

Advances in Screening for Obstructive Sleep Apnea During Pregnancy: Postprint

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Abstract

Obstructive sleep apnea (OSA) is a common sleep-related breathing disorder in pregnant populations, which is not only associated with multiple adverse pregnancy outcomes but may also exert significant long-term impacts on maternal and infant health. Currently, the gold standard for OSA diagnosis, polysomnography (PSG), is challenging to implement on a large scale in pregnant populations, resulting in the majority of pregnancy-related OSA cases failing to receive timely diagnosis, thereby jeopardizing maternal and infant health. Accurately identifying pregnant women at potential risk for OSA through screening strategies and tools beyond PSG and providing timely diagnosis and treatment is of significant importance for improving adverse pregnancy outcomes. This article presents a review on the topic of OSA screening during pregnancy, aiming to provide reference and theoretical basis for screening pregnancy-related OSA.

Full Text

A Review of Screening Obstructive Sleep Apnea in Pregnant Population

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Abstract

Obstructive sleep apnea (OSA) is a common sleep-disordered breathing disease in pregnant populations. It is not only associated with various adverse perinatal outcomes but may also have significant long-term health impacts on both mothers and infants. Currently, polysomnography (PSG), the gold standard for diagnosing OSA, is difficult to implement on a large scale in pregnant populations, resulting in the vast majority of pregnancy-related OSA cases failing to receive timely diagnosis and posing risks to maternal and infant health. Accurately identifying pregnant women at potential risk for OSA through screening strategies and tools beyond PSG, and providing timely diagnosis and treatment, is of great significance for improving adverse pregnancy outcomes. This article provides a comprehensive review of OSA screening during pregnancy to offer reference and theoretical basis for clinical practice.

Keywords: Pregnancy; Obstructive sleep apnea; Screening

Obstructive sleep apnea (OSA) is a prevalent sleep-disordered breathing condition in pregnant women. During pregnancy, physiological changes including weight gain, altered anatomy, and hormonal shifts lead to a marked increase in OSA prevalence [1]. Pregnancy-related OSA represents an independent risk factor for gestational hypertension, diabetes mellitus, and preeclampsia [2-4], while also increasing risks of preterm birth, fetal growth restriction, and neonatal asphyxia [5], thereby seriously endangering maternal and infant health and potentially affecting their long-term wellbeing [6-8]. Early identification and timely management of OSA during pregnancy are therefore crucial measures for improving or even reversing adverse pregnancy outcomes, representing a necessary and priority maternal-child health issue. However, two major challenges exist: first, PSG, the diagnostic gold standard for OSA, cannot be widely implemented; second, accurate and convenient screening tools for pregnancy-related OSA are lacking. Consequently, the vast majority of pregnant women with OSA remain undiagnosed and untreated, increasing the risk of adverse outcomes [9]. Developing precise, efficient screening strategies and accurate, convenient screening tools is thus essential for identifying high-risk pregnant populations, optimizing utilization of limited medical resources, and safeguarding maternal and infant health. This article summarizes the current status, timing, target populations, and screening tools for OSA screening in pregnancy to provide theoretical foundations for improving clinical screening efficiency.

1. Prevalence of OSA in Pregnancy and Current Screening Status

The exact prevalence of OSA in pregnancy remains unclear due to variations in study populations, ethnicity, pregnancy risk levels, gestational age, and diagnostic tools and criteria [10-14]. Current data indicate that among the over 200 million pregnant women worldwide each year, OSA prevalence is at least 9% [9], with significantly higher rates in high-risk pregnancies reaching 20-35% [15].

Prevalence increases with gestational age, rising from 10.5% in early pregnancy to 26.7% in late pregnancy [16], and in high-risk pregnancies, from 30% in the first trimester to 47% in the third trimester. Studies have identified significant weight gain in early pregnancy [16-18], increased neck circumference [16, 17, 19], advanced maternal age [16, 19], and history of chronic hypertension [20] as risk factors for OSA development in late pregnancy [21].

However, PSG as the classical diagnostic method is constrained by being time-consuming, expensive, and having long waiting lists, resulting in diagnosis and treatment rates below 1% among OSA patients in China [22]. Third-trimester monitoring may cause discomfort for pregnant women, making large-scale implementation impractical in clinical practice. The lack of effective and convenient screening tools for pregnancy-related OSA, combined with insufficient awareness among most obstetricians regarding OSA and its dynamic changes during pregnancy, and pregnant women's tendency to neglect their symptoms, contributes to low screening and treatment rates in this population [9].

2. Screening Timing and Target Populations for Pregnancy-Related OSA

No consensus currently exists regarding the optimal timing for OSA screening in pregnancy. Dominguez et al. [23] recommend screening at 12-18 weeks gestation to enable early assessment and timely treatment. However, given that OSA prevalence peaks in the third trimester, other experts suggest that late-pregnancy screening may be more effective and efficient, though this approach risks missing a critical therapeutic window, particularly if the goal includes preventing or mitigating pregnancy complications [24]. Recognizing the complexity and dynamic nature of screening timing, Xu et al. [25] propose integrating OSA screening into routine prenatal care, both preconceptionally and during pregnancy, to enhance obstetricians' awareness of the condition. This approach would facilitate screening for pregnant women with OSA risk factors during preconception counseling and prenatal visits, with dynamic rescreening even if initial screening is negative, enabling timely continuous positive airway pressure therapy to maximize improvement of pregnancy outcomes.

Based on international literature and domestic expert consensus [26, 27], women with the following characteristics are considered at risk for OSA: (1) Symptoms: snoring, morning dry mouth, witnessed apneas, nocturnal choking; (2) Physical signs: obesity (BMI $\geq 30\text{kg}/\text{m}^2$), short thick neck, upper airway structural abnormalities such as macroglossia, retrognathia, or micrognathia; and (3) Medical history: gestational hypertension, gestational diabetes, unexplained fetal growth restriction, or previous personal or family history of OSA.

3. Advances in Screening Tools

Due to PSG's clinical limitations, researchers have explored simple and effective OSA screening tools for pregnant populations to improve diagnostic efficiency.

The validity of major screening tools is summarized below:

3.1 Application of Traditional Screening Questionnaires in Pregnancy

Screening questionnaires such as the Epworth Sleepiness Scale (ESS), Berlin Questionnaire (BQ), and Stop-Bang Questionnaire were developed for rapid, effective preliminary OSA screening and have demonstrated good utility in diagnosing and assessing OSA severity in non-pregnant populations [28]. These questionnaires evaluate somnolence and fatigue—primary OSA manifestations in adults—to screen and assess patients [29-31]. However, sleep fragmentation and daytime sleepiness are common in pregnancy due to exacerbated gastroesophageal reflux symptoms and increased nocturia [32, 33], making somnolence and fatigue non-specific symptoms and poor predictors of OSA in pregnancy [13, 34]. Consequently, these questionnaires generally have low predictive value in pregnant populations.

Facco et al. [12] evaluated ESS and BQ in 122 second-trimester pregnant women with OSA risk factors, validating results with home portable monitoring (WatchPAT 100). ESS and BQ demonstrated poor sensitivity (36% and 39%) and moderate specificity (77% and 68%), indicating limited predictive ability in high-risk pregnant populations. Antony et al. [35] conducted a two-year prospective observational study of 1,617 pregnant women at 26-28 weeks gestation, using ESS and BQ to screen for OSA followed by diagnostic PSG. While the questionnaires identified 31.9% as positive, PSG confirmed only 15.5% as true positives, further confirming poor screening efficacy during pregnancy. Tantrakul et al. [10] found that BQ and Stop-Bang had modest overall predictive value in pregnancy (AUC 0.72 and 0.75, respectively), with BQ AUCs of 0.49, 0.84, and 0.81 across trimesters, and Stop-Bang AUCs of 0.71, 0.78, and 0.75, suggesting dynamic predictive value that peaks in the second trimester. However, Olivarez et al. [13] reported BQ sensitivity and specificity of only 35% and 63.8% compared to PSG, with similarly poor accuracy in obese pregnant populations [36]. A meta-analysis [15] revealed pooled sensitivities of 0.66 for BQ and 0.44 for ESS, with specificities of 0.62. In summary, due to non-specific symptoms of OSA in pregnancy compared to the general population, traditional adult OSA screening questionnaires demonstrate suboptimal effectiveness and fail to achieve expected performance in identifying high-risk patients.

3.2 Pregnancy-Specific OSA Risk Prediction Models

Given the low predictive value of screening questionnaires, several pregnancy-specific OSA risk prediction models have been developed to improve identification efficiency through risk stratification. Wilson et al. [14] utilized Berlin and MAP index questionnaires from 380 pregnant women to develop a three-factor model (snoring loudness, BMI, morning fatigue) with excellent predictive performance (AUC 0.952). Louis et al. [37] conducted larger studies analyzing data from 3,264 first-trimester and 2,512 second-trimester women, identifying frequent snoring, chronic hypertension, advanced maternal age, BMI, neck circumference, and systolic blood pressure as risk factors. Their logistic regression model incorporating

three variables (age, BMI, and frequent snoring) accurately predicted OSA risk in early pregnancy, mid-pregnancy, and newly developed OSA in mid-pregnancy (AUCs 0.870, 0.838, and 0.809, respectively), demonstrating high predictive value in low-risk populations. Facco et al. [12] studied 114 high-risk pregnant women (with chronic hypertension, diabetes, obesity, and/or preeclampsia history) using home portable monitoring, finding that a model comprising frequent snoring, chronic hypertension, age, and BMI had superior predictive value (AUC 0.86, $p > 0.001$) compared to BQ and ESS. However, this model performed less well in obese pregnant women (BMI 40 kg/m^2), with an AUC of only 0.752, sensitivity of 1.0, and specificity of 0.21. An alternative model including age, BMI, neck circumference, witnessed apneas, and sleepiness while driving showed better predictive value in this specific population [36], though some studies suggest that snoring complaints alone may be a simpler and effective predictor in obese pregnant women [38].

These models have limitations, including reliance on subjective reports of snoring from women or their partners. Bourjeily et al. [39] investigated the predictive value of objective anthropometric models for OSA diagnosis in early pregnancy, finding that among women with Mallampati class 1, OSA risk tripled with increasing neck circumference. Izci-Balserak et al. [40] subsequently developed the BATE model (BMI, Age, Tongue Enlargement) that eliminates dependence on snoring awareness. In multivariate analysis, a model including BMI, age, and tongue enlargement best predicted OSA, with AUCs of 0.86 and 0.87 in early and late pregnancy, respectively. Using early pregnancy data to predict late-pregnancy OSA risk yielded an AUC of 0.87, with high sensitivity (0.76-0.79) and specificity (0.82-0.83) in both trimesters. Compared to subjective information alone, screening tools combining multiple assessment methods with demographic and anthropometric measures better predict OSA in pregnant women.

3.3 Home Sleep Apnea Test (HSAT) PSG's limitations have resulted in diagnosis and treatment rates below 1% in China [41]. HSAT technology, with its simple operation and high diagnostic value [42], has been recommended as an alternative monitoring technique for diagnosing OSA in adults with moderate to severe symptoms and no comorbidities [43]. Given the urgent need for timely OSA diagnosis and treatment in pregnancy, several studies have examined HSAT device utility in pregnant women with OSA.

O'Brien et al. [44] simultaneously applied the wrist-worn Watch-PAT 200 device and home PSG in 31 third-trimester women during the same night, demonstrating high concordance between devices for apnea-hypopnea index (AHI), respiratory disturbance index (RDI), and mean/minimum oxygen saturation. The device showed high diagnostic value for OSA (AUC 0.96 for AHI 5 events/hour and 0.94 for RDI 10 events/hour), with 88.5 events/hour . Sharkey et al. [45] compared the ARE mounted device with PSG in 16 pregnant women suspected of OSA, finding high correlation between device AHI and PSG AHI in 16 obese pregnant women (BMI 30 kg/m^2) wear the ApneaLink HSAT device at home for one night within two weeks of completing PSG,

comparing its automated scoring system with laboratory PSG. Among 30 valid recordings, HSAT automated scoring, HSAT technician scoring, and laboratory PSG showed good pairwise concordance, with intraclass correlation coefficients of 0.78, 0.76, and 0.70, and absolute agreements of 80.0%, 83.3%, and 76.7%, respectively.

4. Summary

Research demonstrates that OSA significantly impacts maternal and infant health during pregnancy and long-term. Despite current limitations in diagnosis and treatment, timely management is crucial for improving adverse outcomes. Given severe PSG accessibility constraints, HSAT is recommended to assist screening and diagnosis in pregnant women with OSA risk factors to expand coverage and efficiency. Considering the complexity and dynamic nature of pregnancy-related OSA, high-risk pregnancies require rescreening even after initial negative results to avoid missing critical treatment windows and ensure maternal and fetal health protection.

Conflict of Interest All authors declare no conflict of interest.

References

Liu L, Su G, Wang S, et al. The prevalence of obstructive sleep apnea and its association with pregnancy-related health outcomes: a systematic review and meta-analysis[J]. *Sleep Breath*, 2019, 23(2): 399-412. DOI: 10.1007/s11325-018-1714-7.

Bourjeily G, Danilack VA, Bublitz MH, et al. Obstructive sleep apnea in pregnancy is associated with adverse maternal outcomes: a national cohort[J]. *Sleep Med*, 2017, 38: 50-57. DOI: 10.1016/j.sleep.2017.06.035.

Phan K, Pamidi S, Gomez YH, et al. Sleep-disordered breathing in high-risk pregnancies is associated with elevated arterial stiffness and increased for preeclampsia[J]. *Am J Obstet Gynecol*, 2021. DOI: 10.1016/j.ajog.2021.11.1366. 2018, 219(6): 613.e611-613.e610.

Facco FL, Parker CB, Reddy UM, et al. Association Between Sleep-Disordered Breathing and Hypertensive Disorders of Pregnancy and Gestational Diabetes Mellitus[J]. *Obstet Gynecol*, 2017, 129(1): 31-41. DOI: 10.1097/aog.0000000000001805.

Pamidi S, Marc I, Simoneau G, et al. Maternal sleep-disordered breathing and the risk of delivering small for gestational age infants: a prospective cohort study[J]. *Thorax*, 2016, 71(8): 719-725. DOI: 10.1136/thoraxjnl-2015-

Bellamy L, Casas JP, Hingorani AD, et al. Type 2 diabetes mellitus after gestational diabetes: a systematic review and meta-analysis[J]. *Lancet*, 2009, 373(9677): 1773-1779. DOI: 10.1016/s0140-6736(09)60731-5.

Tapia IE, Shults J, Doyle LW, et al. Perinatal Risk Factors Associated with the

Obstructive Sleep Apnea Syndrome in School-Aged Children Born Preterm[J]. *Sleep*, 2016, 39(4): 737-742. DOI: 10.5665/sleep.5618.

Morrakotkhiew W, Chirdkiatgumchai V, Tantrakul V, et al. Early developmental outcome in children born to mothers with obstructive sleep apnea[J]. *Sleep Med*, 2021, 88: 90-95. DOI: 10.1016/j.sleep.2021.10.010.

Malhamé I, Bublitz MH, Bourjeily G. The Challenge of Screening for Obstructive Sleep Apnea in Pregnancy[J]. *Ann Am Thorac Soc*, 2019, 16(10): 1242-1244. DOI: 10.1513/AnnalsATS.201907-507ED.

Tantrakul V, Sirijanchune P, Panburana P, et al. Screening of obstructive sleep apnea during pregnancy: differences in predictive values of questionnaires across trimesters[J]. *J Clin Sleep Med*, 2015, 11(2): 157-163. DOI: 10.5664/jcsm.

Lockhart EM, Ben Abdallah A, Tuuli MG, et al. Obstructive Sleep Apnea in Pregnancy: Assessment of Current Screening Tools[J]. *Obstet Gynecol*, 2015, 126(1): 93-102. DOI: 10.1097/aog.0000000000000848.

Facco FL, Ouyang DW, Zee PC, et al. Development of a pregnancy-specific screening tool for sleep apnea[J]. *J Clin Sleep Med*, 2012, 8(4): 389-394. DOI: 10.5664/jcsm.2030.

Olivarez SA, Maheshwari B, McCarthy M, et al. Prospective trial on obstructive sleep apnea in pregnancy and fetal heart rate monitoring[J]. *Am J Obstet Gynecol*, 2010, 202(6): 552.e551-557. DOI: 10.1016/j.ajog.2009.12.008.

Wilson DL, Walker SP, Fung AM, et al. Can we predict sleep-disordered breathing in pregnancy? The clinical utility of symptoms[J]. *J Sleep Res*, 2013, 22(6): 670-678. DOI: 10.1111/jsr.12063.

Tantrakul V, Numthavaj P, Guilleminault C, et al. Performance of screening questionnaires for obstructive sleep apnea during pregnancy: A systematic review and meta-analysis[J]. *Sleep Med Rev*, 2017, 36: 96-106. DOI: 10.1016/j.smrv.2016.11.003.

Pien GW, Pack AI, Jackson N, et al. Risk factors for sleep-disordered breathing in pregnancy[J]. *Thorax*, 2014, 69(4): 371-377. DOI: 10.1136/thoraxjnl-2012-202718.

Ursavas A, Karadag M, Nalci N, et al. Self-reported snoring, maternal obesity and neck circumference as risk factors for pregnancy-induced hypertension and preeclampsia[J]. *Respiration*, 2008, 76(1): 33-39. DOI: 10.1159/000107735.

Louis JM, Mogos MF, Salemi JL, et al. Obstructive sleep apnea and severe maternal-infant morbidity/mortality in the United States, 1998-2009[J]. *Sleep*, 2014, 37(5): 843-849. DOI: 10.5665/sleep.3644.

Sahin FK, Koken G, Cosar E, et al. Obstructive sleep apnea in pregnancy and fetal outcome[J]. *Int J Gynaecol Obstet*, 2008, 100(2): 141-146. DOI: 10.1016/j.ijgo.2007.08.012.

Louis J, Auckley D, Bolden N. Management of obstructive sleep apnea in pregnant women[J]. *Obstet Gynecol*, 2012, 119(4): 864-868. DOI: 10.1097/AOG.0b013e31824c0c2f.

Carnelio S, Morton A, McIntyre HD. Sleep disordered breathing in pregnancy: the maternal and fetal implications[J]. *J Obstet Gynaecol*, 2017, 37(2): 170-178. DOI: 10.1080/01443615.2016.1229273.

Han F. Development of sleep medicine in China[J]. *Chin Med J*, 2009, 122(12): 1462-1463.

Dominguez JE, Krystal AD, Habib AS. Obstructive Sleep Apnea in Pregnant Women: A Review of Pregnancy Outcomes and an Approach to Management[J]. *Anesth Analg*, 2018, 127(5): 1167-1177. DOI: 10.1213/ane.0000000000003335.

Sanapo L, Goldman D, Bourjeily G. Obstructive sleep apnea in pregnancy: 1 sleep study may not be enough in high-risk women[J]. *J Clin Sleep Med*, 2021, 17(9): 1953-1956. doi: 10.5664/jcsm.9340.

许琦, 刘国莉, 王山米. 重视妊娠期阻塞性睡眠呼吸暂停的临床诊治 [J]. *实用妇产科杂志*, 2019, 35(2): 106-109.

Chung F, Memtsoudis SG, Ramachandran SK, et al. Society of Anesthesia and Sleep Medicine Guidelines on Preoperative Screening and Assessment of Adult Patients With Obstructive Sleep Apnea[J]. *Anesth Analg*, 2016, 123(2): 452-473. DOI: 10.1213/ane.0000000000001416.

妊娠期阻塞性睡眠呼吸暂停低通气综合征临床诊治专家共识写作组. 妊娠期阻塞性睡眠呼吸暂停低通气综合征临床诊治专家共识 (草案)[J]. *中国呼吸与危重监护杂志*, 2018, 17(5): 439-444. DOI: 10.7507/1671-6205.201809006

Chiu HY, Chen PY, Chuang LP, et al. Diagnostic accuracy of the Berlin questionnaire, STOP-BANG, STOP, and Epworth sleepiness scale in detecting obstructive sleep apnea: A bivariate meta-analysis[J]. *Sleep Med Rev*, 2017, 36: 57-70. DOI: 10.1016/j.smrv.2016.10.004.

Damiani MF, Quaranta VN, Falcone VA, et al. The Epworth Sleepiness Scale: conventional self vs physician administration[J]. *Chest*, 2013, 143(6): 1569-1575. DOI: 10.1378/chest.12-2174.

Kang K, Park KS, Kim JE, et al. Usefulness of the Berlin Questionnaire to identify patients at high risk for obstructive sleep apnea: a population-based door-to-door study[J]. *Sleep Breath*, 2013, 17(2): 803-810. DOI: 10.1007/s11325-

Chung F, Abdullah HR, Liao P. STOP-Bang Questionnaire: A Practical Approach to Screen for Obstructive Sleep Apnea[J]. *Chest*, 2016, 149(3): 631-638. DOI: 10.1378/chest.15-0903.

Sedov ID, Cameron EE, Madigan S, et al. Sleep quality during pregnancy: A meta-analysis[J]. *Sleep Med Rev*, 2018, 38: 168-176. DOI: 10.1016/j.smrv.2017.06.005.

Pengo MF, Won CH, Bourjeily G. Sleep in Women Across the Life Span[J]. Chest, 2018, 154(1): 196-206. DOI: 10.1016/j.chest.2018.04.005.

Pien GW, Fife D, Pack AI, et al. Changes in symptoms of sleep-disordered breathing during pregnancy[J]. Sleep, 2005, 28(10): 1299-1305. DOI: 10.1093/sleep/28.10.1299.

Antony KM, Agrawal A, Arndt ME, et al. Association of adverse perinatal outcomes with screening measures of obstructive sleep apnea[J]. J Perinatol, 2014, 34(6): 441-448. DOI: 10.1038/jp.2014.25.

Dominguez JE, Grotegut CA, Cooter M, et al. Screening extremely obese pregnant women for obstructive sleep apnea[J]. Am J Obstet Gynecol, 2018, 219(6): 613.e611-613.e610. DOI: 10.1016/j.ajog.2018.09.001.

Louis JM, Koch MA, Reddy UM, et al. Predictors of sleep-disordered breathing in pregnancy[J]. Am J Obstet Gynecol, 2018, 218(5): 521.e521-521.e512. DOI: 10.1016/j.ajog.2018.01.031.

Pearson F, Batterham AM, Cope S. The STOP-Bang Questionnaire as a Screening Tool for Obstructive Sleep Apnea in Pregnancy[J]. J Clin Sleep Med, 2019, 15(5): 705-710. DOI: 10.5664/jcsm.7754.

Bourjeily G, Chambers A, Salameh M, et al. Anthropometric Measures and Prediction of Maternal Sleep-Disordered Breathing[J]. J Clin Sleep Med, 2019, 15(6): 849-856. DOI: 10.5664/jcsm.7834.

Izci-Balserak B, Zhu B, Gurubhagavatula I, et al. A Screening Algorithm for Obstructive Sleep Apnea in Pregnancy[J]. Ann Am Thorac Soc, 2019, 16(10): 1286-1294. DOI: 10.1513/AnnalsATS.201902-131OC.

Han F. Development of sleep medicine in China[J]. Chin Med J (Engl) 2009, 122(12): 1462-1463.

Xu L, Han F, Keenan BT, et al. Validation of the Nox-T3 Portable Monitor for Diagnosis of Obstructive Sleep Apnea in Chinese Adults[J]. J Clin Sleep Med, 2017, 13(5): 675-683. DOI: 10.5664/jcsm.6582.

Kapur VK, Auckley DH, Chowdhuri S, et al. Clinical Practice Guideline for Diagnostic Testing for Adult Obstructive Sleep Apnea: An American Academy of Sleep Medicine Clinical Practice Guideline[J]. J Clin Sleep Med, 2017, 13(3): 479-504. DOI: 10.5664/jcsm.6506.

O' Brien LM, Bullough AS, Shelgikar AV, et al. Validation of Watch-PAT-200 against polysomnography during pregnancy[J]. J Clin Sleep Med, 2012, 8(3): 287-294. DOI: 10.5664/jcsm.1916.

Sharkey KM, Waters K, Millman RP, et al. Validation of the Apnea Risk Evaluation System (ARES) device against laboratory polysomnography in pregnant women at risk for obstructive sleep apnea syndrome[J]. J Clin Sleep Med, 2014, 10(5): 497-502. DOI: 10.5664/jcsm.3694.

Facco FL, Lopata V, Wolsk JM, et al. Can We Use Home Sleep Testing for the Evaluation of Sleep Apnea in Obese Pregnant Women[J]? Sleep Disord, 2019, 2019 3827579. DOI: 10.1155/2019/3827579.

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