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ORIGINAL ARTICLE

External Quality Assessment Program for Newborn Screening of Acylcarnitine in China, 2018

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SUMMARY

Background: **The aim of this study was to analyze the 2018 external quality assessment (EQA) results of newborn screening by MS/MS of acylcarnitine by Chinese National Center for Clinical Laboratories and to determine the performance of clinical laboratories.**
Methods: **Five dried blood spots were distributed to participants every round. Satisfactory performance was defined as scores more than 80 of acceptable results within the evaluation criterion. The robust coefficient of variability (RCV) of each sample was calculated by measurement systems. The chi-square (χ^2) test was used to compare the correct recognition rates.**
Results: **EQA results were collected from 150 laboratories for 15 different acylcarnitines between C0 - C18. The overall acceptable rates of the qualitative results were between 81.21% and 96.67%, and the proportion of acceptable quantitative results were between 78.38% and 93.24%. There were significant differences in the rates of acceptable quantitative results among different items and between the four methods.**
Conclusions: **Most of the participant laboratories had satisfactory performance for the quantitative results in this EQA scheme. But for qualitative assessment, a laboratory should re-evaluate and validate their reference intervals on a regular basis to improve the consistency of clinical assessment.**
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KEY WORDS

external quality assessment, newborn screening, acylcarnitine, MS/MS

COVER LETTER

This study, as the first analysis of EQA results of acylcarnitine in China, reflected the status quo of this project. By having testing items of newborn screening of acylcarnitine and participating in external quality assessment (EQA), clinical laboratories can understand and improve their testing performance to make the diagnosis of relative genetic diseases more accurate and offer more timely and effective treatment.

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INTRODUCTION

Newborn screening is important for the early detection of many congenital genetic and metabolic disorders, aimed at the earliest possible recognition and management of affected newborns, and to prevent morbidity and mortality [1,2]. Newborn screening by tandem mass spectrometry (MS/MS) was first introduced to China in 2000. MS/MS has turned out to be more specific, sensitive, reliable, and comprehensive than traditional assays [3]. Currently, there are more than 150 laboratories performing neonatal screening by MS/MS each year, and the number of laboratories is still increasing rapidly. To ensure the accuracy and reliability of testing results by MS/MS within each laboratory, as well as the comparability among different laboratories, quality assessment of methods and measurement systems is essential for newborn screening [4]. Therefore, the National Center for Clinical Laboratories (NCCL), an official provider of Proficiency Testing (PT) in China, has initiated the biannual national external quality assessment (EQA) schemes of newborn screening by MS/MS for acylcarnitine. We evaluated the results of the 2018 EQA scheme of newborn screening by MS/MS in China, which includes free carnitine (C0), acetylcarnitine (C2), propionyl (C3), butyryl carnitine (C4), 3-hydroxybutyryl carnitine (C4OH), glutaryl carnitine (C5), glutarine (C5DC), caproyl carnitine (C6), octylcarnitine (C8), decanoylcarnitine (C10), capryloylcarnitine (C12), 3-hydroxy-fourteen carnitine (C14OH), lauryl carnitine (C16), and eighteen carnitine (C18), This study intends to help clinical laboratories realize their own testing performance and provide them with practical advice to improve quality management.

MATERIALS AND METHODS

Material preparation

Panels were prepared, the homogeneity and the stability of all the blood spots were guaranteed by a specific manufacturer certified by Chinese Food and Drug Administration (FDA) to produce and sell quality control materials. Each panel consisted of five blood spots for biannual determination of acylcarnitine (2 rounds, 5 samples for each round). The concentrations of all the spots were different. The panels were stored at 2 - 8°C until distribution. All the samples were labeled and distributed to clinical laboratories of hospitals, Maternal and Child Health Care Centers, and commercial/non-commercial medical institutions that provided newborn screening and participated in each round, instruction manuals were also sent along with these EQA samples.

Study design

After distributing EQA samples, there was a two-week period during which participants were to treat EQA samples the same as the patient specimens. Testing is done routinely by MS/MS method in all laboratories and the results were to be submitted. Methods, instruments, reagents, and testing results with quantitative results, as well as qualitative test results (whether within normal limits) were all to be submitted to the reporting system.

Target values assigned and evaluation of the results

In China, newborn screening EQA program data were assessed according to consensus method. The assigned value of the quantitative test of a subgroup used in our EQA program was the median of the results reported by all the participants in this subgroup [5]. For qualitative test results, the result of within cutoffs or without cutoffs, which exceeded 60% in all results would be considered as assigned values of this item [6].

To evaluate the EQA quantitative results, scores were awarded on the basis of bias against the assigned value. For each round, 20 points were assigned if the quantitative results of each acylcarnitine fell in the range of ± 30% or 5.40 mmol/L (whichever was larger) for C0, ± 30% or 3.60 mmol/L (whichever was larger) for C2, ± 30% or 0.45 mmol/L (whichever was larger) for C3, ± 30% or 0.04 mmol/L (whichever was larger) for C4, ± 30% or 0.04 mmol/L (whichever was larger) for C4OH, ± 30% or 0.04 mmol/L (whichever was larger) for C5, ± 30% or 0.08 mmol/L (whichever was larger) for C5DC, ± 30% or 0.04 mmol/L (whichever was larger) for C10, ± 30% or 0.04 mmol/L (whichever was larger) for C12, ± 30% or 0.04 mmol/L (whichever was larger) for C14OH, ± 30% or 0.42 mmol/L (whichever was larger) for C16, and ± 30% or 0.21 mmol/L for C18. Other results were not scored in the EQA panel. For qualitative test results, we assigned 20 points for being the same as the assigned value whereas the different results were not scored in every EQA panel. Every EQA blood spot should be tested and report a definitive conclusion such as within normal limits or outside normal limits. Thus 100 points was the best score for participant laboratories in both quantitative and qualitative assessment.

For the newborn screening according to the MS/MS EQA program of the NCCL, 80 points or more would be considered as “acceptable” performance whereas less than 80 points was an “unacceptable” performance, just like other studies and EQA programs [3]. The acceptable rate of each EQA panel was calculated as the number of participants considered as acceptable via divided by the number of all participant laboratories.

Statistical analysis

Data submitted by participants were analyzed using SPSS 19.0 and Clinet-EQA evaluation system V1.0 which was also developed by NCCL of China and employed in the national EQA schemes. For each sample, the median, the standard deviation (SD), the percentage difference to the assigned value, and the robust average of concentration, the robust standard deviation (RSD), and the robust coefficient of variation (RCV) explained in the ISO 13528 with statistical methods, were calcu-

Table 1. Analysis of the qualitative results.

Amino Acid and Acylcarnitine	Round	Number of laboratories	EQA scores = 100 a		80 ≤ scores < 100		EQA scores < 80	
			No. of labs	Proportion (%)	No. of labs	Proportion (%)	No. of labs	Proportion (%)
C0	1st	149	141	94.6	5	3.4	3	2
	2nd	149	146	98	3	2	0	0
C2	1st	149	141	94.6	3	2	5	3.4
	2nd	149	146	98	2	1.3	1	0.7
C3	1st	149	134	89.9	6	4	9	6.1
	2nd	149	146	98	3	2	0	0
C4	1st	149	130	87.2	10	6.7	9	6.1
	2nd	149	142	95.3	6	4	1	0.7
C4OH	1st	146	116	79.5	8	5.5	22	15
	2nd	146	138	94.5	4	2.7	4	2.8
C5	1st	149	113	75.8	23	15.4	13	8.8
	2nd	149	125	83.9	19	12.8	5	3.3
C5DC	1st	148	115	77.7	10	6.8	23	15.5
	2nd	148	138	93.2	3	2	7	4.8
C6	1st	149	120	80.5	15	10.1	14	9.4
	2nd	149	134	89.9	9	6	6	4.1
C8	1st	149	138	92.6	8	5.4	3	2
	2nd	149	142	95.3	7	4.7	0	0
C10	1st	149	125	83.9	12	8.1	12	8
	2nd	149	139	93.3	9	6	1	0.7
C12	1st	148	128	86.5	7	4.7	13	8.8
	2nd	148	134	90.5	9	6.1	5	3.4
C14	1st	149	98	65.8	24	16.1	27	18.1
	2nd	149	129	86.6	10	6.7	10	6.7
C14OH	1st	129	115	89.1	4	3.1	10	7.8
	2nd	129	125	96.9	3	2.3	1	0.8
C16	1st	149	141	94.6	6	4	2	1.4
	2nd	149	147	98.7	1	0.7	1	0.6
C18	1st	149	145	97.3	1	0.7	3	2
	2nd	149	143	96	5	3.4	1	0.6

[a] **- 100 points was the full score. 20 points were assigned if the qualitative results of each item fell in the evaluation criterion above.**

lated according to different methods and applied to assess performance of participants [4].

RESULTS

Participant laboratories

In total, 156 screening laboratories in hospitals and newborn screening centers were enrolled in the 2018 EQA program, among which 150 laboratories submitted effective results. There were four MS/MS methods used in newborn screening in China. Thirty-five participants used a derivatized-MS/MS non-kit method, 14 participants used a non-derivatized-MS/MS-non-kit method 80 participants used a non-derivatized-MS/MS Perkin-Elmer NeoBase Kit method, and 21 participants used a non-derivatized-MS/MS GuangZhou method.

Results of qualitative assays

Qualitative results were analyzed and scored according to the criteria described above. We compared the full-score ratio and acceptable ratio of the EQA program for

Table 2. The analysis of EQA scores for measurement methods in each item.

Item	Measurement system	No. of labs reporting five effective results	EQA score = 100 [a]		80 ≤ EQA score < 100		EQA score < 80	
			No. of labs	Proportion (%)	No. of labs	Proportion (%)	No. of labs	Proportion (%)
C0	derivatized - MS/MS	74	72	97.30	2	2.70	0	0.00
	non-derivatized - MS/MS non-kit	27	23	85.19	2	7.41	2	7.41
	non-derivatized - MS/MS PerkinElmer NeoBase Kit	156	153	98.08	2	1.28	1	0.64
	non-derivatized - MS/MS Guangzhou	41	39	95.12	2	4.88	0	0.00
C2	derivatized - MS/MS	74	72	97.30	2	2.70	0	0.00
	non-derivatized - MS/MS non-kit	27	24	88.89	0	0.00	3	11.11
	non-derivatized - MS/MS PerkinElmer NeoBase Kit	156	152	97.44	2	1.28	2	1.28
	non-derivatized - MS/MS Guangzhou	41	39	95.12	1	2.44	1	2.44
C3	derivatized - MS/MS	74	67	90.54	3	4.05	4	5.41
	non-derivatized - MS/MS non-kit	27	24	88.89	2	7.41	1	3.70
	non-derivatized - MS/MS PerkinElmer NeoBase Kit	156	152	97.44	2	1.28	2	1.28
	non-derivatized - MS/MS Guangzhou	41	37	90.24	2	4.88	2	4.88
C4	derivatized - MS/MS	74	59	79.73	6	8.11	9	12.16
	non-derivatized - MS/MS non-kit	27	22	81.48	4	14.81	1	3.70
	non-derivatized - MS/MS PerkinElmer NeoBase Kit	156	155	99.36	1	0.64	0	0.00
	non-derivatized - MS/MS Guangzhou	41	36	87.80	5	12.20	0	0.00
C4OH	derivatized - MS/MS	70	52	74.29	6	8.57	12	17.14
	non-derivatized - MS/MS non-kit	27	17	62.96	4	14.81	6	22.22
	non-derivatized - MS/MS PerkinElmer NeoBase Kit	154	148	96.10	1	0.65	5	3.25

Table 2. The analysis of EQA scores for measurement methods in each item (continued).

Item	Measurement system	No. of labs reporting five effective	EQA score = 100 [a]		80 ≤ EQA score < 100		EQA score < 80	
			No. of labs	Proportion (%)	No. of labs	Proportion (%)	No. of labs	Proportion (%)
C4OH	non-derivatized - MS/MS Guangzhou	41	37	90.24	1	2.44	3	7.32
C5	derivatized - MS/MS	74	48	64.86	18	24.32	8	10.81
	non-derivatized - MS/MS non-kit	27	20	74.07	6	22.22	1	3.70
	non-derivatized - MS/MS PerkinElmer NeoBase Kit	156	134	85.90	15	9.62	7	4.49
	non-derivatized - MS/MS Guangzhou	41	36	87.80	3	7.32	2	4.88
C5DC	derivatized - MS/MS	72	56	77.78	6	8.33	10	13.89
	non-derivatized - MS/MS non-kit	27	19	70.37	3	11.11	5	18.52
	non-derivatized - MS/MS PerkinElmer NeoBase Kit	156	146	93.59	2	1.28	8	5.13
	non-derivatized - MS/MS Guangzhou	41	32	78.05	2	4.88	7	17.07
C6	derivatized - MS/MS	74	45	60.81	9	12.16	20	27.03
	non-derivatized - MS/MS non-kit	27	20	74.07	5	18.52	2	7.41
	non-derivatized - MS/MS PerkinElmer NeoBase Kit	156	150	96.15	6	3.85	0	0.00
	non-derivatized - MS/MS Guangzhou	41	37	90.24	4	9.76	0	0.00
C8	derivatized - MS/MS	74	60	81.08	9	12.16	5	6.76
	non-derivatized - MS/MS non-kit	27	22	81.48	3	11.11	2	7.41
	non-derivatized - MS/MS PerkinElmer NeoBase Kit	156	153	98.08	2	1.28	1	0.64
	non-derivatized - MS/MS Guangzhou	41	40	97.56	1	2.44	0	0.00
C10	derivatized - MS/MS	74	51	68.92	10	13.51	13	17.57
	non-derivatized - MS/MS non-kit	27	24	88.89	3	11.11	0	0.00

Table 2. The analysis of EQA scores for measurement methods in each item (continued).

Item	Measurement system	No. of labs reporting five effective results	EQA score = 100 [a]		80 ≤ EQA score < 100		EQA score < 80	
			No. of labs	Proportion (%)	No. of labs	Proportion (%)	No. of labs	Proportion (%)
C10	non-derivatized - MS/MS PerkinElmer NeoBase Kit	156	150	96.15	6	3.85	0	0.00
	non-derivatized - MS/MS Guangzhou	41	39	95.12	2	4.88	0	0.00
C12	derivatized - MS/MS	72	54	75.00	8	11.11	10	13.89
	non-derivatized - MS/MS non-kit	27	20	74.07	4	14.81	3	11.11
	non-derivatized - MS/MS PerkinElmer NeoBase Kit	156	149	95.51	3	1.92	4	2.56
	non-derivatized - MS/MS Guangzhou	41	39	95.12	1	2.44	1	2.44
C14	derivatized - MS/MS	74	41	55.41	18	24.32	15	20.27
	non-derivatized - MS/MS non-kit	27	19	70.37	6	22.22	2	7.41
	non-derivatized - MS/MS PerkinElmer NeoBase Kit	156	138	88.46	8	5.13	10	6.41
	non-derivatized - MS/MS Guangzhou	41	27	65.85	4	9.76	10	24.39
C14 OH	derivatized - MS/MS	69	62	89.86	3	4.35	4	5.80
	non-derivatized - MS/MS non-kit	27	21	77.78	2	7.41	4	14.81
	non-derivatized - MS/MS PerkinElmer NeoBase Kit	121	118	97.52	2	1.65	1	0.83
	non-derivatized - MS/MS Guangzhou	40	39	97.50	0	0.00	1	2.50
C16	derivatized - MS/MS	73	69	94.52	2	2.74	2	2.74
	non-derivatized - MS/MS non-kit	27	25	92.59	2	7.41	0	0.00
	non-derivatized - MS/MS PerkinElmer NeoBase Kit	156	153	98.08	2	1.28	1	0.64
	non-derivatized - MS/MS guangzhou	41	40	97.56	1	2.44	0	0.00
C18	derivatized - MS/MS	73	69	94.52	3	4.11	1	1.37

Table 2. The analysis of EQA scores for measurement methods in each item (continued).

Item	Measurement system	No. of labs reporting five effective results	EQA score = 100 [a]		80 ≤ EQA score < 100		EQA score < 80	
			No. of labs	Proportion (%)	No. of labs	Proportion (%)	No. of labs	Proportion (%)
C18	non-derivatized - MS/MS non-kit	27	24	88.89	2	7.41	1	3.70
	non-derivatized - MS/MS PerkinElmer NeoBase Kit	156	154	98.72	1	0.64	1	0.64
	non-derivatized - MS/MS Guangzhou	41	40	97.56	0	0.00	1	2.44

[a] - 100 points was the full score. 20 points were assigned if the qualitative results of each item fell in the evaluation criterion above.

Table 3. Analysis of quantitative results.

Amino Acid and Acylcarnitine	Round	Number of laboratories	EQA scores = 100 [a]		80 ≤ scores < 100		EQA scores < 80	
			No. of labs	Proportion (%)	No. of labs	Proportion (%)	No. of labs	Proportion (%)
C0	1st	147	88	59.86	44	29.9	15	10.2
	2nd	146	92	63.01	39	26.7	15	10.3
C2	1st	147	49	33.33	81	55.1	17	11.6
	2nd	146	75	51.37	50	34.2	21	14.4
C3	1st	147	89	60.54	47	32	11	7.5
	2nd	147	71	48.30	56	38.1	20	13.6
C4	1st	147	81	55.10	59	40.1	7	4.8
	2nd	147	103	70.07	38	25.9	6	4
C4OH	1st	144	119	82.64	17	11.8	8	5.6
	2nd	144	131	90.97	9	6.3	4	2.7
C5	1st	147	109	74.15	32	21.8	6	4.1
	2nd	147	110	74.83	32	21.8	5	3.4
C5DC	1st	146	83	56.85	52	35.6	11	7.6
	2nd	146	100	68.49	40	27.4	6	4.1
C6	1st	147	122	82.99	17	11.6	8	5.4
	2nd	147	125	85.03	16	10.9	6	4.1
C8	1st	147	126	85.71	16	10.9	5	3.4
	2nd	147	121	82.31	21	14.3	5	3.4
C10	1st	147	89	60.54	53	36.1	5	3.4
	2nd	147	102	69.39	40	27.2	5	3.4
C12	1st	146	135	92.47	6	4.1	5	3.4
	2nd	146	135	92.47	6	4.1	5	3.4
C14	1st	140	133	95.00	2	1.4	5	3.6
	2nd	147	134	91.16	7	4.8	6	4
C14OH	1st	128	114	89.06	6	4.7	8	6.2
	2nd	127	118	92.91	3	2.4	6	4.7
C16	1st	147	92	62.59	47	32	8	5.4
	2nd	147	98	66.67	42	28.6	7	4.7
C18	1st	147	80	54.42	59	40.1	8	5.5
	2nd	147	109	74.15	32	21.8	6	4.1

[a] - 100 points was the full score. 20 points were assigned if the quantitative results of each item fell in the evaluation criterion above.

Table 4. The robust average of concentration and RCV of each item.

Item	The robust CV of 1st round (%)			The robust CV of 2nd round (%)		
	Low concentration (1.00 - 200 nmol/L)	Medium concentration (3.00 - 500 nmol/L)	High concentration (15.00 - 800 nmol/L)	Low concentration (1.00 - 200 nmol/L)	Medium concentration (3.00 - 500 nmol/L)	High concentration (15.00 - 800 nmol/L)
C0	8.76	8.84	9.11	8.63	9.58	7.87
C2	9.41	10.28	11.40	9.97	9.39	12.08
C3	8.02	11.50	10.08	9.42	7.85	8.21
C4	9.03	9.76	9.33	12.33	10.59	13.53
C4OH	10.13	9.86	9.81	9.96	8.99	9.12
C5	16.17	13.36	16.71	15.72	13.67	15.05
C5DC	11.88	13.96	15.51	10.80	11.83	13.67
C6	13.70	15.49	14.77	11.86	10.48	11.58
C8	8.18	9.14	8.49	7.46	7.75	6.22
C10	7.89	9.49	9.24	12.50	9.90	8.93
C12	10.39	13.59	8.62	11.35	8.84	11.96
C14	50.13	30.15	35.15	52.13	25.16	22.24
C14OH	24.81	23.14	28.02	19.61	18.86	18.56
C16	13.97	15.73	15.96	12.02	10.76	11.75
C18	8.01	11.95	9.67	8.12	10.30	7.86

acylcarnitine. For most items, the proportion of laboratories with satisfactory performance was higher in the second round than in the first round. The proportion of laboratories whose EQA scores were 100 points ranged from 65.8% (C14) to 97.3% (C18) in the first round, and 83.9% (C5) to 98.7% (C16) in the second round (see Table 1). The χ^2 test showed the overall acceptable rates differed significantly among different items ($p < 0.05$).

Table 2 shows that the different methods for each item were different in the proportions of participants with EQA scores of full marks, 80 points and < 80 points. For the group of non-derivatized-MS/MS PerkinElmer NeoBase Kit, the proportions of laboratories with satisfactory performance (≥ 80 points) ranged from 94.87% to 100%. For the group of derivatized-MS/MS, the proportions of laboratories with satisfactory performance (≥ 80 points) ranged from 72.97% to 100%. For the group of non-derivatized-MS/MS non-kit, the proportions of laboratories with satisfactory performance (≥ 80 points) ranged from 77.77% to 100%. For the group of non-derivatized-MS/MS Guangzhou, the proportions of laboratories with satisfactory performance (≥ 80 points) ranged from 75.61% to 100%. The χ^2 test showed significant differences in the overall acceptable rates and in the proportion of participants with satisfactory performance between the different measurement systems for each item ($p < 0.05$).

Results of quantitative assays

The quantitative results are summarized in Table 3. We compared the full-score ratio and unacceptable ratio of the expected clinical assessment for each item, regardless of the methods which laboratories use. The proportion of participant laboratories with a full mark ranged from 33.33% (C2, 1st round) to 92.47% (C14OH, 2nd round). The proportion of laboratories with unacceptable reports ranged from 2.70% (C4OH, 2nd round) to 14.40 % (C2, 2nd round). The χ^2 test showed the overall acceptable rates differed significantly among different items ($p < 0.05$).

Analysis of the robust CV

The RCV of different level EQA items were shown in Table 4. The range of RCV for C0, C2, C3, C4, C4OH, C5, C5DC, C6, C8, C10, C12, C14, C14OH, C16, and C18 was 7.87 - 9.58%, 9.39 - 12.08%, 7.85 - 11.5%, 9.03 - 13.53%, 8.99 - 10.13%, 13.36 - 16.71%, 10.8 - 15.51%, 10.48 - 15.49%, 6.22 - 9.14%, 7.89 - 12.50%, 8.62 - 13.59%, 18.56 - 28.02%, 22.24 - 52.13%, 10.76 - 15.96%, and 7.86 - 11.95%, respectively. The RCV on average of C14 was 32.65%, which was approximately twice as much as the average of RCV for other items. Meanwhile, the RCV of low concentration was higher than that of medium/high concentration for C14.

DISCUSSION

The EQA program plays an instrumental role in monitoring and promoting the performance of newborn screening by MS/MS for acylcarnitine. By 2018, all laboratories providing newborn screening by MS/MS for acylcarnitine in China had enrolled in this NCCL EQA scheme, although they volunteered to participate. In addition, it is the first time the results of the expected clinical assessment have been evaluated.

For qualitative evaluation, the evaluation criterion of 30% or ± given value for acylcarnitine was different from the criteria in the EQA schemes of other countries. This criterion was established according to the assessment of a great number of experts of laboratory medicine and clinical medicine for testing performance of newborn screening by MS/MS, conforming to the state-of-the-art of this project in China. Considering that acylcarnitine is easily degraded and EQA samples of low concentration might be close to the detection limit, the evaluation criterion was broad. The C14 acceptable rates were obviously lower than other acylcarnitines. The RCV of Arg was remarkably higher than other acylcarnitines, especially in the low concentration (1.27 μmol/L 1st, 1.55 μmol/L 2nd), the RCV was larger (50.13% 1st, 52.13% 2nd) than others. By comparing the acceptable rates of different measurement systems, we found that the group of non-derivatized-MS/MS non-kit and the group of derivatized-MS/MS is lower than the other two. The reason could be that the consistency of the results of tests which use the in-house reagents were poor. Therefore, the laboratories need to compare their results according to EP6 to ensure the comparability of the results.

For qualitative results, the laboratory assesses the expected clinical result based on its own reference range. If the result is out of the range, it is screened as positive. If it is in the range, it is screened as negative. Qualitative assessment in the EQA scheme only assesses whether the clinical assessment of the laboratory matches the expectation while the method is not taken into consideration. The expected clinical assessment reflects on the results of the laboratory and whether the reference range is appropriate. Our EQA results find that the acceptable performance rates of C0, C2, C3, C5DC, C8, C16, and C18 in the qualitative assessment are less than that of the quantitative assessment. Also, the acceptable performance rate of low concentration samples which are close to the cutoff are relatively low. Those laboratories whose acceptable performance was for quantitative assessment instead of qualitative assessment should be re-evaluated and validate their reference interval [7].

The EQA samples were blood spots with added acylcarnitine, so the uniformity and stability of spots should be comprehensively evaluated. The stability of EQA samples which had just been evaluated before distributed to each laboratory, but lacked evaluation of the transport process. In addition, the EQA program should add more clinical information such as gestational week, weight, and gender, in order to reasonably assess the expected clinical result. It is obvious that more effort should be made to overcome limitations.

CONCLUSION

The overall acceptable rates of quantification results for the 15 items were more than 80%, which means that most of quantification results satisfied the evaluation criterion, whereas for qualitative assessment, laboratories should re-evaluate and validate the reference intervals on a regular basis to improve the consistency of clinical assessment.

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Declaration of Interest:
The authors declare that they have no conflict of interest.

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