

นิพนธ์ต้นฉบับ

การพัฒนาคะแนนทางเดินหายใจในเด็กแม่สะเรียง (Maesariang Respiratory Score) สำหรับผู้ป่วยโรคติดเชื้อเฉียบพลันของระบบหายใจส่วนล่าง อายุต่ำกว่า 5 ปี เพื่อทำนายการช่วยเหลือระบบทางเดินหายใจ

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ความเป็นมา: ผู้ป่วยโรคติดเชื้อเฉียบพลันของระบบหายใจส่วนล่าง เป็นกลุ่มโรคสาเหตุหลักของการเกิดทุพพลภาพ และการเสียชีวิต โดยเฉพาะอย่างยิ่งในเด็กอายุต่ำกว่า 5 ปี ถือเป็นกลุ่มเสี่ยงในการเกิดโรคที่มีความรุนแรง การประเมินในเด็กเล็กจำเป็นต้องอาศัยการซักประวัติ การตรวจร่างกาย และประสบการณ์ของผู้ตรวจ ยังไม่มีเครื่องมือมาตรฐานที่เหมาะสมสำหรับทำนายความรุนแรงของโรคกลุ่มนี้ในเด็ก จึงมีการพัฒนาเครื่องมือขึ้นมาใหม่ ช่วยทำนายการช่วยเหลือระบบทางเดินหายใจ

วัตถุประสงค์: เพื่อพัฒนาและประเมินความสามารถของคะแนนทางเดินหายใจในเด็กแม่สะเรียง (Maesariang Respiratory Score: MRS) สำหรับทำนายการช่วยเหลือระบบทางเดินหายใจในผู้ป่วยเด็กอายุต่ำกว่า 5 ปีที่เป็นโรคติดเชื้อเฉียบพลันของระบบหายใจส่วนล่าง

วิธีการศึกษา: การศึกษานี้เป็นการศึกษาแบบภาคตัดขวาง เก็บรวบรวมข้อมูลระหว่างเดือนพฤศจิกายน พ.ศ. 2567 ถึง เดือนมกราคม พ.ศ. 2569 ณ แผนกฉุกเฉิน และแผนกผู้ป่วยนอกของโรงพยาบาลแม่สะเรียง ในผู้ป่วยอายุ 1 เดือน ถึง ต่ำกว่า 5 ปี แพทย์วินิจฉัยโรคติดเชื้อเฉียบพลันของระบบหายใจส่วนล่าง เกณฑ์การคัดออก ได้แก่ โรคหลอดลมและกล่องเสียงอักเสบเฉียบพลัน โรคฝีปอดกล่องเสียงอักเสบเฉียบพลัน โรคปอดแต่กำเนิด โรคหัวใจพิการแต่กำเนิด ผู้ป่วยเจาะคอ ผู้ป่วยที่ใช้ออกซิเจนที่บ้าน และผู้ปกครองปฏิเสธเข้าร่วมการวิจัย ปัจจัยของ MRS ได้มาจากการศึกษาวิทยานิพนธ์ และการวิเคราะห์ข้อมูลด้วยการถดถอยโลจิสติกหลายตัวแปรโดยใช้การได้รับการช่วยเหลือระบบทางเดินหายใจเป็นเกณฑ์ การศึกษานี้เป็นการศึกษาเชิงพรรณนาและเชิงอนุมาน วิเคราะห์ข้อมูลด้วย receiver operating characteristic curve (ROC) การทดสอบแบบถดถอยโลจิสติก กราฟมาตรฐานเทียบ (calibration plot) และการทดสอบของ Hosmer-Lemeshow (H-L) โดยใช้โปรแกรม SPSS เวอร์ชัน 31.0 กำหนดระดับนัยสำคัญค่า p value < 0.05

ผลการศึกษา: มีผู้เข้าร่วมวิจัยทั้งหมด 504 คน MRS ประกอบด้วย 7 ปัจจัย ได้แก่ ภาวะเบื้องต้นทั่วไป สิว การใช้กล้ามเนื้อช่วยหายใจ อัตราการหายใจ อัตราการเต้นของหัวใจ เสียงปอดผิดปกติ และระดับออกซิเจนปลายนิ้ว การทดสอบความเที่ยงของการใช้เครื่องมือระหว่างกุมารแพทย์และแพทย์ใช้ทุน อยู่ในระดับดี พบค่า Intraclass Correlation Coefficiency (ICC) เท่ากับ 0.83 เมื่อวิเคราะห์พื้นที่ใต้กราฟ ROC (AUC) สำหรับ MRS ในการทำนายการให้ออกซิเจนทุกระดับ การให้ออกซิเจนแรงดันสูง และการใช้เครื่องช่วยหายใจ มีค่าเท่ากับ 0.86 (95%CI 0.82-0.89), 0.91 (95%CI 0.88-0.95) และ 0.90 (95%CI 0.82-0.98) ตามลำดับ เมื่อคะแนนจุดตัด ≥ 4 คะแนน ทำนายการให้ออกซิเจน และคะแนนจุดตัด ≥ 6 ทำนายการให้ออกซิเจนแรงดันสูงและการใช้เครื่องช่วยหายใจ ให้ค่าความไว เท่ากับ 86.9%, 91.4%, 86.3% และค่าความจำเพาะเท่ากับ 67.4%, 70%, 66.7% ตามลำดับ

สรุป: คะแนนทางเดินหายใจในเด็กแม่สะเรียง (MRS) ที่สร้างขึ้นใหม่นี้ อาจช่วยทำนายการได้รับการช่วยเหลือระบบทางเดินหายใจโดยเฉพาะการให้ออกซิเจนแรงดันสูง ในผู้ป่วยเด็กอายุต่ำกว่า 5 ปีที่มีโรคติดเชื้อเฉียบพลันของระบบหายใจส่วนล่างในบริบทของโรงพยาบาลชุมชน คะแนนที่สูงขึ้นสัมพันธ์กับการช่วยเหลือระบบทางเดินหายใจมากขึ้น การใช้ MRS ร่วมกับการตรวจร่างกายและการติดตามสัญญาณชีพอย่างต่อเนื่องอาจช่วยให้ผู้ป่วยได้รับการประเมินและรักษาอย่างเหมาะสมยิ่งขึ้น อย่างไรก็ตามเป็นการศึกษาในโรงพยาบาลแห่งเดียว และยังต้องการการศึกษาความถูกต้องจากภายนอก

คำสำคัญ: Pediatric early warning score, Pediatric respiratory score, Respiratory failure in children, Respiratory clinical score, Acute lower respiratory tract score

The newly developed Maesariang Respiratory Score (MRS) for acute lower respiratory tract infections in children under 5 years in predicting respiratory support

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Abstract

Background: Acute lower respiratory tract infections (LRTIs) are the leading causes of mortality and morbidity especially in children under 5 years. LRTIs have a severity ranging from mild to life-threatening conditions. The ability to recognize the severity of disease for giving respiratory support in young children depends on parental history, physical examinations and experienced physicians. Currently, there is no ideal or gold standard of predicting tool for LRTIs in children. The newly developed tool may be a guide for respiratory support.

Objectives: To develop and validate the MRS for LRTIs in children under 5 years in predicting respiratory support.

Methods: A cross-sectional study, data were collected between November 2024 and January 2026 at the emergency department and outpatient department of Maesariang Hospital, Mae Hong Son Province, Thailand. We enrolled children aged 1 month to under 5 years who were diagnosed with acute LRTIs. The exclusion criteria were acute laryngotracheobronchitis, acute epiglottitis, congenital lung disease, congenital heart disease, status post tracheostomy, home oxygen therapy, and parental refusal. MRS parameters and score were developed from literature reviews and multivariable regression analysis, which had statistical significance with respiratory support. Descriptive and inferential studies, receiver operating characteristic curve (ROC), correlation, univariable, multivariable regression analysis, and internal validation using calibration plot and Hosmer-Lemeshow (H-L) test were performed. Using SPSS version 31.0, the significance level was p value <0.05.

Results: A total of 504 children were enrolled. MRS is seven parameters tool included general appearance, skin color, chest retraction, respiratory rate, heart rate, lung sound, and oxygen saturation. Agreement in measurement between pediatrician and interns was good with an Intraclass Correlation Coefficient (ICC) of 0.83. The Area under the ROC (AUC) of MRS to predict all levels of respiratory support, high flow oxygen, and ventilator support were 0.86 (95%CI 0.82-0.89), 0.91 (95%CI 0.88-0.95), and 0.90 (95%CI 0.82-0.98), respectively. Cut-off point score ≥ 4 predicted oxygen supplement and cut-off point score ≥ 6 predicted high flow oxygen and ventilator support giving a sensitivity of 86.9%, 91.4%, 86.3% and specificity of 67.4%, 70%, 66.7%, respectively.

Conclusion: MRS could be a screening tool for predicting respiratory support, especially for high flow oxygen for LRTIs patients under 5 years in the setting of community hospitals. Higher score correlated with a higher level of respiratory support. In the situation of pediatricians and interns are limited, MRS, concurrent with physical examinations and monitoring, should guide proper management. Limitations of MRS were developed from a single center and needs further external validation.

Keywords: Pediatric early warning score, Pediatric respiratory score, Respiratory failure in children, Respiratory clinical score, Acute lower respiratory tract score

Introduction

Acute lower respiratory tract infections (pneumonia, acute bronchitis, and acute bronchiolitis) in Maesariang Hospital were top five diseases of outpatient and inpatient visits. Acute lower respiratory tract infections are the leading cause of illness for children under 5 years in Thailand.¹ In Thailand, the prevalence of pneumonia in children aged 0-18 years was 61.58% in hospitalized patients. The mortality rate of pneumonia in children under 5 years, 11.85 per 100,000 children in 2019.² Respiratory distress and respiratory failure in children depend on history taking, physical examinations, and blood gas examination, which are not available in all community hospitals and difficult for practice in young patients. From our literature reviews, we found few literature studies on the prediction for respiratory support in children younger than 10 months with acute bronchiolitis.³ The Thai Society of Pediatric Respiratory and Critical care Medicine and The Royal College of Pediatricians of Thailand had launched the clinical practice guideline of acute respiratory tract infections on 2019.⁴ This guideline had given a severity grading but did not establish the initiation of low flow or high flow cannula or ventilator support.

Currently there is no ideal or gold standard of screening respiratory score for LRTIs in children. The general indications for high flow oxygen were moderate to severe hypoxemia, respiratory distress, and postextubation support.⁵ For decision making on respiratory support in our hospital using clinical judgement. Our clinical practice guidelines for pneumonia had admission criteria and severity grading but no scoring tool for respiratory support.

We newly developed respiratory score for young children which we named “Maesariang Respiratory Score” (MRS) for community hospital to predict respiratory support without laboratory examinations and easy for general physicians and nurses to use. MRS focused on level of respiratory support.

Objectives

The objective of this study was to develop and validate the MRS for acute lower respiratory tract infections in children under 5 years for predicting respiratory support. In our research, the respiratory support included low flow oxygen, high flow oxygen, and ventilator support. When high flow cannula is defined only Heated Humidified High-Flow Nasal Cannula (HHHFNC) dose not include an oxygen mask with bag, for ventilator support included both noninvasive and invasive ventilator support.

Methods

Patients

A cross-sectional study, data were collected between November 2024 and January 2026 at the emergency department and outpatient department of Maesariang Hospital, Mae Hong Son Province, Thailand. We enrolled children aged 1 month to under 5 years who were diagnosed with acute LRTIs (Acute bronchiolitis, acute bronchitis and pneumonia) with written informed consent from their parents. We excluded patients who were diagnosed with acute laryngotracheobronchitis (viral croup), acute epiglottitis, congenital lung disease, congenital heart disease, status post tracheostomy, home oxygen therapy and parent refusal.

Developing of Maesariang Respiratory Score (MRS) parameters

MRS parameters were developed from literature reviews. From the study of Hakizimana et al.⁶ was reviewing 7 articles which respiratory tools had the potential for used in resource-limited settings in children under 2 years. The parameters in those tools were respiratory rate (7 literatures), wheezing (6 literatures), oxygen saturation (5 literatures), heart rate (4 literatures), retractions (4 literatures), breath sound (4 literatures), general appearance (3 literatures), dyspnea (3 literatures), accessory muscle usage (2 literatures), cyanosis (2 literatures), mental status (1 literature), lethargy (1 literature), cough ability/secretion (1 literature), feeding (1 literature), apnea (1 literature), air-entry (1 literature), chest X-ray /lung sound (1 literature), capillary refill time (1 literature), surgical status (1 literature), and urine output (1 literature). Tool for acute bronchiolitis, De Rose et al.³ studied in comparison of 3 tools for patients under 3 months. GRSS⁷ showed the highest predictive ability for respiratory assistance, with 9 parameters in Respiratory Syncytial virus (RSV) infection. Tools for pneumonia, mRDAI⁸ had 4 parameters, which had the advantage that all parameters were objective but lacked of oxygen saturation parameter. PRESS⁹ had 5 parameters, which contained only one subjective parameter. RISC¹⁰ has 5 parameters, lacked oxygen saturation parameter. The parameters from our literature review are shown in Table 1.

Table 1. Reviews of respiratory tools and parameters in children.

Tools	Disease	Age	Study (n)	General appearance	Skin color	Decrease Intake/ refuse food	Accessory muscle usage/retraction	Respiratory rate	Wheezing	lung sound	Oxygen saturation	Heart rate	parameters
CRS¹¹	Respiratory distress	1 month-16 years	112	/	/		/	/		/	/		6
mRDAI⁸	LRTIs	2 -24 months	140		/		/	/		/			4
PRESS⁹	RTI*	0-15 years	202			/	/	/	/		/		5
RSS¹²	RTI	<1 year	630				/	/	/		/		4
RISC¹⁰	LRTIs	<2 years	4148			/	/		/		/		4-6 (other 2)
WBSS¹³	Acute bronchiolitis	<2 years	56	/			/	/	/				4
GRSS⁷	Acute bronchiolitis	<10 months	139	/	/		/	/	/	/	/		9 (other 2)
KRS¹⁴	Acute bronchiolitis	<18 months	34	/	/		/	/		/			5
mTal¹⁵	Acute bronchiolitis	<2 years	115		/		/	/	/		/		5
CHWRS¹⁶	Acute bronchiolitis	<1 year	195	/			/	/		/		/	10 (other 5)
LIBSS¹⁷	Acute bronchiolitis	<1 year	128	/		/	/	/			/	/	9 (other 3)
MRS	LRTIs	1month – 5 years	504	/	/		/	/		/	/	/	7

*RTI = respiratory tract infections

The screening tools should be user-friendly. Appropriate numbers of parameters for respiratory tools usually have 4-7 parameters and contain most objective parameters. Most patients in Maesariang district are in the low to middle-income economic status. Their parents are mostly elderly, lacking health education knowledges, and answers may not be accurate. Therefore, some parameters that were subjective, previously showed statistically insignificant results or were difficult for assessment, such as blood pressure and capillary refill time were excluded. We also grouped parameters that were in the same category; for example, mental status and food intake were combined into general appearance, wheezing, abnormal breath sounds, and air entry were combined into lung sound. For the respiratory rate parameter, we used the WHO criteria¹⁸ which were also documented in the guidelines for the management of acute respiratory infections in children by the Pediatric Respiratory and Critical Care Society, Royal College of Pediatricians of Thailand. For the heart rate parameter, we decided to keep this parameter because some of our patients had sepsis as a comorbid.

Developing a scoring system

A scoring system, scoring 0-2, was used from previous literature reviews which showed relation to the severity of disease, and from logistic regression analysis of MRS parameters with respiratory support.

Finally, we newly developed MRS from literature reviews, statistically significant by correlation analysis from previous studies, and general practical parameters. Aims for using this tool in a community hospital which no need of laboratory testing, with user-friendly and time-saving, MRS has seven parameters, fourteen points, including two subjective parameters (general appearance and skin color) and five objective parameters (respiratory rate, heart rate, oxygen saturation, chest retraction, and lung sound) based on our hypotheses, as shown in Table 2.

Table 2. Maesariang Respiratory Score (MRS).

Parameter/Score	0	1	2
1. General appearance	Normal	Mild irritable Decrease play/drowsiness/ decrease intake	Poor response/Coma/Apnea/ no intake
2. Skin Color	Pink	Pale	cyanosis
3. Respiratory rate (time/min)	Normal for age	≤1 year RR 60-70 > 1 year RR 40-50	≤1 year RR >70 >1 years RR >50

Parameter/Score	0	1	2
4. Heart rate (beat/min)	Normal for age Newborn – <2 months (≤ 160) 2 months- <1 year (≤ 150) 1-5 years (≤ 140)	More than normal for age 10-19 beats/min	More than normal for age ≥ 20 beats/min
5. Oxygen saturation	$\geq 95\%$	92-94 %	$\leq 91\%$
6. Chest retraction	No	One location of retraction	>1 location of retractions
7. Lung sound	Normal	Expiratory wheezing/ crepitation	Inspiratory & Expiratory wheezing/ poor air entry

Inter-rater reliability test and MRS assessment

Inter-rater reliability test between two pediatricians and between a pediatrician and interns before data collection were done. MRS was assessed at the initial clinical evaluation and before providing respiratory support or treatment.

Sample size

The sample size was calculated using the formula $(n = z^2 pq/d^2)^{19}$, where p represented the prevalence of LRTIs in Maesariang Hospital who needed respiratory support (5years prevalence), which was 10.9%. The power was 0.8, and Type I error probability associated with the test of this null hypothesis was 0.05; the study number was 151. This study protocol was approved by the ethical committee of Mae Hong Son Provincial Public Health Office (MHS REC 013.2567 and MHS REC 005.2568).

Statistical analysis

Descriptive statistics: continuous variables are expressed as the median and interquartile range (IQR), and categorical variables are expressed as frequencies and percentiles. Inferential statistics, inter-rater reliability test used Cronbach's alpha due to continuous data. Correlation analysis, univariable, and multivariable regression analysis were used to analyze the relationships between MRS and parameters for predicting respiratory support. The optimal cut-off point for MRS was determined by using the Youden index (the maximum value of [sensitivity-(1-specificity)])²⁰ based on the ROC. The AUC, sensitivity, specificity, positive predictive value, and negative predictive value were also reported. For predictive tools, the calibration plot and Hosmer-Lemeshow (H-L) test were analyzed. Statistical significance was determined by a p value < 0.05. Statistical using the software package SPSS program version 31.0; IBM, Armonk, NY, USA.

Results

Five hundred and four patients were included in our study. Demographic data (Table 3) showed no difference in sex, age, underlying asthma, day of fever, and Respiratory Syncytial Virus infection. The median age was 17.38 months (IQR 20.41). The admission rate was 77.4%. The respiratory support was 53% and no respiratory support was 47%. The percentage of level of respiratory support: low flow oxygen 41.3%, high flow oxygen 9.9%, and ventilator support 1.8%. The median score of MRS was 4 (IQR 4). The median scores of MRS for the group with no respiratory support and respiratory support were 2 (IQR 2) and 5 (IQR 3), respectively; p value <0.001.

Inter-rater reliability tests between two pediatricians in 10 patients and between a pediatrician and interns on 40 patients were done. The intraclass correlation coefficients were 0.48 (95%CI -0.569-0.860, p value 0.137) and 0.83 (95%CI 0.670-0.915, p value <0.001), indicating low and good reliability, respectively. For community hospitals, first physician who screened and evaluated patients was interns. When the reliability of pediatrician and intern was good, MRS can be used in the community hospital when interns were the first physician patients met.

Table 3 Baseline characteristics of the study patients and correlation with respiratory support.

Variable	Total Number (percent) n=504	No respiratory support number (percent) n=237	Respiratory support number (percent) n=267	p value
Male	287 (56.9)	132 (55.7)	155 (58.1)	0.59
Female	217 (43.1)	105 (44.3)	112 (41.9)	
Age				0.50
Months, median (IQR)	17.38 (20.41)	16.20 (19.48)	18.40 (22.70)	
min, max	(1, 59.9)	(2.1, 59.9)	(1, 58.8)	
Age group				
1 month - 1 year	181(35.9)	90 (38)	91 (34.1)	
>1-2 years	146 (29)	67 (28.3)	79 (29.6)	
>2-5 years	177 (35.1)	80 (33.7)	97 (36.3)	

Variable	Total Number (percent) n=504	No respiratory support number (percent) n=237	Respiratory support number (percent) n=267	p value
Data collection department				
Emergency department	345 (68.5)	96 (27.8)	249 (72.2)	<0.001
Outpatient department	159 (31.5)	141 (88.7)	18 (11.3)	
Duration from home to hospital > 1 hour	345 (68.5)	106 (44.7) 131 (55.3)	164 (61.4) 103 (38.6)	<0.001
Refer-in cases	56 (11.1)	3 (1.3)	53 (19.9)	<0.001
Underlying Asthma	30 (6)	9 (3.8)	21 (7.9)	0.54
Day of fever, median (IQR)	2 (3)	2 (3)	1 (3)	0.27
Day of cough, median (IQR)	3 (3)	3 (2)	2 (3)	<0.001
Comorbid with sepsis	25 (5)	0 (0)	25 (9.4)	<0.001
RSV* Antigen rapid test positive from nasopharyngeal swab	139 (27.6) (test case n =439)	58/188 (30.9)	81/251 (32.3)	0.75
Admission	390 (77.4)	123 (51.9)	267 (100)	<0.001
MRS, median (IQR) (min, max)	4 (4) (0, 13)	2 (2) (0, 7)	5 (3) (1, 13)	<0.001

* RSV = Respiratory Syncytial Virus

MRS was correlated with all respiratory support levels. Logistic regression analysis, MRS had odds ratio for low flow oxygen, high flow oxygen, ventilator, and all respiratory support of 1.25 (95%CI 1.15-1.36, p value <0.001), 2.32 (95%CI 1.88-2.85, p value <0.001), 2.16 (95%CI 1.56-2.99, p value <0.001), and 2.34 (95%CI 2.02-2.7, p value <0.001), respectively. (Table 4)

Table 4. Correlation and univariable logistic regression analysis of MRS and respiratory support.

Level of respiratory support	No oxygen	Low flow oxygen	High flow oxygen	Ventilator	All levels of oxygen support
Number (percent)	237 (47)	208 (41.3)	50 (9.9)	9 (1.8)	267 (53)
MRS, median (IQR) (min, max)	2 (2) (0, 7)	5 (2) (1, 9)	7.5 (3) (4, 11)	8 (5.5) (5, 13)	5 (3) (1, 13)
Spearman's correlation (rho Correlation coefficient, p value)	-0.62 <0.001	0.32 <0.001	0.43 <0.001	0.18 <0.001	0.62 <0.001
Crude OR (95%CI) p value	0.43 (0.37-0.50) <0.001	1.25 (1.15-1.36) <0.001	2.32 (1.88-2.85) <0.001	2.16 (1.56-2.99) <0.001	2.34 (2.02-2.71) <0.001

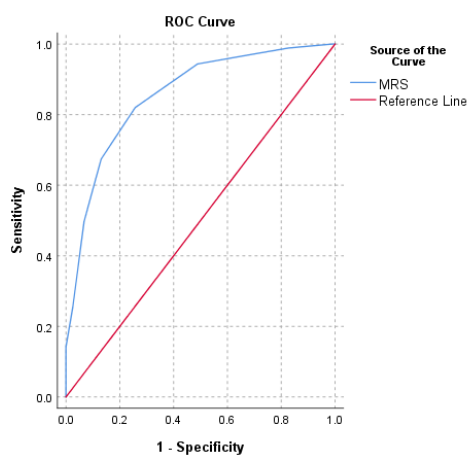
Multivariable regression analysis of MRS parameters with all levels of respiratory support were significant for six parameters: general appearance, skin color, respiratory rate, heart rate, oxygen saturation, and chest retraction and had odds ratio of 1.86 (95%CI 1.14-3.02, p value 0.012), 3.07 (95%CI 1.02-9.27, p value 0.047), 2.51 (95%CI 1.56-4.06, p value 0.000), 3.55 (95%CI 2.21-5.70, p value 0.000), 14.64 (95%CI 6.25-34.32, p value 0.000), and 4.23 (95%CI 2.46-7.28, p value 0.000), respectively. Lung sound parameter had an odds ratio of 1.08 (95%CI 0.49-2.41, p value 0.844) which was statistically insignificant, because most of the nature of disease with LRTIs had abnormal lung sound. (Table 5)

Table 5. Logistic regression analysis of MRS factors with respiratory support.

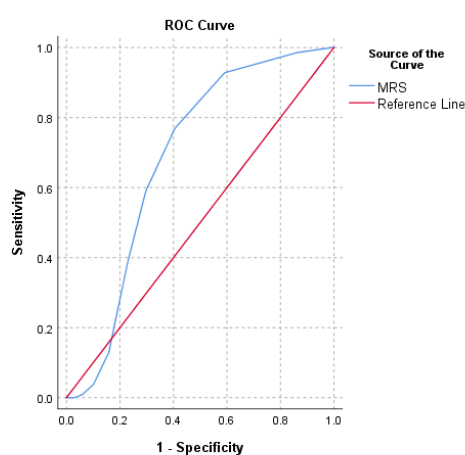
Parameters	Univariable regression analysis			Multivariable regression analysis		
	OR	95%CI	p value	OR	95%CI	p value
General appearance	0.54	0.33-0.88	0.012	1.86	1.14-3.02	0.012
Skin color	0.33	0.11-0.99	0.047	3.07	1.02-9.27	0.047
Respiratory rate	0.40	0.25-0.64	0.000	2.51	1.56-4.06	0.000
Heart rate	0.28	0.18-0.45	0.000	3.55	2.21-5.70	0.000
Oxygen saturation	0.07	0.03-0.16	0.000	14.64	6.25-34.32	0.000
Chest retraction	0.24	0.14-0.41	0.000	4.23	2.46-7.28	0.000
Lung sound	0.92	0.42-2.05	0.844	1.08	0.49-2.41	0.844

Receiver operating characteristic curve (ROC)

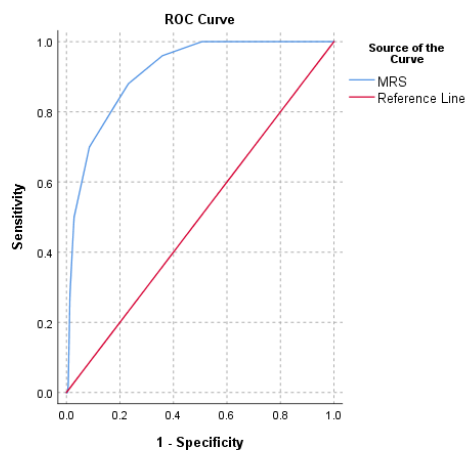
ROC analysis of MRS with the need for respiratory support was done. Area under the receiver operating characteristic curve (AUC) of MRS and respiratory support for all levels of respiratory, low flow oxygen, high flow oxygen, and ventilator were 0.86 (95%CI 0.82-0.89), 0.69 (95%CI 0.64-0.73), 0.91 (95%CI 0.88-0.95), and 0.90 (95%CI 0.82-0.98), respectively (Figure 1). Cut-off point score ≥ 4 predicted oxygen supplement, and low flow oxygen when cut-off point score ≥ 6 predicted high flow oxygen and ventilator support with a sensitivity of 86.9%, 59.5%, 91.4%, 86.3% and specificity of 67.4%, 59.1%, 70%, 66.7%, respectively. (Table 6)



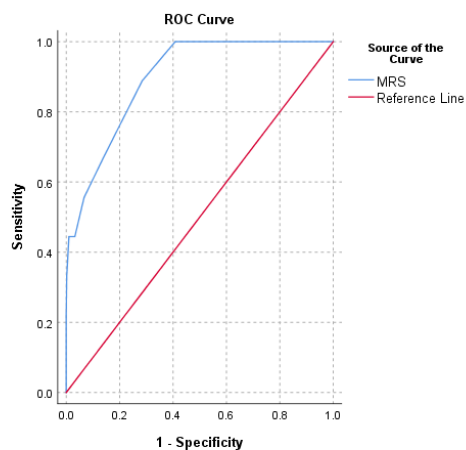
(a)



(b)



(c)



(d)

Figure 1. Receiver operating characteristic curve (ROC) of MRS predicting all levels of respiratory support (a), low flow oxygen (b), high flow oxygen (c), and ventilator support (d).

Table 6. Sensitivity and specificity of MRS on respiratory support.

Predicting	AUC (95%CI)	MRS	Sensitivity (%)	Specificity (%)	Positive predictive value (%)	Negative predictive value (%)	Youden's index
All respiratory support	0.86 (0.82-0.89)	≥ 3	74.3	82.0	78.6	78.2	0.45
		≥ 4	86.9	67.4	70.3	85.3	0.56
		≥ 5	93.3	49.8	62.3	89.3	0.54
		≥ 6	97.5	25.5	53.7	91.9	0.43
		≥ 7	100	14.2	50.9	100	0.23
		≥ 8	100	7.5	49.0	100	0.14
Low flow oxygen	0.69 (0.64-0.73)	≥ 3	59.5	76.9	78.6	57.1	0.34
		≥ 4	70.3	59.1	71.0	58.3	0.36
		≥ 5	77.0	39	64.2	54.4	0.29
		≥ 6	84.1	13.0	57.9	36.5	0.16
		≥ 7	89.9	3.8	57.1	21.1	-0.03
		≥ 8	100	1.0	57.4	100	-0.06

Predicting	AUC (95%CI)	MRS	Sensitivity (%)	Specificity (%)	Positive predictive value (%)	Negative predictive value (%)	Youden's index
High flow oxygen	0.91 (0.88-0.95)	≥ 3	49.3	100	100	17.9	0.31
		≥ 4	64.1	96	99.3	22.8	0.50
		≥ 5	76.9	88	98.3	29.5	0.62
		≥ 6	91.4	70	96.5	47.3	0.66
		≥ 7	97.1	50	94.6	65.8	0.62
		≥ 8	100	28	92.6	100	0.49
Ventilator support	0.90 (0.82-0.98)	≥ 3	45.3	100	100	3.2	0.28
		≥ 4	59.2	100	100	4.3	0.45
		≥ 5	71.5	88.9	99.7	5.4	0.59
		≥ 6	86.3	66.7	99.3	8.1	0.60
		≥ 7	93.3	55.6	99.1	13.2	0.53
		≥ 8	100	44.4	99.0	100	0.49

Calibration test

The calibration curve was shown in Figure 2. The predicted probability of respiratory support and observe proportion were shown, R square was 0.954. Hosmer-Lemeshow (H-L) test was analyzed with p value 0.318 for respiratory support.

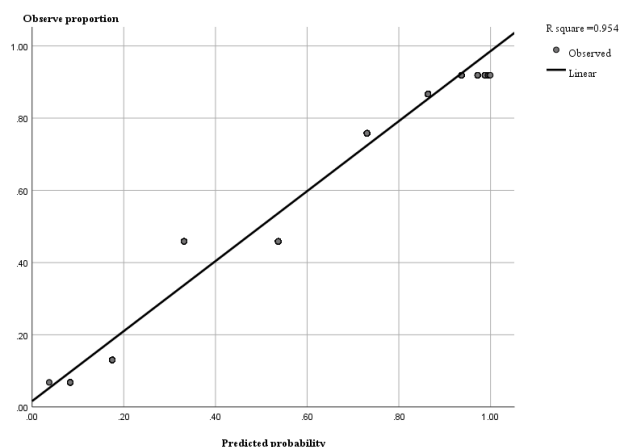


Figure 2. Calibration curve of predicted probability and observe proportion of respiratory support.

Age group analysis

Age group was discrimination into three groups by equal percentage: age group 1 (AG1: 1 month-1 year), age group 2 (AG2: >1-2 years), and age group 3 (AG3: >2 years). The percentages of patients in AG1, AG2 and AG3 were 35.9%, 29.0% and 35.1%, respectively. The percentage of respiratory support in each AG1, AG2 and AG3 were 50.3%, 54.1% and 54.8%, respectively. The median MRS in AG1, AG2 and AG3 were 3 (IQR 3), 5 (IQR 3) and 4 (IQR 3), respectively. When comparing the median MRS for each age group, AG1 had the lowest score and AG2 had the highest score, as shown in Table 7.

Table 7. Respiratory support level from age group analysis.

Age group	All patients	No respiratory support	Low flow oxygen	High flow oxygen	Ventilator support	All respiratory support
Age group 1 (AG1) 1 month-1 year, no. (%) MRS median (IQR)	181(35.9) 3 (3)	90 (49.7 in AG) 2 (3)	63 (34.8 in AG) 4 (2)	21 (11.6 in AG) 7 (2)	7 (3.9 in AG) 8 (6)	91 (50.3 in AG) 4 (3)
Age group 2 (AG2) >1- 2 years, no. (%) MRS median (IQR)	146 (29) 5 (3)	67 (45.9 in AG) 3 (5)	62 (42.5 in AG) 5 (0.25)	16 (11 in AG) 8 (3)	1 (7 in AG) 13 (0)	79 (54.1 in AG) 6 (2)
Age group 3 (AG3) >2 years, no. (%) MRS median (IQR)	177 (35.1) 4 (3)	80 (45.2 in AG) 2 (3)	83 (46.9 in AG) 5 (2)	13 (7.3 in AG) 8 (2.5)	1 (0.6 in AG) 6 (0)	97 (54.8 in AG) 6 (2)

Discussion

The prevalence of respiratory support was 53%, most of this was low flow oxygen correlated with our major of patients were low severity of disease in community hospital. MRS had good sensitivity for predicting respiratory support but fair specificity. MRS was used as a screening tool, which gave highest AUC for predicting high flow cannula, with sensitivity more than 90% when score were ≥ 6 . A fair level of specificity varied from 28-70%, for the reason of screening tool could not directly predict the respiratory support with high false positive. Internal validation for prediction tool by the calibration plot and Hosmer Lemeshow test interpreted MRS was a good fit for predictive tool. From univariable logistic regression analysis, MRS correlated with all respiratory support levels, more score will give more respiratory support level. For age

group analysis, the youngest age group had the highest percentages of high flow cannula and ventilator support from all study group while AG1 had the lowest median of MRS. In patient below 1 year, consideration of respiratory support might depend on the physician and also parental concern, cut-off point for high flow cannula and ventilator for this age group might need further study.

When comparing our tool with other studies for predicting respiratory support in the young age group, we found two studies which had sensitivity more than 90%. First, the study in children under 10 months, a study by Kubota et al.²¹ examined the ability of GRSS when using a cut-off score of 4.52, had sensitivity 69% and specificity 90%. Second, the study in children under 3 months, a study by De Rose et al.³ found that GRSS when using a cut-off score of 3.8, had sensitivity 93.55% and specificity 88.24%. GRSS contained parameter of general appearance for the young age group with concurrent with our MRS, which also had this parameter. In our hospital, when compared with another pediatric tool, a study by Tangchawal et al.²² developed a tool named the Pediatric Clinical Alert Score (PCAS) was studied in 1,470 pediatric patients aged 1 month to 15 years. The PCAS was nine-parameters tool predicted the unplanned intensive care unit transfer, which gave the sensitivity and specificity of 100% and 77.68%, respectively. However, a limitation of this tool was time-consuming from 9 parameters and it had difficulty on blood pressure parameter.

Limitations of this study. First, the level of agreement in measurement between two pediatricians was low, with Intraclass Correlation Coefficient (ICC) of 0.48 due to the limited number of patients, only 10 cases. Second, systemic errors might occur on the measurements of vital signs in children included respiratory rate, heart rate, and pulse oximetry. For vital signs, if the patient had a fever, crying or pain the respiratory rate might be false faster than normal. In cases of fever, vital signs should be measured after administering antipyretic medication and tepid sponge to reduce fever, and in cases of crying, remeasurements should be rechecked after 30 minutes. For pulse oximetry, checking for a consistent pulse waveform or a Perfusion Index (PI) before recording the value will give more reliable data. Third, limitation of the frequency in ventilator support group had only 9 patients (1.79%) due to the fact that our hospital had a prevalence of ventilator support patient of 0.74-1.99% over the last 5 years. This might interpret the low confidence level for ventilator support group. Lastly, This study was only a single community hospital study.

Interestingly, MRS had high confidence level for high flow oxygen and low confidence level for low flow oxygen. In the future, external validation of MRS will be useful. We highlighted the importance of external validation for using this tool in primary care units and primary hospitals before referral, especially in remote area. More rapid management could reduce deterioration of patients.

Conclusions

MRS could be a screening tool for predicting respiratory support, especially high flow oxygen for LRTIs patients under 5 years in the setting of community hospital. Higher score correlated with a higher level of respiratory support. In the situation of pediatricians and interns are limited, MRS concurrent with physical examinations and monitoring should guide proper management. Limitations of MRS were developed from a single center and needed further external validation.

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References

1. Prapphal N, Limudomporn S, Chumdermpadetsuk S. Risk factors of acute respiratory infection in Thai Children. *Chula Med J.* 1993;37:13-20.
2. Sitthikarnkha P, Uppala R, Niamsanit S, Sutra S, Thepsuthammarat K, Techasatian L, et al. Epidemiology of acute lower respiratory tract infection hospitalizations in Thai children: A 5-year national data analysis. *Influenza Other Respir Viruses.* 2022;16:142-50.
3. De Rose DU, Maddaloni C, Martini L, Braguglia A, Dotta A, Auriti C. Comparison of three clinical scoring tools for bronchiolitis to predict the need for respiratory support the need for respiratory support and length of stay in neonates and infants up to three months of age. *Front Pediatr.* 2023;11:1040354.

4. The committee for the development of guidelines for the management of acute respiratory infections in children. Guidelines for the management of acute respiratory infections in children. Bangkok: Pediatric Respiratory and Critical Care Society. Royal College of Pediatricians of Thailand. 2019:116-44.
5. Nolasco S, Manti S, Leonardi S, Vancheri C, Spicuzza L. High-flow nasal cannula oxygen therapy: Physiological mechanisms and clinical applications in children. *Front Med.* 2022;9:920549.
6. Hakizimana B, Saint G, Miert CV, Cartledge P. Can a respiratory severity score accurately assess respiratory distress in children with bronchiolitis in a resource-limited setting? *J Trop Pediatr.* 2019;66:234-43.
7. Caserta MT, Qiu X, Tesini B, Wang L, Murphy A, Corbett A, et al. Development of a global respiratory severity score (GRSS) for respiratory syncytial virus infection in infants? *J Infect Dis.* 2017;215:750-6.
8. Khan HI, Nasir A, Malih KA. Use of modified respiratory distress assessment instrument (RDAI) score to determine short-term morbidity in children with acute lower respiratory tract infections (ALRI). *PJMHS.* 2009;3:253-7.
9. Miyaji Y, Sugai K, Nozawa A, Kobayashi M, Niwa S, Tsukagoshi H, et al. Pediatric respiratory severity score (PRESS) for respiratory tract infections in children. *Austin Virol and Retrovirology.* 2015;2:1009.
10. Reed C, Madhi SA, Klugman KP, Kuwanda L, Ortiz JR, Finelli L, et al. Development of the Respiratory Index of Severity in Children (RISC) score among young children with respiratory infections in South Africa. *PLoS One.* 2012;7:e27793.
11. Nayani K, Naeem R, Munir O, Naseer N, Feroze A, Brown N, et al. The clinical respiratory score predicts paediatric critical care disposition in children with respiratory distress presenting to the emergency department. *BMC Pediatrics.* 2018;18:339
12. Feldman AS, Hartert TV, Gebretsadik T, Carroll KN, Minton PA, Woodward KB, et al. Respiratory severity score separates upper versus lower respiratory tract infections and predicts measures of disease severity. *Pediatr Allergy Immunol Pulmonol.* 2015;28:117-20.
13. Wang EE, Milner RA, Navas L, Maj H. Observer agreement for respiratory signs and oximetry in infants hospitalized with lower respiratory infections. *Am Rev Respir Dis.* 1992;145:106-9.

14. Kristjánsson S, Lødrup Carlsen KC, Wennergren G, Strannegård IL, Carlsen KH. Nebulised racemic adrenaline in the treatment of acute bronchiolitis in infants and toddlers. *Arch Dis Child*. 1993;69:650-4.
15. McCallum GB, Morris PS, Wilson CC, Versteegh LA, Ward LM, Chatfield MD, et al. Severity scoring systems: Are they internally valid, reliable and predictive of oxygen use in children with acute bronchiolitis? *Pediatr Pulmonol*. 2013;48:797-803.
16. Destino L, Weisgerber MC, Soung P, Bakalarski D, Yan K, Rehborg R, et al. Validity of respiratory scores in bronchiolitis. *Hosp Pediatr*. 2012;2:202-9.
17. Van Miert C, Abbott J, Verheoff F, Lane S, Carter B, McNamara P. Development and validation of the liverpool infant bronchiolitis severity score: A research protocol. *J Adv Nurs*. 2014;70:2353-62.
18. World Health Organization. The management of acute respiratory infection in children: Practical guideline for outpatient care. Geneva: World Health Organization. 1995:9.
19. Daniel WW. Biostatistics: A foundation for analysis in the health sciences. 7th ed. New York: John Wiley & Sons. 1999.
20. Perkins NJ, Schisterman EF. The inconsistency of “optimal” cutpoints obtained using two criteria based on the receiver operating characteristic curve. *Am J Epidemiol*. 2006;163:670-5.
21. Kubota J, Hirano D, Okabe S, Yamauchi K, Kimura R, Numata H, et al. Utility of the global respiratory severity score for predicting the need for respiratory support in infants with respiratory syncytial virus infection. *PLoS ONE*. 2021;16:e0253532.
22. Tangchawal S, Wongsuriya J, Kamalporn H, Chaiyakulsil C, Tansriratanawong S. The pediatric clinical alert score for the community hospital. *Thai J Pediatr*. 2020;59:139-47.