BMJ Open

Pneumoconiosis combined with connective tissue disease in China: a cross-sectional study

Wenjing Xu,¹ ² Ruimin Ma,¹ Jingwei Wang,¹ Di Sun,¹ Shiwen Yu,¹ Qiao Ye ²

ABSTRACT

Objective To describe the prevalence, clinical features and potential risk factors of pneumoconiosis in combination with connective tissue disease (CTD) or positive autoantibodies.

Design Cross-sectional study.

Setting A retrospective study of adults recruited in China between December 2016 and November 2021.

Participants A total of 931 patients with pneumoconiosis at Beijing Chao-Yang Hospital were enrolled in this study; of these, 580 patients were included in the final analysis.

Main outcome measures Pneumoconiosis combined with CTD or positive autoantibodies was a major adverse outcome.

Results In total, 13.8% (80/580) of the participants had combined pneumoconiosis with CTD, among whom the prevalence of CTD was 18.3% (46/251) in asbestosis and 11.4% (34/298) in silicosis/coal mine workers’ pneumoconiosis. In comparison to the general Chinese adult population, the relative risk of various CTD in pneumoconiosis, including rheumatoid arthritis, systemic lupus erythematosus, systemic sclerosis, primary Sjögren’s syndrome, idiopathic inflammatory myopathy and antineutrophil cytoplasmic antibodies-associated vasculitis, were 11.85, 12.12, 127.40, 4.23, 9.94 and 644.66, respectively. Multivariate analysis revealed that female sex (OR 2.55, 95% CI 1.56 to 4.17) and a later stage of pneumoconiosis (OR 2.04, 95% CI 1.24 to 3.34) were the independent risk factors for CTD in patients with pneumoconiosis (all p<0.050).

Conclusion CTD is highly prevalent in patients with pneumoconiosis, especially in patients of asbestosis, and silicosis/coal mine workers’ pneumoconiosis. Female sex and later stages of pneumoconiosis are associated with an increased risk of combined with CTD.

INTRODUCTION

Pneumoconiosis is a group of heterogeneous diseases characterised by different degrees of lung tissue damage due to inhalation of mineral dust.¹ Between 1990 and 2017, the number of patients with pneumoconiosis worldwide increased by 66%.² In 2019, the global incidence of coal workers’ pneumoconiosis was 7153 patients, and the highest number (4974 patients) of incidents occurred in Mainland China.³ The use of asbestos has not been completely banned in low-income and middle-income countries, particularly in Asia, which was responsible for the increased age-standardised incidence rate of pneumoconiosis globally from 1990 to 2017.⁴

Numerous studies have shown that autoantibodies increase with excessive exposure to mineral dust, including antinuclear antibodies (ANA), rheumatoid factor (RF), antineutrophil cytoplasmic antibodies (ANCA) and so on.⁵ ⁶ In addition, various studies have demonstrated that connective tissue disease (CTD) can be complicated in patients with pneumoconiosis,⁷ ⁸ such as Caplan’s syndrome and Erasmus syndrome, which have been reported histologically.⁹ ¹⁰ In these pneumoconiosis patients, though the incidence of CTD is markedly lower than the incidence of positive autoantibodies, it is not known if patients with positive autoantibodies will develop CTD later. Previous reports have revealed that comorbidity with CTD may cause an even worse prognosis for patients with pneumoconiosis because of the increased incidence of pulmonary hypertension.¹¹ Therefore, the identification of risk factors for CTD secondary to pneumoconiosis may help to identify high-risk patients who can benefit from early therapeutic interventions.

Although numerous studies have confirmed a modest association between pneumoconiosis and an increased risk of CTD or positive autoantibodies, the mechanisms that trigger this association are not completely

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ This was a retrospective study of patients with pneumoconiosis recruited from a single medical centre in China over a 5-year period.

⇒ A cross-sectional study with a large sample size highlighted connective tissue disease as a comorbid condition in patients with pneumoconiosis.

⇒ However, this cross-sectional study could not address the causality between pneumoconiosis and connective tissue diseases.


© Author(s) (or their employer(s)) 2023. Re-use permitted under CC BY-NC. No commercial re-use. See rights and permissions. Published by BMJ.

1Department of Occupational Medicine and Toxicology, Clinical Center for Interstitial Lung Diseases, Beijing Institute of Respiratory Medicine, Beijing Chao-Yang Hospital, Capital Medical University, Beijing, China

2Department of Pulmonary and Critical Care Medicine, Wuhan Pulmonary Hospital, Wuhan, China

Correspondence to Professor Qiao Ye; yeqiao_chaoyang@sina.com

Received 05 October 2022
Accepted 18 March 2023

Check for updates
Therefore, this study aimed to describe the prevalence, possible clinical traits and potential risk factors of pneumoconiosis with CTD or positive autoantibodies in a hospital-based population in China.

**METHODS**

**Study design and population**

This descriptive study adopted a cross-sectional design and followed the guidelines established by the Strengthening the Reporting of Observational Studies in Epidemiology checklist.21 Between December 2016 and November 2021, patients presenting with pneumoconiosis at the Beijing Chao-Yang Hospital were recruited consecutively. Patients diagnosed with pneumoconiosis were to follow the diagnostic criteria of the International Labour Organization classification, with a multidisciplinary panel diagnosis. Patients were diagnosed with CTD according to the American Rheumatism Association and the American College of Rheumatology guidelines, including idiopathic inflammatory myositis (IIM), systemic lupus erythematosus (SLE), systemic sclerosis (SSc), primary Sjogren’s syndrome (pSS), rheumatoid arthritis (RA) and ANCA-associated vasculitis (AAV).22-27 Patients were excluded in the following cases: (1) absence of serological autoantibody testing and (2) other autoimmune diseases. Further details on the methodology can be found in online supplemental material.

**Data collection**

Clinical data, including age, sex, height, weight, current and medical histories, smoking status, occupational history (including type of exposure and start and end dates of employment), family history at the time of inclusion, laboratory tests, pulmonary function testing and chest radiographs, were collected from medical reports. Body mass index (BMI) was classified as underweight (<18.5 kg/m²), normal (18.5–25.0 kg/m²) and overweight/obese (≥25.0 kg/m²).28 Smoking status was expressed as current, former or never-smokers, and...
intensity was measured in pack-years. Details are provided in online supplemental material.

**Statistical analysis**

Statistical analyses were performed by using SPSS Statistics V25 (IBM), and GraphPad Prism V7.00 (GraphPad Software, La Jolla, California, USA). The sample size was calculated using the following formula: N=Z1−α/2 2 (1−p)/ε2 p, where Z1−α/2=1.96 and ε=0.2. As per the available literature, the incidence of CTD in pneumoconiosis patients ranges from 5.6% to 27.8%, and the required minimum sample size is 249. The distribution of continuous variables was checked. Comparisons of normally distributed continuous variables across the three groups were performed using a one-way analysis of variance. Comparisons of non-normally distributed variables were determined using the Mann-Whitney U or Kruskal-Wallis test. Continuous variables are shown as mean (95% CI). The prevalence of pneumoconiosis was 11.85% (95% CI: 7.42 to 18.93).

<table>
<thead>
<tr>
<th>CTDs</th>
<th>Population prevalence % (refs.)</th>
<th>Prevalence of pneumoconiosis % (N)</th>
<th>RR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RA</td>
<td>0.41 (4)</td>
<td>11.85 (7.42 to 18.93)</td>
<td></td>
</tr>
<tr>
<td>SLE</td>
<td>0.03 (2)</td>
<td>12.12 (2.03 to 72.47)</td>
<td></td>
</tr>
<tr>
<td>SSc</td>
<td>0.01 (7)</td>
<td>127.4 (15.70 to 1033.76)</td>
<td></td>
</tr>
<tr>
<td>pSS</td>
<td>0.77 (19)</td>
<td>4.23 (2.19 to 8.17)</td>
<td></td>
</tr>
<tr>
<td>IIM</td>
<td>0.015 (4)</td>
<td>9.94 (6.37 to 15.52)</td>
<td></td>
</tr>
<tr>
<td>AAV</td>
<td>0.0017 (7)</td>
<td>644.66 (316.76 to 1312.00)</td>
<td></td>
</tr>
</tbody>
</table>

AAV, antineutrophil cytoplasmic antibodies (ANCA)-associated vasculitis; CTD, connective tissue disease; IIM, idiopathic inflammatory myopathy; LSLE, primary Sjögren’s syndrome; RA, rheumatoid arthritis; RR, relative risk; SLE, systemic lupus erythematosus; SSc, systemic sclerosis.

**Figure 2** A composition of pneumoconiosis combined with or without connective tissue disease (CTD). *p<0.05, **p<0.01, ***p<0.001. DLCO, diffusion capacity of lung for carbon monoxide; FEV1, forced expiratory volume in 1 s; FVC, forced vital capacity; LDH, lactate dehydrogenase; PaO2, arterial oxygen pressure; TLC, total lung capacity.
Table 2  Demographics of pneumoconiosis with and without CTD

<table>
<thead>
<tr>
<th></th>
<th>Pneumoconiosis (N=580)</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>With CTD (N=90)</td>
<td>Without CTD (N=500)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age, mean (SD)</td>
<td>61.31 (10.17)</td>
<td>59.71 (11.38)</td>
<td>0.236</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female gender, N (%)</td>
<td>38 (47.5)</td>
<td>142 (28.4)</td>
<td>0.001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Smoking status</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Never-smoker, N (%)</td>
<td>48 (60.0)</td>
<td>236 (47.4)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Former-smoker, N (%)</td>
<td>25 (31.3)</td>
<td>187 (37.4)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Current-smoker, N (%)</td>
<td>7 (8.8)</td>
<td>77 (15.4)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cumulative pack-years, median (IQR)</td>
<td>27 (25.0)</td>
<td>20.0 (30.0)</td>
<td>0.972</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BMI, mean (SD)</td>
<td>24.89 (4.06)</td>
<td>24.80 (3.99)</td>
<td>0.847</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;18.5, N (%)</td>
<td>4 (5)</td>
<td>25 (5)</td>
<td>0.929</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18.5–24.9, N (%)</td>
<td>41 (51.2)</td>
<td>245 (49.0)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥25.0, N (%)</td>
<td>35 (43.8)</td>
<td>230 (46.0)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Duration of exposure, median (IQR)</td>
<td>19 (21)</td>
<td>19 (20)</td>
<td>0.062</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;10, N (%)</td>
<td>32 (40.0)</td>
<td>162 (32.4)</td>
<td>0.181</td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥10, N (%)</td>
<td>48 (60.0)</td>
<td>338 (67.6)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stage of pneumoconiosis</td>
<td></td>
<td></td>
<td>0.018</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I, N (%)</td>
<td>32 (40.0)</td>
<td>271 (54.2)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>II, III, N (%)</td>
<td>48 (60.0)</td>
<td>229 (45.8)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exposure dust</td>
<td></td>
<td></td>
<td>0.001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asbestos, N (%)</td>
<td>34 (42.5)</td>
<td>264 (52.8)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Silica, N (%)</td>
<td>46 (57.5)</td>
<td>205 (41.0)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other dust, N (%)</td>
<td>0</td>
<td>31 (6.2)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Data were presented as mean±SD or N (%) or median (IQR). BMI, body mass index; CTD, connective tissue disease.

RESULTS

Demographics
From December 2016 to November 2021, 931 patients with pneumoconiosis participated in this study (figure 1). Clinical data of 580 patients were available, including 298 with silicosis/coal mine workers’ pneumoconiosis, 251 with asbestosis and 31 with other pneumoconiosis subtypes. The mean age of the patients with pneumoconiosis was 59.93±11.23 years. Among the patients, 180 (31%) were female, and the median duration of exposure was 19 years. There were statistically significant differences in age, sex, BMI, smoking, duration of dust exposure and constituent ratio of pneumoconiosis among different pneumoconiosis subtypes (all p<0.05). The demographic characteristics of the study group are shown in online supplemental table S1.

Prevalence of pneumoconiosis combined with CTD
Among 580 patients with pneumoconiosis, 80 individuals (13.8%) had CTD, including 28 with RA, 2 with SLE, 7 with SSc, 19 with pSS, 7 with AVV, 4 with IIM, 12 with unclassified connective tissue disease and 1 with mixed connective tissue disease, which was a patient with SSc and IIM. CTD was observed in 18.3% of 251 patients with asbestosis and 11.4% of 298 coal mine workers with silicosis or pneumoconiosis. The estimated prevalence of these CTDs in the general population, their respective prevalence’s in those with pneumoconiosis and the corresponding relative risks are shown in table 1.20-31

Clinical features of pneumoconiosis with CTD
The patients combined with pneumoconiosis and CTD had lower forced vital capacity accounted for percentage of the predicted value (76.16% vs 85.10%, p=0.014); lower total lung capacity accounted for percentage of the predicted value (70.75% vs 84.31%, p<0.001) and lower diffusing capacity of the lung for carbon monoxide single breath (SB) accounted for percentage of the predicted value (58.68% vs 72.32%, p<0.001) (figure 2, table 2). The demographics and clinical characteristics of the subtypes of pneumoconiosis in patients with CTD are listed in online supplemental tables S2 and S3, respectively.

Risk factors for pneumoconiosis with CTD
In univariate logistic regression analysis, the risk factors associated with CTD included female sex, smoking status and stage of pneumoconiosis. In multivariable-adjusted analyses, the risk factors for CTD were female sex (OR 2.55, 95% CI 1.56 to 4.17, p<0.001) and stage II or III pneumoconiosis (OR 2.04, 95% CI 1.24 to 3.34, p=0.005) (table 3). The risk factors for the subtypes of pneumoconiosis in patients with CTD are shown in online supplemental tables S4 and S5.

Autoantibodies in patients with pneumoconiosis
Among the 580 patients who underwent autoantibody testing, 227 (39.1%) tested positive for autoantibodies (online supplemental table S6). Patients with positive autoantibodies were more likely to be females (41.9% vs 24.1%, p<0.001), non-smokers (44.9% vs 55.2%, p=0.015) or have stage II or III pneumoconiosis (54.6% vs 43.3%, p=0.008) than those with negative autoantibodies (online supplemental tables S7–S10).

Risk factors for pneumoconiosis with positive autoantibody
In univariate logistic regression analysis, the risk factors linked to autoantibody positivity included female...
sex, smoking and stage of pneumoconiosis. In the multivariable-adjusted analyses, the risk factors for positive autoantibodies were female sex (OR 2.50, 95% CI 1.73 to 3.62, p<0.001) and stage II or III pneumoconiosis (OR 1.80, 95% CI 1.27 to 2.55, p=0.001) (online supplemental table S11).

**DISCUSSION**

This retrospective cross-sectional study assessed the prevalence of CTD and positivity of autoantibodies in pneumoconiosis. Compared with the general population, pneumoconiosis had a higher prevalence of CTD and an increased positive rate of autoantibodies. The independent risk variables for pneumoconiosis with a CTD or positive autoantibodies were female sex and stage II or III pneumoconiosis.

In patients with silicosis, the prevalence of CTD varied considerably compared with other studies. The prevalence of CTD in silicosis in the USA was 5.6% in a total of 44 individuals, including 33 (4.2%) RA, 2 (0.3%) SSc, 1 (0.1%) SLE, 2 (0.3%) SS and 6 (0.8%) AAV.32

In a Spanish study, 54 (11%) patients with silicosis had systemic autoimmune rheumatic disease, including 12 (2.4%) RA, 10 (2.0%) SSc, 10 (2.0%) SLE, 2 (0.4%) AAV, 6 (1.2%) psoriatic arthritis, 3 (0.6%) ankylosing spondylitis and 8 (1.6%) other autoimmune diseases without any special characteristics.33

The prevalence of CTD in those with pneumoconiosis was 13.8%, including 28 (4.8%) of RA, 7 (1.2%) of SSc, 2 (0.3%) of SLE, 19 (3.3%) of pSS, 4 (0.7%) of IIM and 7 (1.2%) of AVV in our study. The total prevalence of CTD in silicosis/coal mine workers with pneumoconiosis was 11.5%, which was higher than that reported by Makol et al and similar to that described by Blanco-Pérez et al.32 33

Autoantibodies such as ANA, RF and ANCA are common in pneumoconiosis. In our silicosis/coal mine workers’ pneumoconiosis series, the prevalence of ANA was 31.9%, which is higher than the 17% previously reported.33 In this study, the prevalence of ANA was 32.7%, which was lower than that of the amphibole cohort (43%), but higher than that of the chrysotile cohort (23%).34 Recent reports have shown that occupational exposure to artificial stone-derived silica is a major contributor to rapidly progressing silicosis.35 36 Interstitial histiocytic and lymphocytic inflammation can be seen in the lung biopsy, and bronchoalveolar lavage demonstrates lymphocytosis.37 38 These findings suggested an immune response in these patients. Exposure to respirable crystalline silica results in increased levels of autoantibodies, which highlights the silicosis outbreaks linked to CTD.39

Patients with various pneumoconiosis were eligible for analysis in this study, including 298 (51.4%) with asbestosis, 251 (43.3%) with silicosis and 31 (5.3%) with others, such as welder’s pneumoconiosis and anthracosis. The physiological patterns differed between asbestosis, silicosis and other pneumoconiosis cases.40 In this study, the stages evaluated using chest radiography were used to determine the severity of pneumoconiosis. The later stage of pneumoconiosis was an independent risk factor for CTD in patients with pneumoconiosis; however, the correlations between baseline stages or lung function values and the development of CTD were unclear. Previous data showed that a dose–response relationship and a temporal association may exist between occupational exposure to artificial...
stone-derived silica and poor PFTs or a high positive rate of autoantibodies. In addition, the inclusion of a large group of females (31%) is of particular importance. Women had a significantly increased risk of positive autoantibodies, with or without pneumoconiosis. To the best of my knowledge, this is the first study on pneumoconiosis where the female gender was included, indicating the important public health implications. Specifically, a careful monitoring of workplace exposure among women is needed.

The potential mechanisms underlying the biological effects of occupational dust remain unknown. A study on genetically heterogeneous outbred mice showed that the levels of anti-ENA5 (Sm, RNP, SS-A, SS-B and Scl-70) in silica-exposed mice were significantly higher than those in mice not exposed to silica. Acute crystalline silica (SiO2) exposure persistently provoked recruitment of macrophages, neutrophils and lymphocytes into the alveoli and elevated secretion of the cytokines IL-1α, IL-1β, IL-18, TNF-α, IL-6, monocyte chemoattractant protein (MCP) -1 and B cell activation factor. Inhalation of silica particles may trigger activation of macrophages and the RhoA/ROCK pathway to decrease the efferocytosis of alveolar macrophages and epithelial cells. The asbestos-instilled animals had a significantly higher frequency of positive ANA than the saline controls. Limitations should be cautioned when reading the paper. First, as a cross-sectional retrospective study, it did not have the power to identify the related factors affecting other organ involvement, malignancy or death induced by pneumoconiosis with CTD. Second, owing to the lack of studies on the prevalence of asbestosis with CTD, the sample size of this study was estimated based on the prevalence of silicosis with CTD. Third, monitoring data on dust concentration in the dust exposure environment of patients with pneumoconiosis are lacking. Years of occupational dust exposure were used to roughly reflect the dust exposure situation. Fourth, previous studies have found that exposure to silica or asbestos dust increases the risk of serologically negative and positive RA. Our data showed that all patients with RA were serologically positive and that there was a probability that the diagnosis of patients who were serologically negative for RA was missed. Finally, in our study, all patients with asbestosis were exposed to chrysotile asbestos fibres. The findings could not clarify the situation of CTD or positive autoantibodies in asbestosis patients with amphibole asbestos exposure.

In conclusion, the prevalence of pneumoconiosis with CTD was as high as 13.8%, while that of asbestosis and silicosis was 18.3% and 11.4%, respectively. Female sex and a later stage of pneumoconiosis were independent risk factors for pneumoconiosis with CTD. These findings provide a new evidence for the high prevention of autoimmune diseases in pneumoconiosis, calling for the formulation of early detection and strengthening prevention strategies, particularly in low-income and middle-income countries.

Contributors WX performed all data collection, analysed and wrote the manuscript. RM and JW were responsible for data analysing, DS and SY were responsible for recruiting the patients. QY contributed as primary investigator and was responsible for designing the study, recruiting the patients and writing the manuscript. All authors read and approved the final manuscript. QY is responsible for the overall content as guarantor.

Funding The work was supported by Reform and Development Program of Beijing Institute of Respiratory Medicine (yshr2022013) and Consulting Research Project of Chinese Academy of Engineering (2021-JJDZ-10).

Disclaimer The funding sources had no role in the study conduct, data collection, analyses, data interpretation and the decision to submit the manuscript.

Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not applicable.

Ethics approval This study was approved by the Institutional Review Board of Beijing Chao-Yang Hospital (2018-KE-289) and conducted in accordance with the World Medical Association Declaration of Helsinki. Written informed consent was obtained from all patients.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available on reasonable request. The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Supplemental material This content has been supplied by the author(s). It has not been vetted by BMJ Publishing Group Limited (BMJ) and may not have been peer-reviewed. Any opinions or recommendations discussed are solely those of the author(s) and are not endorsed by BMJ. BMJ disclaims all liability and responsibility arising from any reliance placed on the content. Where the content includes any translated material, BMJ does not warrant the accuracy and reliability of the translations (including but not limited to local regulations, clinical guidelines, terminology, drug names and drug dosages), and is not responsible for any error and/or omissions arising from translation and adaptation or otherwise.

Open access This is an open access article distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited, appropriate credit is given, any changes made indicated, and the use is non-commercial. See: http://creativecommons.org/licenses/by-nc/4.0/.

ORCID iD Qiao Ye http://orcid.org/0000-0002-0932-0487

REFERENCES


Correction: Pneumoconiosis combined with connective tissue disease in China: a cross-sectional study


This article was previously published with an error.

In Prevalence of pneumoconiosis combined with CTD section under Results the representation of the data was incomplete. This has now been rectified as shown below:

Among the 580 patients with pneumoconiosis, 80 individuals (13.8%) had CTD, including 28 with RA, 2 with SLE, 7 with SSc, 19 with pSS, 7 with AVV, 4 with IIM, 12 with unclassified connective tissue disease, and 1 with mixed connective tissue disease, which was a patient with SSc and IIM.

Open access  This is an open access article distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited, appropriate credit is given, any changes made indicated, and the use is non-commercial. See: http://creativecommons.org/licenses/by-nc/4.0/.

© Author(s) (or their employer(s)) 2023. Re-use permitted under CC BY-NC. No commercial re-use. See rights and permissions. Published by BMJ.

BMJ Open 2023;13:e068628corr1. doi:10.1136/bmjopen-2022-068628corr1