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Simulation and education

The perceived workload of first-line healthcare professionals during neonatal resuscitation

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Abstract

Background: Neonatal resuscitation is stressful for healthcare professionals as measured using the National Aeronautics and Space Administration-Task Load Index (NASA-TLX). Little is known regarding the perceived workload and associated factors among healthcare professionals including medical doctors (MDs) and nurses/midwives who have differences in training and experiences. We aimed to characterize and compare the perceived workload between MDs and nurses/midwives who provided neonatal resuscitation.

Methods: In a prospectively designed, cellphone-based surveillance, perceived workload and stress of MDs and nurses/midwives during neonatal resuscitation was evaluated using a modified multi-dimensional NASA-TLX survey in three tertiary Neonatal Intensive Care Units in China. The NASA-TLX data on mental, physical, temporal demand, performance, effort, and frustration were independently rated by participants and collated to a composite score of all dimensions. Demographics of participants and deliveries were also collected for statistical analyses using univariate comparison and multiple linear regression.

Results: From 410 valid surveys (187 (46%) MDs; 223 (54%) nurses/midwives), significant differences were noted between MDs and nurses/midwives including working years and dimensional and overall NASA-TLX scores. While MDs had lower overall NASA-TLX scores than nurses, their scores were inversely related with simulation-based training. More team members presence during resuscitation was associated with higher NASA-TLX scores. Other independent factors associated with NASA-TLX scores included gestational age, Apgar score at 1 min, year of practice for MDs and all resuscitation questions asked by nurses/midwives.

Conclusions: MDs and nurses/midwives attending deliveries had different perceptions in workload and stress which could be lowered from simulation-based training in neonatal resuscitation.

Keywords: Workload, Training, Simulation, Neonatal resuscitation

Introduction

Neonatal resuscitation is an important skillset for all healthcare professionals (HPs) attending deliveries. Neonatal Resuscitation Program (NRP®) training has been provided to all HPs attending deliveries in most centers in North America, and NRP® was introduced in China in 2004.[1] This has resulted in significant improvements in clinical outcomes with decreased neonatal and perinatal mortality and reduced birth asphyxia in China.[1,2] However, the conventional training in NRP® consisted of didactic lectures, videos and skill stations, at which participants practiced procedural skills on manikins. With this approach, knowledge and skill acquisition was improved immediately, but retention of knowledge and skills among participants reportedly lasted for only 6 months.[3] Recently the training of NRP® integrates simulation-based training (SBT) with emphasis on team performance and behaviors during neonatal resuscitation. SBT is an important and powerful tool to improve HP technical and non-technical skills. It utilizes a multiple learning approach, i.e., online testing, online case-based simulations, practical case-based simulation and debriefing which focus on key behaviors such as communication, critical leadership, and teamwork skills.[4,5]

Approximately two thirds of sentinel events during neonatal resuscitation were caused by non-technical problems such as poor

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communication or breakdown in teamwork.[6] These errors may occur due to excess HPs workload. Indeed, HPs perceive an increased workload and stress during high acuity deliveries or advanced measures.[7] Workload perception can be assessed using the National Aeronautics and Space Administration's Task Load Index (NASA-TLX) during neonatal delivery room care.[7] NASA-TLX is a frequently used subjective measure of workload and has been successfully used in air traffic control, civilian or military aviation and medicine.[7,8]

The neonatal resuscitation team in China is composed of medical doctors (MDs) and nurses or midwives,[1] which is different from the resuscitation team abroad such as in Canada. The latter consists of HPs including registered nurse, registered respiratory therapist, neonatal nurse practitioner or MDs depending on local institutional policy.[7] Further, HPs who attend deliveries may come from disciplines other than the Neonatal Intensive Care Unit (NICU). There is little information regarding the perceived workload and associated factors among MDs and nurses/midwives who have differences in training and experiences in neonatal resuscitation.

We aimed to characterize and compare the perceived workload between first-line MDs and nurses/midwives who provided neonatal resuscitation in three tertiary hospitals in China. We also examined clinical and infant characteristics that the deliveries they attended as well as their training and experiences in neonatal resuscitation. We hypothesized that SBT in neonatal resuscitation could be associated with lower NASA TLX scores in perceived workload.

Methods

The University of Hong Kong-Shenzhen Hospital is a comprehensive hospital, which had 6,000 deliveries in 2021, and has conducted neonatal resuscitation simulation training workshops to provide training to NICU and obstetric staffs since 2016. The Maternal and Child Health Hospital of Shenzhen and Shanghai First Maternity and Infant Hospital are tertiary specialized hospitals in maternity which had a total of 17,000 births and 22,400 births in 2021, respectively. The Maternal and Child Health Hospital of Shenzhen and Shanghai First Maternity and Infant Hospital have conducted SBT in neonatal resuscitation since 2017 and 2016, respectively. This multi-center survey received approval by the Institutional Ethics Committee of University of Hong Kong–Shenzhen Hospital (#202024), Shanghai First Maternity and Infant Hospital (#202114), and Maternal and Child Health Hospital of Shenzhen (#2024148).

We conducted this prospective cohort study that involved HPs including MDs, nurses/midwives who attended high-risk deliveries at three hospitals in 2021. The HPs consented to complete the cell-phone based online survey during study period at their earliest convenience after the delivery attendance. A simplified Chinese version of the NASA-TLX survey has been validated by Liang et al.[9] The survey was linked to an anonymous unique code and was provided to HPs during their work shifts, and they were asked to voluntarily complete the survey after they attended a delivery regardless of their role, profession, level of training, or which interventions were performed at the delivery. No personal identifiable information was collected. The project study coordinators (KS/HBH) tracked completed questionnaires and worked collaboratively with the local study coordinator to improve enrolment and questionnaires completion and validity.

The NASA-TLX is a six-dimension tool designed to obtain an overall perception of workload related to high-stress tasks[7,8] which was initially developed to measure workload in laboratory-based aviation settings. The tool has since been applied to workload measurement in other sectors such as nuclear energy, transportation, and increasingly in health care.[7,8] The 6 dimensions are cognitive demand (mental and perceptual activity required), physical demand (physical activity required), time pressure (rate or pace of activities), performance (individual success in completing assignments), effort (how hard one had to work to accomplish one's level of performance), and frustration (how irritated, stressed, or annoyed one feels during the day). NASA global scores were calculated in two different ways (Raw TLX as calculated and a scoring system) which have been shown to correlate closely.[10]

In this cell-phoned based online questionnaire, we modified the raw score for each dimension on a scale of 1 (very low) to 12 (very high), except the dimension on performance which was rated in reverse from perfect as 1 to failure as 12. Workload perception in each dimension was calculated by converting the non-raw score into percent, ranging from a minimum of 8.3 to a maximum of 100 percent. Finally, the overall NASA-TLX score was calculated as the mean of all dimension scores into percents. The higher score indicated higher workload. Also, we collected demographic characteristics of participants (gender, profession, years of working, number of team members, neonatal resuscitation training mode and roles in resuscitation), infant (gestational age, birth weight and Apgar score) and delivery (reason for resuscitation and interventions during resuscitation) variables for each attendance.

Statistical analysis

All analyses were conducted using IBM Statistical Product and Service Solutions Version 26 (SPSS Inc., Chicago, IL). Descriptive statistics were summarized as median (IQR) or mean ± SD for continuous variables, and frequencies and percentages for categorical variables. The distribution of data set was tested for normality. Parametric (Student t) and non-parametric (Mann-Whitney U) tests were used to analyze variables accordingly. Comparisons of categorical variables were performed using the Pearson chi-square test. For multi-groups comparisons, ANOVA with Bonferroni *post hoc* testing was used. Variables with $P < 0.1$ in the univariate comparisons were entered into multivariate linear regression models to identify independent risk factors using stepwise regression. The β coefficients of the multivariable model represent the change in the overall NASA-TLX score due to the presence of an independent variable. β Coefficients with 95% confidence intervals (CI) were presented. $P < 0.05$ was considered statistically significant in all tests if applied.

Results

There were 410 valid surveys completed by 187 (46%) MDs and 223 (54%) nurses/ midwives. Of the surveys, 389 (95%) were from female, 21 (5%) from male gender. Among nurses/midwives, 119 (53%) were midwives, others (47%) were from nurses in NICU, obstetrics and operating room. A total of 254 (62%) completed the survey in the 2 h after attending the delivery. The total median (IQR) working years were 2 (1–9) years with MDs having significantly less experience than nurses/midwives group [1 (1–2) vs. 9 (5–12) years, respectively, $P < 0.001$].

The NASA-TLX scores of each domain and the overall scores of MDs, midwives and nurses were analyzed by ANOVA and are presented in Table 2. The overall NASA-TLX scores and many domain

scores (except frustration) were significantly higher for nurses compared to that of MDs (Table 2). Midwives had lower overall NASA-TLX scores and scores in mental and physical domains than those of nurses and similar scores to those of MDs except for higher effort scores. The overall NASA-TLX score of nurses as team leader was also significantly higher than those of MDs and midwives whereas the scores of roles in airway management did not differ (Table 2). There was no significant difference in neonatal training mode between two groups (Table 1). The clinical characteristics, dimensional and overall NASA-TLX scores results are shown in Table 1 and Table 2, respectively.

In univariate linear regression analyses of overall NASA-TLX, risk factors were categorized into those related to participants, infants and deliveries (Table 3). Univariable regression showed that number of team members of participants, neonatal resuscitation training mode, gestational age, birth weight, numbers of infant(s), Apgar score at 1 min and 5 min, resuscitation for extremely preterm infants, roles and intubation during resuscitation were associated with overall NASA-TLX in MDs (all $P < 0.05$) (Table 3). Nevertheless, only number of team members of participants and all 4 resuscitation questions asked were related with overall NASA-TLX in the nurses/midwives group (both $P < 0.05$) (Table 3).

Multivariate linear regression analysis was used to investigate the relationship between the perceived workload and independently associated factors among MDs and nurses/midwives. While MDs had lower overall NASA-TLX scores than that of nurses/midwives, both groups had an inverse relationship between the score and SBT [MDs: β = -10.6, CI (−14.6–-6.6); nurses/midwives: β = -6.0, CI (−10.6–-1.3)] (Table 4). In other words, the overall NASA-TLX scores of HPs decreased by 10.6 and 6.0 percent points in MDs and nurses/midwives, respectively, when participants underwent SBT in neonatal resuscitation. The presence of team members during resuscitation was positively associated with workload [MDs: β = 1.8, CI (0.6–2.9); nurses/midwives: β = 3.5, CI (2.4–4.6)]. This indicated that if the presence of team members increased by 1 HP, the NASA-TLX increased by 1.8 and 3.5 percent points in both groups, respectively. Other independent factors associated with overall NASA-TLX scores included gestational age, Apgar score at 1 min, year of practice for MDs and all resuscitation questions asked in nurses/midwives group (Table 4).

Discussion

In this study of workload perception in healthcare professionals, we found that SBT for neonatal resuscitation was independently associated with a lower workload perceived by participants during deliveries instead of conventional neonatal resuscitation training including either theory or skills training (Table 4). Of note, the effect of SBT on NASA-TLX scores was high as measured by the β coefficients of 6.0–10.6 whereas the effect of other factors ranged from 0.7 to 5.7 despite of the significant associations.

Simulation was best defined as an instructional strategy "used to replace or amplify real experiences with guided experiences that

Table 1 – Demographics, characteristics of deliveries attended by medical doctors (MDs) and nurses/midwives expressed in n (%) or median (IQR).

	Total (n = 410)	MDs (n = 187)	nurses/midwives (n = 223)	P value
Participants				
NICU/Obstetrics working years	2 (1–9)	1 (1–2)	9 (5–12)	<0.001
Number of team members	4 (3–5)	3 (2–5)	4 (3–5)	<0.001
Neonatal resuscitation training mode				
Theory	384 (94%)	176 (94%)	208 (93%)	0.84
Skill	376 (92%)	175 (94%)	201 (90%)	0.28
Simulation	304 (74%)	141 (75%)	163 (73%)	0.65
Theory + skill + simulation	289 (70%)	136 (73%)	153 (69%)	0.36
Roles in neonatal resuscitation				<0.001
Team leader	115 (28%)	94 (50%)	21 (9%)	
Breathing	113 (28%	63 (34%)	50 (22%)	
Others	182 (44%)	30 (16%)	152 (68%)	
Infants				
Gestational age (weeks)	34 (30–38)	34 (29–38)	35 (31–38)	0.14
Birth weight (kilograms)	2 (1.3–2.9)	1.9 (1.1–2.8)	2.1 (1.4–2.9)	0.11
Infant(s)	1 (1–2)	1 (1–2)	1 (1–2)	0.17
Apgar score at 1 min	9 (8–9)	8 (8–9)	9 (8–9)	0.27
Apgar score at 5 min	10 (9–10)	9 (9–10)	10 (9–10)	0.22
Deliveries				
Reason for resuscitation				
Preterm	236 (58%)	104 (56%)	132 (59%)	0.48
Extremely preterm	47 (11%)	29 (16%)	18 (8.1%)	0.02
Fetal distress	109 (27%)	54 (29%)	55 (25%)	0.37
Neonatal distress	135(33%)	59 (32%)	76 (34%)	0.59
All 4 resuscitation questions asked	269 (66%)	122 (65%)	147(66%)	0.09
Intervention				
CPAP/PPV	302 (73%)	143 (76%)	159 (71%)	0.25
Intubation	69 (17%)	41 (22%)	28 (13%)	0.02

NICU, Neonatal Intensive Care Unit; CPAP, continuous positive airway pressure; PPV, positive pressure ventilation

Table 2 – Dimension score and overall NASA-TLX score by occupation and primary role at deliveries. Data are presented in median (IQR) and mean ± SD.

	Total (N = 410)	Medical doctors (n = 187)	midwives (n = 119)	nurses (n = 104)	P value (ANOVA)
NASA-TLX score (percent)					
Mental	67 (50–83)	61 ± 22	62 ± 26[b]	71 ± 25[a]	0.002
Physical	58 (42–75)	55 ± 22	53 ± 26[b]	70 ± 24[a]	<0.001
Temporal	75 (50–83)	63 ± 24	68 ± 26	73 ± 25[a]	0.004
Performance	75 (58–83)	71 ± 15	76 ± 21	81 ± 17[a]	<0.001
Effort	75 (58–83)	71 ± 17	77 ± 20[a]	77 ± 18[a]	0.006
Frustration	25 (8–50)	34 ± 25	34 ± 28	36 ± 28	0.875
Overall NASA-TLX	63 (50–75)	59 ± 15	62 ± 17[b]	68 ± 16[a]	<0.001
Overall NASA-TLX (percent)					
Team leader	54 (44–65) (N = 115)	53 ± 13 (n = 94)	59 ± 19[b] (n = 10)	75 ± 12[a] (n = 11)	<0.001
Breathing	64 (53–76) (N = 113)	66 ± 15 (n = 63)	63 ± 20 (n = 32)	60 ± 16 (n = 18)	0.378
Other roles	67 (55–78) (N = 182)	67 ± 11 (n = 30)	61 ± 16[b] (n = 77)	69 ± 16 (n = 75)	0.011

[a] P < 0.05 vs. MDs;
[b] P < 0.05 vs. nurses (Bonferroni *post hoc* testing).

Table 3 – P-values of univariate linear regression analyses of overall NASA-TLX scores in medical doctors (MDs) and nurses/midwives, respectively.

	Overall NASA-TLX in MDs	Overall NASA-TLX in nurses/midwives
Participants		
NICU/Obstetrics (working years)	0.06	0.34
Number of team members	<0.001	<0.001
Neonatal resuscitation training mode		
Theory	0.03	0.39
Skill	0.006	0.68
Simulation	0.001	0.07
Theory + skill + simulation	<0.001	0.34
Infants		
Gestational age (weeks)	<0.001	0.93
Birth weight (kilograms)	<0.001	0.85
Numbers of infant(s)	0.007	0.54
Apgar score at 1 min	<0.001	0.18
Apgar score at 5 min	<0.001	0.08
Deliveries		
Reason for resuscitation		
Preterm	0.95	0.62
Extremely preterm	0.001	0.35
Fetal distress	0.10	0.12
Neonatal distress	0.47	0.34
Roles in neonatal resuscitation	<0.001	0.88
All 4 resuscitation questions asked	0.63	0.02
Interventions		
CPAP/PPV	0.41	0.98
Intubation	0.008	0.18

NICU, Neonatal Intensive Care Unit.
CPAP, continuous positive airway pressure; PPV, positive pressure ventilation

evoke or replicate substantial aspects of the real world in a fully interactive manner". Simulation allowed interactive, and at times immersive, activity by recreating all or part of clinical experience without exposing patients to the associated risks.[11] Simulation was first introduced to neonatal resuscitation training in the mid-1990s following its success in the field of aviation for training and assessing pilots.[12] The conventional neonatal resuscitation training focused on didactic lectures, videos and skill stations, in which trainees practiced procedural skills on manikins.[3] Compared to conventional training, SBT involves the participation of trainees in a realistic situation (scenario)

Table 4 – Multiple linear regression analyses of overall NASA-TLX scores in medical doctors (MDs) and nurses/midwives, respectively.

	Independent variables	Adjusted R^2	β coefficient	95% Confidence Intervals	P value
NASA-TLX in MDs (n = 187)	Theory + skill + simulation	0.393	−10.6	−14.6 to −6.6	<0.001
	NICU/Obstetrics years		−5.7	−8.6 to −2.8	<0.001
	Number of team members		1.8	0.6 to 2.9	0.003
	Apgar score at 1 min		−1.2	−2.1 to −0.4	0.006
	Gestational age (weeks)		−0.7	−1.1 to −0.3	0.001
NASA-TLX in nurses/midwives (n = 223)	Simulation	0.175	−6.0	−10.6 to −1.3	0.01
	All 4 resuscitation questions asked		−5.3	−9.7 to −1.0	0.02
	Number of team members		3.5	2.4 to 4.6	<0.001

NICU, Neonatal Intensive Care Unit.

created within a physical space (simulator) that replicates fidelity sufficient to achieve the suspension of disbelief in trainees.[12] The learning experience in authentic activities via hands-on training was significant,[13] while trainees were more motivated by audiovisual methods of learning than theoretical lectures.[14] Furthermore, simulation better prepared providers with cognitive, technical and behavioral skills, in addition to teamwork and communication during neonatal resuscitation.[15] Indeed, SBT has positive impacts on neonatal outcomes.[16–19] Zanno et al reported that a simulation-based outreach program improved self-confidence among rural delivery room teams after training, including airway management, emergent intravenous access, and the ability to manage a code in the delivery room and operating room.[20] We believed that all factors including the improvement in resuscitation skills, collaborative and cooperative work between NICU, midwifery and obstetrical staff help reduce the perceived workload of HPs during deliveries.

Interestingly, this study found that nurses perceived a heavier workload than first-line MDs during deliveries, even though they have more experience than MDs and there was no difference in their neonatal resuscitation training (Tables 1 and 2). The workload perception by MDs with the primary role as team leader was lower than that of nurses as team leaders whereas workload perception was similar between groups when they were in airway management and other roles (Table 2). We speculate that this interesting phenomenon could be related to the professional training and roles in the health care team rather than the job experience. Our data set, however, precludes the detailed examination of confounding effects of caseload details including severity of resuscitation and intubation and the complex relation of training and experience of MDs in workload perception at different roles in neonatal resuscitation. In Australia, a systematic review suggests that nurses commonly experience several stressors, including heavy workloads, conflicts between colleagues, working with inadequately prepared or inexperienced staff, aggressive patients and relatives, role ambiguity and shift work.[21] Occupational stress in nursing is of global concern.[22,23]

Understanding the workload distribution between team members and its effect on each team member's performance will allow us to design targeted interventions to improve equitable role assignment and workload management.[23] Furthermore, there was a significant increase in the number of team members attending the delivery in the nurses/midwives group compared to the MDs (Table 1). We observed that the presence of more team members during resuscitation was positively associated with higher workload [MDs: β = 1.8, CI (0.6–2.9); nurses/midwives: β = 3.5, CI (2.4–4.6)] (Table 4). This finding was similar to that in the study of Zehnder et al.[7] We believe that the number of team members is a proxy of the anticipation of at-risk deliveries or infants. There was a significantly increased overall workload when MDs cared for infants with a lower 1-min Apgar score or with a smaller gestational age instead of nurses/midwives (Table 4). The increased overall workload usually implies interventions as required in these deliveries. Garvey et al[24] found that a significantly higher perceived workload for HPs who attended deliveries of infants who required any delivery room intervention compared to no delivery room intervention. We found that in this study most MDs acted as team leaders or airway managers during resuscitation (Table 1). Zehnder et al reported HPs who acted as team leader and/or airway manager had a higher raw NASA-TLX score,[7] which was similar to the findings of greater workload perception by team leaders compared to their team during simulated neonatal resuscitation[25] and sepsis scenarios.[26]

Other independent factors inversely associated with workload included year of practice for MDs and all four resuscitation questions asked in nurses/midwives (Table 4). It suggests that the more years of practice a physician has, implying the more experience and confidence in resuscitation which may contribute to lower workload perception. It is important for the obstetric and neonatal HPs to coordinate care by establishing effective communication. Therefore, before every birth, review of the antepartum and intrapartum risk factors and asking the 4 pre-birth questions is recommended in SBT in neonatal resuscitation. It is so important to anticipate perinatal risks and deploy team members with appropriate skill sets based on risks assessment,[27,28] as well as collaboration and cooperation in risks assessment and resuscitation between NICU, midwifery and obstetrical staff.[29] On the other hand, if all resuscitation questions were asked pre-birth, it might mean that better preparation and all appropriate supplies and equipment could have been checked and ready for immediate use which helped reduce the stress during resuscitation.

Limitations

There are several limitations of this study. Our study is an observational study which we cannot adequately account for confounders and cautious interpretation of these results is required. Due to institutional policy and SBT are variably practiced in China, differences that were inherent to HPs received SBT or not might have confounded our observations. Of note, the roles of nurses and midwives

at deliveries are different. While we analyzed the workload perception separately (Table 2) we put them together in other data analyses similar nursing training background and work arrangements (e.g. shifts) of nurses and midwives. Further, majority of deliveries were due to preterm, extremely preterm and fetal distress when nurses and midwives might have similar roles in resuscitation. Midwives who were the first responder to deliveries often changed roles and might have functioned as nurses when MDs were present. Nevertheless, separating nurses and midwives in comprehensive data analyses could have helped understand differences and contributing factors in workload perception between MDs, nurses and midwives. Recall bias might have resulted in inaccuracies in reporting of their perceived workload, especially beyond 2 h. Some HPs did not complete the survey until after their shift was completed, which may have affected their perceptions. Increased workload during a shift might also have influenced their perceptions. Shifts of MDs and nurses varied significantly with respect to responsibilities and shift-related duties. The NASA-TLX are subjective and therefore may not be consistent across individuals. Nonetheless, the perception of workload is a meaningful measure that should be targeted to improve performance. The present study was conducted in three hospitals. The different workplaces, as well as the collaboration between NICU, midwifery, and obstetrical staff, might have influenced their perceptions. Therefore, generalization of findings in this study requires caution in other local, national and international health systems.

CRediT authorship contribution statement

Hai-Bo Huang: Writing – review & editing, Writing – original draft, Validation, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Kui Sang:** Writing – review & editing, Validation, Software, Resources, Project administration, Methodology, Investigation, Data curation, Conceptualization. **Ming Zhou:** Writing – review & editing, Validation, Software, Resources, Project administration, Methodology, Investigation, Data curation, Conceptualization. **Lin Yi:** Writing – review & editing, Validation, Software, Resources, Project administration, Methodology, Investigation, Data curation, Conceptualization. **Jiang-Qin Liu:** Writing – review & editing, Validation, Supervision, Resources, Project administration, Methodology, Investigation, Funding acquisition, Data curation, Conceptualization. **Chuan-Zhong Yang:** Writing – review & editing, Validation, Supervision, Resources, Project administration, Methodology, Investigation, Funding acquisition, Data curation, Conceptualization. **Brenda H.Y. Law:** Writing – review & editing, Validation, Methodology, Investigation, Conceptualization. **Georg M. Schmölzer:** Writing – review & editing, Validation, Methodology, Investigation, Conceptualization. **Po-Yin Cheung:** Writing – review & editing, Validation, Supervision, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Po-Yin Cheung reports financial support was provided by Sanming Project of Medicine in Shenzhen. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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