmb.22.3.3690

Lei, X., Sun, X., Strauss, J., Zhang, P., & Zhao, Y. (2014). Depressive symptoms and SES among the mid-aged and elderly in China: Evidence from the China health and retirement longitudinal study national baseline. *Social Science & Medicine, 120*, 224–232. https://doi.org/10.1016/j.socscimed.2014.09.028

Lu, Y., Feng, L., Feng, L., Nyunt, M. S., Yap, K. B., & Ng, T. P. (2013). Systemic inflammation, depression and obstructive pulmonary function: A population-based study. *Respiratory Research, 14*(1), 53. https://doi.org/10.1186/1465-9921-14-53

Mannino, D. M., & Davis, K. J. (2006). Lung function decline and outcomes in an elderly population. *Thorax, 61*(6), 472. https://doi.org/10.1136/thx.2005.052449

Mannino, D. M., Ford, E. S., & Redd, S. C. (2003). Obstructive and restrictive lung disease and markers of inflammation: Data from the third national health and nutrition examination. *The American Journal of Medicine, 114*(9), 758–762. https://doi.org/10.1016/S0002-9343(03)00185-2

Naqvi, T. Z., Naqvi, S. S., & Merz, C. N. (2005). Gender differences in the link between depression and cardiovascular disease. *Psychosomatic medicine, 67*(Suppl 1), S15–S18. https://doi.org/10.1097/01.psy.0000164013.55453.05

Nilsson, B. O. (2007). Modulation of the inflammatory response by estrogens with focus on the endothelium and its interactions with leukocytes. *Inflammation Research, 56*(7), 269–273. https://doi.org/10.1007/s00011-007-6198-z

Park, Y., Jung, J. Y., Kim, Y. S., Chung, K. S., Song, J. H., Kim, S. Y., et al. (2018). Relationship between depression and lung function in the general population in Korea: A retrospective cross-sectional study. *International Journal of Chronic Obstructive Pulmonary Disease, 13*, 2207–2213. https://doi.org/10.2147/COPD.S169025

Qiao, H., Chen, M., Li, S., Li, Y., Sun, Y., & Wu, Y. (2020). Poor lung function accelerates cognitive decline in middle-aged and older adults: Evidence from the English longitudinal study of ageing. *Archives of Gerontology and Geriatrics, 90*, Article 104129.

Riekert, K. A., Bartlett, S. J., Boyle, M. P., Krishnan, J. A., & Rand, C. S. (2007). The association between depression, lung function, and health-related quality of life among adults with cystic fibrosis. *Chest, 132*(1), 231–237.

Roberts, M. H., & Mapel, D. W. (2012). Limited lung function: Impact of reduced peak expiratory flow on health status, health-care utilization, and expected survival in older adults. *American Journal of Epidemiology, 176*(2), 127–134. https://doi.org/10.1093/aje/kwr503

Rocha, V., Fraga, S., Moreira, C., Carmeli, C., Lenoir, A., Steptoe, A., et al. (2021). Life-course socioeconomic disadvantage and lung function: A multicohort study of 70, 496 individuals. *European Respiratory Journal, 57*(3), Article 2001600. https://doi.org/10.1183/13993003.01600-2020

Salk, R. H., Hyde, J. S., & Abramson, L. Y. (2017). Gender differences in depression in representative national samples: Meta-analyses of diagnoses and symptoms. *Psychological Bulletin, 143*(8), 783.

Santus, P., Corsico, A., Solidoro, P., Braido, F., Di Marco, F., & Scichilone, N. (2014). Oxidative stress and respiratory system: Pharmacological and clinical reappraisal of N-acetylcysteine. *COPD: Journal of Chronic Obstructive Pulmonary Disease, 11*(6), 705–717. https://doi.org/10.3109/15412555.2014.898040

Singh-Manoux, A., Dugravot, A., Kauffmann, F., Elbaz, A., Ankri, J., Nabi, H., et al. (2011). Association of lung function with physical, mental and cognitive function in early old age. *Age, 33*(3), 385–392. https://doi.org/10.1007/s11357-010-9189-x *(Melbourne, Vic.)*.

Smith, A., Krishnan, J. A., Bilderback, A., Riekert, K. A., Rand, C. S., & Bartlett, S. J. (2006). Depressive symptoms and adherence to asthma therapy after hospital discharge. *Chest, 130*(4), 1034–1038.

Smith, M., Zhou, M., Wang, L., Peto, R., Yang, G., & Chen, Z. (2013). Peak flow as a predictor of cause-specific mortality in China: Results from a 15-year prospective study of ~170 000 men. *International Journal of Epidemiology, 42*(3), 803–815. https://doi.org/10.1093/ije/dyt079

Tanriverdi, F., Silveira, L. F. G., MacColl, G. S., & Bouloux, P. M. G. (2003). The hypothalamic-pituitary-gonadal axis: Immune function and autoimmunity. *The Journal of Endocrinology, 176*(3), 293–304. https://doi.org/10.1677/joe.0.1760293

Valkanova, V., Ebmeier, K. P., & Allan, C. L. (2013). CRP, IL-6 and depression: A systematic review and meta-analysis of longitudinal studies. *Journal of Affective Disorders, 150*(3), 736–744. https://doi.org/10.1016/j.jad.2013.06.004

Valko, M., Leibfritz, D., Moncol, J., Cronin, M. T. D., Mazur, M., & Telser, J. (2007). Free radicals and antioxidants in normal physiological functions and human disease. *The International Journal of Biochemistry & Cell Biology, 39*(1), 44–84. https://doi.org/10.1016/j.biocel.2006.07.001

Viniol, C., & Vogelmeier, C. F. (2018). Exacerbations of COPD. *European Respiratory Review: An Official Journal of the European Respiratory Society*, (147), 27. https://doi.org/10.1183/16000617.0103-2017

Xia, Y., Zhang, H., Cao, L., & Zhao, Y. (2021). Household solid fuel use and peak expiratory flow in middle-aged and older adults in China: A large cohort study (2011–2015). *Environmental Research, 193*, Article 110566. https://doi.org/10.1016/j.envres.2020.110566

Xue, T., Han, Y., Fan, Y., Zheng, Y., Geng, G., Zhang, Q., et al. (2021). Association between a rapid reduction in air particle pollution and improved lung function in adults. *Annals of the American Thoracic Society, 18*(2), 247–256. https://doi.org/10.1513/AnnalsATS.202003-246OC

Xue, T., Liu, J., Zhang, Q., Geng, G., Zheng, Y., Tong, D., et al. (2019). Rapid improvement of PM2.5 pollution and associated health benefits in China during 2013–2017. *Science China Earth Sciences, 62*(12), 1847–1856. https://doi.org/10.1007/s11430-018-9348-2