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## Original Article

## A survey of current use, dilemma and outlook of antenatal ultrasonography in Taiwan

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## ABSTRACT

**Objective:** According to World Health Organization's Jungner and Wilson criteria for competent screening programs, routine antenatal ultrasound screening is legit and effective to improve both maternal and perinatal outcomes. Health Promotion Administration, Ministry of Health and Welfare in Taiwan followed expert recommendations and started reimbursing one antenatal ultrasonography around mid-second trimester since 1995. However, medical disputes pertaining to examination results grew, while confusions challenged doctors and patients alike. The aim of this study is to assess current use of antenatal ultrasonography for low-risk pregnancies in Taiwan. Specifically, the indications, test frequencies, test items, methods of payment, obstetricians' opinions on important scan timing and areas to be improved are surveyed and analyzed. An overview of international antenatal ultrasound practice guidelines are examined and compared to enhance the quality of antenatal ultrasound screening in Taiwan.

**Materials and methods:** From December 2015 to December 2016, 925 questionnaires were distributed to all licensed obstetricians registered to Taiwan Association of Obstetrics and Gynecology as well as Taiwan Society of Perinatology. A 10-min self-reporting questionnaire was sent by mail, with stamped return envelopes included. Respondents remained entirely anonymous and disclosed no personal information. Data was collected and analyzed for statistical analysis.

**Results:** Most hospitals are well equipped with ultrasound machines of 3 or more functions. Eighty-eight percent of the obstetricians in Taiwan perform prenatal ultrasonography in every office visit for their patients, mostly free of charge. Scans at gestational age 15–22 weeks, <10 weeks, 11–14 weeks and 28–32 weeks are polled as the most importance in the order of significance. In general, they perceive the one-time antenatal scan offered by the Health Promotion Administration as for general obstetrics scan but not higher-leveled studies. Patient education and doctor-patient communications are opined as the 2 most important aspects to enhance antenatal ultrasound quality.

**Conclusion:** This report is the first of its kind in Taiwan. It could potentially serve as guidance for national health policy innovations in maternal and fetal care, such as increasing frequency of scans, specifications of scan timing, indications and consequences as well as patient education about this screening modality.

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## Introduction

Obstetrics ultrasounds have bloomed since Ian Donald reported the ever first fetal ultrasound images in 1958 in Lancet [1]. The now widely used brightness mode (B-mode) is introduced in the 1970s, when gray-scale two-dimensional projection of signals provides

safe and reliable pictures of fetuses [2]. Massive studies were conducted during the next decade to investigate the usefulness, safety and accuracy of ultrasonography scans in obstetrics. Among the most established practices include the determination of intra-uterine pregnancy using double-ring sign, early pregnancy milestones using mean gestational sac diameters, crown-rump length and fetal heart beat ... etc. Regression analysis was performed to lay out a growth chart that allows accurate pregnancy dating and growth rate monitoring. These are essential for improving pregnancy outcomes, for prompt detection of intrauterine growth restrictions may indicate early delivery, while macrosomia may lead

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to Cesarean sections [3]. These tests were so well established that they prevailed into modern obstetric practices, despite of later technology advances. Indeed, most updated international guidelines still recommend pregnancy ultrasonography examinations to determine intrauterine pregnancy, gestation dating, fetal number, chorionicity, fetal heart beats, amniotic fluid amount, fetal growth rate and placenta position. Many countries, such as Australia, Canada, Denmark, Finland, Japan, Switzerland, United Kingdom, the United States ... etc., have incorporated these practices in their maternal healthcare policies [4–12].

Taiwan has followed the expert recommendations. Since 1995, the Health Promotion Administration, Ministry of Health and Welfare funded one antenatal ultrasound screening around gestational age 20 weeks in all pregnant women. The policy has been welcomed by the people and highly utilized by obstetricians. However, after two decades of practice, problems emerged while people's expectations rose. Medical disputes regarding examination results or incongruent perception about test meanings between obstetricians and patients accumulated. A consensual test protocol or domestic practice guideline that defines test principles, measurement standards and interpretations is in dire need to minimize areas of potential misunderstanding. According to World Health Organization's (WHO) Wilson and Jungner's criteria that defines a sound screening test, the test has to address an important health problem, with widely available tools, standardized practices, quality assurance, readily available subsequent managements and cost-effectiveness [13]. Moreover, emerging screening criteria goes further and incorporated education, testing, informed choices, confidentiality and respect for autonomy over the past 40 years [14]. This should be the doctrine to follow when examining the current status and pitfalls of the antenatal sonography test in Taiwan.

The aim of the study is to first assess current antenatal ultrasonography use in Taiwan according to the WHO's screening test criteria and then to identify areas of improvement for better test satisfaction from the obstetricians' point of views. A 10-min questionnaire was designed and distributed to Obstetricians from all regions of Taiwan, addressing specifically how well equipped are their ultrasound machines, what functions on the sonography are used the most, what test content should be offered, the adequate times of test should be provided, and how test qualities should be assessed and improved. The results shall serve as a basis for guiding future policy making in maternal and fetal care. Hopefully in the long run, perception gap among patients and obstetricians would be minimized while maternal and fetal welfare maximized.

## Material and methods

From December 2015 to December 2016, 925 questionnaires were distributed by mail to all licensed obstetricians registered to Taiwan Association of Obstetrics and Gynecology as well as Taiwan Society of Perinatology, with stamped return envelopes included. To ensure the consistency of the questionnaire response, 10% of the samples were randomly selected for the respondents to repeat the survey. The validity of the questionnaire was further determined by professional statisticians. Respondents were ensured to remain anonymous throughout the process.

The 10-min questionnaire is self-reporting and contains five sections. Section one acquired respondents' demographic information, including gender, level of hospitals serviced and length of practice. Section two records respondents' ultrasound machine capacity, number and content of test items, training and licensure of the examiners, ranking of perceived importance of scans at various gestational ages. Section three asks how obstetricians use the one-time antenatal scan offered by National Health Insurance

and whether they see it sufficient to overall maternal care. Section four assesses obstetricians' opinions on how to raise the quality of antenatal ultrasound quality in terms of patient education, doctor-patient communications, technician skills, hardware and number of examinations. The last section of the questionnaire obtains information on pre-scan informed consent, who distributes them, content of the consent and suggestions to current antenatal ultrasound introduced in the Maternal Handbook.

After collecting the returned questionnaires, data is compiled for statistical analysis. Counts and percentages are presented to demonstrate current prenatal ultrasonography use in Taiwan, providers' opinions and suggestions to possible future improvement. Chi-square test is used to examine if levels of hospital make statistically significant difference as to participants' responses. The numbers are weighted for the number of patients cared at different levels of hospitals and areas to minimize confounders. As reported by the National Health Department in 2015, percentages of prenatal care provided were 14.2%, 23.6%, 25.8%, and 36.4% in the medical centers, regional hospitals, local hospitals and private clinics, respectively [15]. The questionnaire is entirely anonymous and no personal information is acquired. The respondents undertake no more, if at all, risks than the non-respondents. It thus qualifies for the exemption from Institutional Review Board (IRB) registration, as approved by the affiliated department in Kaohsiung Medical University Hospital.

## Results

Two hundred and ten out of 925 questionnaires are collected, accounting for 22.7% response rate. The demographic characteristics of the respondents are listed in Table 1. There are 147 (70%) male and 63 (30%) female obstetricians. In terms of level of hospital serviced, 35.2%, 26.2%, 22.9% and 15.2% of the respondents work in the private clinics, local hospitals, regional hospitals and medical centers, respectively.

The capability of ultrasonography machines (i.e. 2-dimensional, 3 dimensional, 4-dimensional and Doppler ultrasonography) equipped in different levels of hospitals are presented in Table 2. The majority of respondents have machines with 3 or more functions: 54% for the private clinics, 60% for the local hospitals and 75% for the medical centers. Only the regional hospitals have proportionally more 2-function machines (41.7%). At all levels of hospitals, 2D ultrasound is used the most, second by Doppler ultrasonography and then 3/4D ultrasounds. More 4D images are used than 3D images in private clinics and local hospitals. In contrast, more 3D images are used than 4D in regional hospitals and medical centers.

**Table 1**  
Demographic characteristics of obstetricians surveyed.

	Count (N)	Percentage (%)
Gender		
Male	147	70.0
Female	63	30.0
Level of medical affiliation		
Private clinics	74	35.2
Local hospital	55	26.2
Regional hospital	48	22.9
Medical center	32	15.2
Missing data	1	0.5
Duration of service		
≤ 5 years	18	8.6
6–10 years	27	12.9
11–15 years	32	15.2
16–20 years	38	18.1
≥ 21 years	95	45.2

**Table 2**  
Capability of ultrasonography machines in use.

	N (%) <sup>a</sup>	Private clinics	Local hospital	Regional hospital	Medical center	Adjusted <sup>b</sup>	P*
Numbers of functions equipped (2D, 3D, 4D, Doppler ultrasound)							0.030
1 function	29 (13.8)	14 (18.9)	7 (12.7)	5 (10.4)	3 (9.4)	14.0	
2 functions	59 (28.1)	20 (27.0)	14 (25.4)	20 (41.7)	5 (15.6)	28.4	
3 functions	46 (21.9)	18 (24.3)	16 (29.1)	8 (16.7)	4 (12.5)	22.1	
4 functions	75 (35.7)	22 (29.7)	17 (30.9)	15 (31.2)	20 (62.5)	35.0	
Missing	1 (0.5)	0 (0.0)	1 (1.8)	0 (0.0)	0 (0.0)	0.5	
Frequency of use for the various functions (Multiple choices)							
2 dimensional	210 (100.0)	74 (100.0)	55 (100.0)	48 (100.0)	32 (100.0)	100.0	1.000
3 dimensional	109 (52.2)	31 (41.9)	23 (42.6)	27 (56.2)	27 (84.4)	51.5	<0.001
4 dimensional	122 (58.4)	42 (56.8)	36 (66.7)	22 (45.8)	21 (65.6)	58.0	0.145
Doppler ultrasonography	142 (67.9)	49 (66.2)	37 (68.5)	30 (62.5)	25 (78.1)	67.6	0.517

\* P value obtained with Chi-square test.

<sup>a</sup> Unadjusted raw data obtained from questionnaire.<sup>b</sup> Number adjusted by number of patients receiving prenatal care (36.4%, 25.8%, 23.6% and 14.2% for private clinics, local hospital, regional hospital and medical centers, respectively).

The number and test items offered by obstetricians in their practice are listed in Table 3. Private clinics, local hospitals and regional hospitals are similar in providing 4 or less test items as the majority (63.5%, 60% and 60.4%, respectively). Medical centers stand out for performing 5 or more tests (81.2%,  $p < 0.001$ ). Near or over 90% of all hospitals provide early gestational scans, general obstetric scan and prenatal scans. Medical centers offer significantly more prenatal scans, fetal echocardiograms, level 2 scans and first-trimester Down syndrome screening ( $p = 0.004$ , 0.001, 0.011 and 0.002, respectively).

When obstetricians were asked when to do the one antenatal ultrasound reimbursed by the National Health Insurance, the responses are summarized in Table 4. At all levels of hospitals, it is mostly designated for regular obstetrics scan: 81.1% for the private clinics, 80% for the local hospitals, 89.6% for the regional hospitals and 90.6% for the medical centers. More than 80% of the respondents from all levels of hospitals think the one-time antenatal scan is insufficient for the overall maternal care. They are likely to perform ultrasound at every visit despite what level of hospitals serviced: 94.6% for the private clinics, 87.3% for the local hospitals, 83.3% for the regional hospitals and 81.3% for the medical centers. The reasons for additional tests are attributed to patient requests, routine practice and/or clinical indications without significant difference across different levels of hospitals ( $p = 0.832$ , 0.123 and 0.229, respectively).

Participants are asked to prioritize the timing of prenatal scans (Table 5). Overall speaking, the most important test timing is

between gestational age 15–22 weeks (55.7% importantly in need and 37.2% necessary), followed by gestational age less than 10 weeks (38.1% importantly in need and 50.4% necessary), and gestational ages 11–14 weeks (26.7% importantly in need and 43.3% necessary), 23–32 weeks (20.6% importantly in need, and 46.0% necessary), >37 weeks (17.1% importantly in need and 49.8% necessary) and finally 33–36 weeks (11.0% importantly in need and 55.3% necessary). The order of ranking is consistent across all levels of hospitals. Obstetricians from all levels of hospitals opined that patients knowledge (overall, 48.1%) and doctor-patient communications (overall, 43.4%) are the most important aspects to improve antenatal ultrasound test quality (Table 6). Different levels of hospitals have different rankings of “number of examinations,” “technician skills” and “hardware & equipment,” without specific patterns observed.

## Discussion

Maternal and fetal health has always been an important public health issue, across generations and nationalities. Ultrasound imaging technologies came in handy since the 1960s for detecting deleterious antenatal conditions. Both obstetricians and the impacted pregnant women were able to be prepared and managed timely. Its availability, affordability, non-invasiveness, effectiveness and ease to use mandated its role as the first-line diagnosing modality in most obstetric settings. The International Society of Ultrasound in Obstetrics and Gynecology (ISUOG) published a

**Table 3**  
Current prenatal ultrasonography examination items provided.

	N (%) <sup>a</sup>	Private clinics	Local hospital	Regional hospital	Medical center	Adjusted <sup>b</sup>	P*
Numbers of item provided							<0.001
≤2	15 (7.1)	3 (4.1)	8 (14.6)	4 (8.3)	0 (0.0)	7.2	
3	54 (25.7)	22 (29.7)	13 (23.6)	14 (29.2)	5 (15.6)	26.0	
4	50 (23.8)	22 (29.7)	12 (21.8)	15 (31.2)	1 (3.1)	24.2	
5	38 (18.1)	12 (16.2)	12 (21.8)	5 (10.3)	9 (28.1)	18.0	
6	50 (23.8)	13 (17.6)	9 (16.4)	10 (20.8)	17 (53.1)	23.1	
Missing	3 (1.4)	2 (2.7)	1 (1.8)	0 (0.0)	0 (0.0)	1.5	
Item (multiple choices)							
Early gestation scan	189 (91.3)	67 (93.1)	48 (88.9)	42 (87.5)	31 (96.9)	91.2	0.425
General obstetrics scan	20 (9.7)	71 (98.6)	52 (96.3)	45 (93.7)	32 (100.0)	97.0	0.313
Fetal echocardiography	63 (30.4)	14 (19.4)	16 (29.6)	13 (27.1)	19 (59.4)	29.5	0.001
Level 2 scan	106 (51.2)	33 (45.8)	25 (46.3)	22 (45.8)	25 (78.1)	50.5	0.011
1st trimester Down syndrome screening	110 (53.1)	40 (55.6)	23 (42.6)	20 (41.7)	26 (81.2)	52.6	0.002

\* P value obtained with Chi-square test.

<sup>a</sup> Unadjusted raw data obtained from questionnaire.<sup>b</sup> Number adjusted by number of patients receiving prenatal care (36.4%, 25.8%, 23.6% and 14.2% for private clinics, local hospital, regional hospital and medical centers, respectively).

**Table 4**

Current use of prenatal ultrasonography.

	N (%) <sup>a</sup>	Private clinics	Local hospital	Regional hospital	Medical center	Adjusted <sup>b</sup>	P*
The one exam reimbursed by National Health Insurance							
Item							0.395
Fetal heart beat and position	7 (3.3)	5 (6.8)	1 (1.8)	1 (2.1)	0 (0.0)	3.4	
Regular obstetric examination	176 (83.8)	60 (81.1)	44 (80.0)	43 (89.6)	29 (90.6)	84.2	
Level 2 scan	20 (9.6)	7 (9.4)	7 (12.7)	3 (6.2)	2 (6.2)	9.0	
Missing	7 (3.3)	2 (2.7)	3 (5.5)	1 (2.1)	1 (3.1)	3.3	
Sufficiency							0.035
No	187 (89.0)	68 (91.9)	45 (81.8)	42 (87.5)	31 (96.9)	89.0	
Yes	17 (8.1)	3 (4.0)	8 (14.6)	6 (12.5)	0 (0.0)	8.2	
Missing	6 (2.9)	3 (4.1)	2 (3.6)	0 (0.0)	1 (3.1)	2.9	
Ultrasonography exam on every visit							0.013
No	19 (9.0)	2 (2.7)	3 (5.5)	8 (16.7)	6 (18.7)	9.0	
Yes	185 (88.1)	70 (94.6)	48 (87.3)	40 (83.3)	26 (81.3)	88.2	
Missing	6 (2.9)	2 (2.7)	4 (7.3)	0 (0.0)	0 (0.0)	2.9	
Indications to additional exams (multiple choices if applicable)							
Patient's request	148 (72.2)	51 (70.8)	40 (76.9)	34 (70.8)	22 (68.7)	72.1	0.832
Routine	164 (80.0)	60 (83.3)	45 (86.5)	33 (68.7)	26 (81.2)	80.4	0.123
Clinical indication	136 (66.3)	42 (58.3)	37 (71.1)	32 (66.7)	24 (75.0)	66.0	0.299

\* P value obtained with Chi-square test.

<sup>a</sup> Unadjusted raw data obtained from questionnaire.<sup>b</sup> Number adjusted by number of patients receiving prenatal care (36.4%, 25.8%, 23.6% and 14.2% for private clinics, local hospital, regional hospital and medical centers, respectively).**Table 5**

Attitudes towards necessity for prenatal ultrasonography examinations at various gestational ages.

Gestational age	Unnecessary	Not really	Maybe	Necessary	Importantly in need	Missing	P*
Adjusted; n (%) <sup>a</sup>							<0.001
15–22 week	0.0	2.8	2.3	37.2	55.7	1.9	
<10 week	0.5	0.5	9.4	50.4	38.1	2.4	
11–14 week	1.4	4.7	15.8	43.3	26.7	8.1	
23–32 week	1.4	5.7	20.6	46.0	20.6	5.7	
>37 week	0.4	8.5	19.3	49.8	17.1	4.8	
33–36 week	1.9	6.1	22.8	55.3	11.0	2.9	
Private clinics; n (%) <sup>b</sup>							<0.001
15–22 week	0 (0.0)	0 (0.0)	0 (0.0)	35 (47.3)	37 (50.0)	2 (2.7)	
<10 week	0 (0.0)	0 (0.0)	5 (6.8)	37 (50.0)	30 (40.5)	2 (2.7)	
11–14 week	1 (1.4)	0 (0.0)	9 (12.2)	42 (56.8)	18 (24.3)	4 (5.4)	
23–32 week	1 (1.3)	4 (5.4)	13 (17.6)	39 (52.7)	15 (20.3)	2 (2.7)	
>37 week	0 (0.0)	5 (6.8)	14 (18.9)	40 (54.0)	13 (17.6)	2 (2.7)	
33–36 week	1 (1.3)	4 (5.4)	21 (28.4)	37 (50.0)	9 (12.2)	2 (2.7)	
Local hospital; n (%) <sup>b</sup>							0.001
15–22 week	0 (0.0)	2 (3.6)	4 (7.3)	18 (32.7)	30 (54.6)	1 (1.8)	
<10 week	0 (0.0)	1 (1.8)	5 (9.1)	25 (45.5)	22 (40.0)	2 (3.6)	
11–14 week	0 (0.0)	2 (3.6)	12 (21.8)	19 (34.6)	16 (29.1)	6 (10.9)	
23–32 week	0 (0.0)	1 (1.8)	11 (20.0)	25 (45.5)	12 (21.8)	6 (10.9)	
>37 week	0 (0.0)	5 (9.1)	9 (16.4)	27 (49.1)	11 (20.0)	3 (5.4)	
33–36 week	1 (1.8)	2 (3.6)	16 (29.1)	27 (49.1)	7 (12.7)	2 (3.6)	
Regional hospital; n (%) <sup>b</sup>							<0.001
15–22 week	0 (0.0)	3 (6.2)	0 (0.0)	18 (37.5)	26 (54.2)	1 (2.1)	
<10 week	1 (2.1)	0 (0.0)	3 (6.2)	29 (60.4)	14 (29.2)	1 (2.1)	
11–14 week	1 (2.1)	5 (10.4)	8 (16.7)	17 (35.4)	12 (25.0)	5 (10.4)	
23–32 week	1 (2.1)	4 (8.3)	12 (25.0)	19 (39.6)	10 (20.8)	2 (4.2)	
>37 week	0 (0.0)	3 (6.2)	14 (29.2)	22 (45.8)	5 (10.4)	4 (8.3)	
33–36 week	1 (2.1)	3 (6.2)	10 (20.8)	29 (60.4)	3 (6.2)	2 (4.2)	
Medical centers; n (%) <sup>b</sup>							<0.001
15–22 week	0 (0.0)	1 (3.1)	1 (3.1)	6 (18.8)	24 (75.0)	0 (0.0)	
<10 week	0 (0.0)	0 (0.0)	7 (21.9)	14 (43.7)	11 (43.4)	0 (0.0)	
11–14 week	1 (3.1)	3 (9.4)	4 (12.5)	12 (37.5)	10 (31.3)	2 (6.2)	
23–32 week	1 (3.1)	5 (15.6)	3 (9.4)	15 (46.9)	7 (21.9)	1 (3.1)	
>37 week	1 (3.1)	3 (9.4)	7 (21.9)	13 (40.6)	6 (18.8)	2 (6.2)	
33–36 week	1 (3.1)	4 (12.5)	0 (0.0)	23 (71.9)	4 (12.5)	0 (0.0)	

\* P value obtained with Chi-square test.

<sup>a</sup> Number adjusted by number of patients receiving prenatal care (36.4%, 25.8%, 23.6% and 14.2% for private clinics, local hospital, regional hospital and medical centers, respectively).<sup>b</sup> Unadjusted raw data obtained from questionnaire.

practice guideline for routine fetal ultrasound scans in 2010. It defined that machines capable of real time, gray-scale imaging, measuring, printing and storage are sufficient for routine antenatal examinations [4]. According to our survey results, ultrasound

machines are widely available in Taiwan with one-hundred percent of the participants utilizing two-dimensional functions regardless of levels of hospitals. Ninety-seven percent of them are capable of offering general obstetric scans (Tables 2 and 3). The

**Table 6**  
Attitudes towards raising ultrasonography examination quality in various aspects.

Aspects	Unnecessary	Not really	Maybe	Necessary	Importantly in need	Missing	P*
Adjusted; (%) <sup>a</sup>							<0.001
Patient knowledge	0.9	1.0	4.4	38.8	48.1	6.8	
Communication	0.9	0.5	6.7	42.2	43.4	6.3	
Technician skills	2.8	1.0	10.2	47.9	27.5	10.6	
Number of examinations	3.2	11.5	16.1	38.5	22.9	7.7	
Hardware & equipment	0.9	0.9	13.6	45.1	21.3	6.8	
Private clinics; n (%) <sup>b</sup>							<0.001
Patient knowledge	1 (1.3)	0 (0.0)	2 (2.7)	35 (47.3)	31 (41.6)	5 (6.8)	
Communication	1 (1.3)	0 (0.0)	7 (9.5)	33 (44.6)	28 (37.8)	5 (6.8)	
Number of examinations	1 (1.3)	7 (9.5)	12 (16.2)	32 (43.2)	17 (23.0)	5 (6.8)	
Technician skills	1 (1.3)	1 (1.3)	9 (12.2)	39 (52.7)	16 (21.6)	8 (10.8)	
Hardware & equipment	1 (1.3)	0 (0.0)	14 (18.9)	43 (58.1)	10 (13.5)	6 (8.1)	
Local hospital; n (%) <sup>b</sup>							0.001
Communication	1 (1.8)	0 (0.0)	2 (3.6)	22 (40.0)	25 (45.5)	5 (9.1)	
Patient knowledge	1 (1.8)	0 (0.0)	2 (3.6)	19 (34.5)	28 (37.8)	5 (9.1)	
Hardware & equipment	1 (1.8)	0 (0.0)	3 (5.5)	29 (52.7)	17 (30.9)	5 (9.1)	
Number of examinations	2 (3.6)	5 (9.1)	9 (16.4)	17 (30.9)	16 (29.1)	6 (10.9)	
Technician skills	2 (3.6)	0 (0.0)	5 (9.1)	24 (43.6)	14 (25.4)	10 (18.2)	
Regional hospital; n (%) <sup>b</sup>							0.053
Patient knowledge	0 (0.0)	2 (4.2)	5 (10.4)	15 (31.2)	22 (45.8)	4 (8.3)	
Communication	0 (0.0)	1 (2.1)	3 (6.2)	20 (41.7)	21 (43.8)	3 (6.2)	
Hardware & equipment	0 (0.0)	1 (2.1)	8 (16.7)	29 (52.7)	17 (30.9)	3 (6.2)	
Technician skills	1 (2.1)	1 (2.1)	6 (12.5)	23 (47.9)	13 (27.1)	4 (8.3)	
Number of examinations	1 (2.1)	7 (14.6)	5 (10.4)	21 (43.8)	9 (18.7)	5 (10.4)	
Medical center; n (%) <sup>b</sup>							<0.001
Patient knowledge	0 (0.0)	0 (0.0)	0 (0.0)	12 (37.5)	20 (62.5)	0 (0.0)	
Communication	0 (0.0)	0 (0.0)	2 (6.2)	13 (40.6)	17 (53.1)	0 (0.0)	
Technician skills	2 (6.2)	0 (0.0)	1 (3.1)	14 (43.7)	15 (46.9)	0 (0.0)	
Hardware & equipment	0 (0.0)	1 (3.1)	3 (9.4)	15 (46.9)	13 (40.6)	0 (0.0)	
Number of examinations	3 (9.4)	5 (15.6)	8 (25.0)	10 (31.2)	6 (18.7)	0 (0.0)	

\* P value obtained with Chi-square test.

<sup>a</sup> Number adjusted by number of patients receiving prenatal care (36.4%, 25.8%, 23.6% and 14.2% for private clinics, local hospital, regional hospital and medical centers, respectively).

<sup>b</sup> Unadjusted raw data obtained from questionnaire.

generalizability of equipment and skills makes universal prenatal ultrasound scans in Taiwan both feasible and practical.

In addition to availability, a sound screening project has to be fairly sensitive and specific in detecting a medical condition early in its natural course. Subsequent management should be effective to prevent or prolong disease progression. In 1990, Helsinki Ultrasound Trial established routine antenatal ultrasound screening's role in promoting maternal fetal welfare [16]. Ninety-five percent of all pregnancy women in Helsinki, Finland entered this study, with 9310 low-risk women randomly allocated for ultrasound screening between 16th–20th gestational weeks and a control group. Detection of fetal anomalies at this stage of pregnancy ensued subsequent termination of pregnancies. As a result, significantly lower perinatal mortality rate and fewer hospital visits resulted in the screened group. Moreover, all twin pregnancies were found before the 21st gestational week with significantly improved perinatal mortality rate [16]. The results of this trial is in concordance of earlier studies that demonstrated clinical diagnostic values in accurate gestation dating, differing rates of labor induction and length of hospital stays [17]. Indeed, textbooks and practice guidelines around the world have recommended for routine early ultrasound (<24 weeks gestation) with documentation of fetal cardiac activity, fetal presentation, amniotic fluid volume, placental position and fetal number to improve early detection of multiple gestations, gestational dating and fewer inductions for post maturity [12]. Melissa Whitworth's work, a Cochrane systematic review in 2014, reached similar conclusions [18].

Another commonly cited work pertaining to the effectiveness of routine antenatal ultrasound scans is the Routine Antenatal Diagnostic Imaging with Ultrasound (RADIUS) Study Group from the United States in 1993 [19]. The result of this randomized controlled

clinical trial of 15,151 pregnant women at low risk did not demonstrate reduced perinatal morbidity or mortality; nor were there significant differences in the rate of preterm delivery, distribution of birth weight, or outcomes in women with multiple gestations [19]. However, more than half of fetal anomalies detected in the study were beyond gestational age of 24 weeks, when legal abortion was not allowed in most states. Other women found with fetal anomalies before 24 weeks chose to continue their pregnancies. Moreover, women in the control group opted for abortion based on abnormal serum biomarkers. These factors have neglected the factors of early detection with early interventions; therefore attribute to the indifferent results of routine antenatal ultrasound screening. Indeed, Skupski's review article in 1995 has re-interpreted the results of RADIUS study and claimed the benefits of early detection of twin pregnancies and accurate gestational dating [20].

It is important to emphasize the difference between routine antenatal screening and specialized level-2 fetal anomaly scans. As Austria and Germany explicitly stated in their maternal care policy, the routine antenatal ultrasounds are basic level-1 tests [21]. Dr. Abuhamad agreed in his textbook that routine obstetric ultrasound is recommended to incorporate fetal cardiac activity, number of fetuses, amniotic fluid volume, localization of placenta, pregnancy dating and estimation of fetal weight [22]. He explained that these are the essential items to identify risk factors in pregnancy that require further planning for prenatal care and delivery. Structural anomalies do not constitute good screening items for a number of reasons. Fetal growth is an ongoing process and not all structural anomalies could be detected in limited number of antenatal scans. There is no robust evidence or consensus to recommend what anomalies to look for; nor are there sufficient test sensitivity and



specificity reported. Approximately 1 out of 100 pregnant women could expect to receive a false anomaly scan result according to an international statistics [21]. Even if detected, some anomalies may not impair the newborn's growth and development. There might not be readily available treatments for the conditions, both technically and economically. Some afflicted women might opt for continuing the pregnancy based on ethical or religious reasons [20,23]. Unnecessary psychological burden and unwarranted interventions are likely to result [23]. To cope, Germany specifically regulate scans that look for signs of congenital abnormalities with German Genetic Diagnostic Act. Doctors do not only carry out the scans and clarify related medical questions, they also provide genetic advice, psychological and social supports relevant to the scan results [21]. Clearly fetal anomaly scans is recommended to be precluded from the population-based screening items. Finding of structural anomalies that are preliminary, incidental or inconclusive should mandate higher level studies conducted by trained specialists. The results of our survey coincide with the expertise opinions in that over ninety percent of the antenatal scans provided were mainly basic obstetric items.

Scan frequency is another area to be investigated in designing antenatal ultrasound screening. The one-time scan offered by the Ministry of Health and Welfare in Taiwan is considered insufficient by obstetricians across all levels of hospitals. This result is not surprising after examining public health policies in other countries. Currently, one prenatal scan is offered in Denmark, Ireland, Malta, Taiwan and the United States, all during the second trimester to assess growth delay, amniotic fluid volume, and major malformations. Canada, Finland and Switzerland offered an addition scan in the first trimester for fetal number, viability, gestational dating and nuchal translucency [15,24,25]. Three scans are offered in Australia/New Zealand, Belgium, Croatia, France, Germany, Greece, Italy and Spain with the additional scan during the third trimester for fetal lie, growth assessment and placenta position for delivery planning [24,26]. Similar pattern is observed in the current study where obstetricians in Taiwan prioritize the importance of antenatal scans at various gestational ages (Table 5) consistently across all levels of hospitals: 15–22 week over <10 weeks scans, 11–14 week scans, 23–32 week scans and those in the third trimesters. This finding could serve as a guidance of specifying the timing for antenatal ultrasounds, both for the one already funded and potentially additional scans in the future.

On the opposite side of test frequency spectrum is the potential overuse of antenatal ultrasonography, as revealed in our survey. As revealed in Table 4, additional scans are performed for patient requests, routine practice and clinical indications across all levels of hospitals. Scans per patient requests and for routine practice are controversial. The principle of “as low as reasonably achievable (ALARA)” is repetitively claimed by expert committees in practice guidelines and systemic reviews [6,12]. US Food and Drug Administration explicitly unproved keepsake fetal videos in 2014 [27]. Cochrane systemic review in 2015 showed that routine ultrasound in late pregnancy does not affect neonatal morbidity or mortality [28]. American College of Radiology stated in 2016 that routine antenatal fetal surveillance by any imaging modality is not recommended in low-risk pregnancies [6]. The perception that fetal ultrasounds are safe is largely based on the fact that no causative harms are identified so far. Studies have demonstrated higher intrauterine growth restriction rates in patients receiving more ultrasounds [29]. Others found increased left-handedness in boys, implying subtle neurologic changes in the developing fetus [30]. The lesson is that antenatal ultrasounds should be limited to medical indications. This is perhaps also an area to work on in terms of patient education and doctor-patient communications.

In her article that revisits Wilson and Jungner's criteria for screening tests in the genomic age, Anne Andermann points out that education and program management should be incorporated into modern screening programs [14]. It is doubtless that quality tests require routine equipment maintenance, audit and feedback systems, adequate training or continued education for the test performers. However, it is patient education and thorough patient-doctor communication that could maximize test satisfaction and minimize medical disputes. There are limitations to all screening tests, and antenatal scans are no exceptions. The United Kingdom specifically informs their pregnant women that the 18–22 week scan would prepare parents for reproductive choice, possibility termination of pregnancy [8]. Parents are also educated that scan accuracy are affected by the type of fetal anomaly, the woman's body mass index and fetal position specifically in National Institute for Health and Clinical Excellence (NICE) guideline and UK National Screening Committee recommendations [8]. Not surprisingly, obstetricians in Taiwan opined it imperative to enhance “patient education” and “doctor-patient communications” as means to promote screening satisfaction rates (Table 6). Satisfaction could be achieved with better understanding of the test purpose, test items and limitations. Pre-test consent forms or information in Maternal Handbooks might be useful media. These are the potential areas for antenatal scan quality improvements, whether it is the number of scans provided or thorough patient educations about the scan.

Overall speaking, we presented the reality of current antenatal ultrasounds use with machine capability, number of scans provided, indications to additional scans, obstetricians' ranking of scan timing and areas needed for improvements. The results prove that a routine antenatal ultrasound is both feasible and beneficial but required areas of improvements: specifically a clearly defined test items, pre-test informed consent and relevant counselling for abnormal test results. The report serves as potential guidance for enhancing antenatal ultrasounds qualities, and hopefully a national health policy better promotes maternal and fetal wellbeing.

## Conflict of interest

The authors report no conflict of interest.

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## References

- [1] Donald I, MacVicar J, Brown TG. Investigation of abdominal masses by pulsed ultrasound. *Lancet* 1958 Jun;1(7032):1188–95.
- [2] Benson CB, Doubilet PM. The history of imaging in obstetrics. *Radiology* 2014 Nov;273(s Suppl.):S92–110.
- [3] Bennett KA, Crane JM, O'shea P, Lacelle J, Hutchens D, Copel JA. First trimester ultrasound screening is effective in reducing postterm labor induction rates: a randomized controlled trial. *Am J Obstet Gynecol* 2004 Apr;190(4):1077–81.
- [4] Salomon LJ, Alfrevic Z, Berghella V, Bilardo C, Hernandez-Andrade E, Johnsen SL, et al. ISUOG Clinical Standards Committee. Practice guidelines for performance of the routine mid-trimester fetal ultrasound scan. *Ultrasound Obstet Gynecol* 2011 Jan;37(1):116–26.
- [5] Committee on practice bulletins-obstetrics and the American Institute of ultrasound in medicine. Practice bulletin No.175: ultrasound in pregnancy. *Obstet Gynecol* 2016 Dec;128(6):e241–56.
- [6] Simpson L, Khati NJ, Deshmukh SP, Dudiak KM, Harisinghani MG, Heinrichsen TL, et al. ACR appropriateness criteria assessment of fetal wellbeing. *J Am Coll Radiol* 2016 Dec;13(12 Pt A):1483–93.

- [7] Minakami H, Maeda T, Fujii T, Hamada H, Iitsuka Y, Itakura A, et al. Guidelines for obstetrical practice in Japan: Japan society of obstetrics and gynecology (JSOG) and Japan association of obstetricians and gynecologists (JAOG) 2014 edition. *J Obstet Gynaecol Res* 2014 Jun;40(6):1469–99.
- [8] National Institute for Health and Care Excellence. Antenatal care for uncomplicated pregnancies. NICE Guideline; 2017 Jan. Updated, <https://www.nice.org.uk/guidance/cg62>. [Accessed 28 February 2018].
- [9] HGSA/RANZCOG Joint Committee of Prenatal Diagnosis and Screening. Prenatal assessment of fetal structural conditions. [https://www.ranzcog.edu.au/RANZCOG\\_SITE/media/RANZCOG-MEDIA/Women's%20Health/Statement%20and%20guidelines/Clinical-Obstetrics/Prenatal-assessment-of-fetal-structural-conditions-\(C-Obs-60\)-Amended-May-2016\\_1.pdf?ext=.pdf](https://www.ranzcog.edu.au/RANZCOG_SITE/media/RANZCOG-MEDIA/Women's%20Health/Statement%20and%20guidelines/Clinical-Obstetrics/Prenatal-assessment-of-fetal-structural-conditions-(C-Obs-60)-Amended-May-2016_1.pdf?ext=.pdf). [Accessed 28 February 2018].
- [10] Cargill Y, Morin. SOGC clinical practice guideline No. 223-Content of a complete routine second trimester obstetrical ultrasound examination and report. *J Obstet Gynaecol Can* 2017;39(8):e144–9.
- [11] World Health Organization. WHO recommendations on antenatal care for a positive pregnancy experience. Geneva, Switzerland: World Health Organization; 2016. <http://apps.who.int/iris/bitstream/10665/250796/1/9789241549912-eng.pdf?ua=1>. [Accessed 28 February 2018].
- [12] Dynamed. Prenatal ultrasound screening. Updated, <http://www.dynamed.com/resultlist?q=prenatal+ultrasound+screening&filter=all>. [Accessed 28 February 2018].
- [13] Harris R, Sawaya GF, Moyer VA, Calonge N. Reconsidering the criteria for evaluating proposed screening programs: reflections from 4 current and former members of the U.S. Preventive services task force. *Epidemiol Rev* 2011;33:20–35.
- [14] Andermann A, Blancaert I, Beauchamp S, Dery V. Revisiting Wilson and Jungner in the genomic age: a review of screening criteria over the past 40 years. *Bull World Health Organ* 2008 Apr;86(4):317–9.
- [15] Health promotion administration, ministry of health and welfare, R.O.C, Taiwan. In: 2016 health promotion administration annual report; 2016. <http://www.hpa.gov.tw/>. [Accessed 28 February 2018].
- [16] Saari-Kemppainen A, Karjalainen O, Rostalo P, Heinonen OP. Ultrasound screening and perinatal mortality: controlled trial of systematic one-stage screening in pregnancy. The Helsinki ultrasound Trial. *Lancet* 1990 Aug 18;336(8712):387–91.
- [17] Waldenström U, Axelsson O, Nilsson S, Eklund G, Fall O, Lindeberg S, et al. Effects of routine one-stage ultrasound screening in pregnancy: a randomized controlled trial. *Lancet* 1988 Sep 10;2(8611):585–8.
- [18] Whitworth M, Bricker L, Mullan C. Ultrasound for fetal assessment in early pregnancy. *Cochrane Database Syst Rev* 2015 Jul 14;(7):CD007058.
- [19] Ewigman GB, Crane JP, Frigoletto FD, LeFevre ML, Bain RP, McNellis D. Effect of prenatal ultrasound screening on perinatal outcome. RADIUS Study Group. *N Engl J Med* 1993 Sep 16;329(12):821–7.
- [20] Skupski DW, Chervenak FA, McCullough LB. Routine obstetric ultrasound. *Int J Gynaecol Obstet* 1995 Sep;50(3):233–42.
- [21] Informed Health Online. Cologne, Germany: Institute for Quality and Efficiency in Health Care (IQWiG); 2006-. Pregnancy and birth: ultrasound scans in pregnancy [Updated 2015 Mar 25], <https://www.ncbi.nlm.nih.gov/books/NBK343308/>. [Accessed 28 February 2018].
- [22] Abuhamad A, Walsh E. Stepwise standardized approach to the basic obstetric ultrasound examination in the second and third trimester. In: *Ultrasound in obstetrics and gynecology: a practical approach*. 1st ed. The Global Library of Women's Medicine; 2014. p. 186.
- [23] Harris G, Connor L, Bisits A, Higgingsbotham N. "Seeing the baby": pleasures and dilemmas of ultrasound technologies for primiparous Australian women. *Med Anthropol Q* 2004 Mar;18(1):23–47.
- [24] European surveillance of congenital anomalies (Eurocat). In: Special report: prenatal screening policies in Europe; 2010. <http://www.eurocat-network.eu/content/Special-Report-Prenatal-Screening-Policies.pdf>. [Accessed 28 February 2018].
- [25] B.C. Perinatal Health Program. BCPHP obstetric guideline 19: maternity care pathway. <http://www.perinatalservicesbc.ca/Documents/Guidelines-Standards/Maternal/MaternityCarePathway.pdf>. [Accessed 28 February 2018].
- [26] Kennedy P, Kodate N, editors. Maternity services and policy in an international context: risk, citizenship and welfare regimes. New York: Routledge; 2015.
- [27] United States Food & Drug Administration(USFDA). Center for Devices and Radiological Health (CDRH). CDRH consumer information: fetal keepsake videos. Updated, <https://www.fda.gov/forconsumers/consumerupdates/ucm095508.htm>. [Accessed 28 February 2018].
- [28] Bricker L, Medley N, Pratt JJ. Routine ultrasound in late pregnancy (after 24 weeks' gestation). *Cochrane Database Syst Rev* 2015 Jun;29(6):CD001451.
- [29] Newnham JP, Evans SF, Michael CA, Stanley FJ, Landau LI. Effects of frequent ultrasound during pregnancy: a randomized controlled trial. *Lancet* 1993 Oct;342(8876):887–91.
- [30] Kieler H, Axelsson O, Haglund B, Nilsson S, Salvesen KA. Routine ultrasound screening in pregnancy and the children's subsequent handedness. *Early Hum Dev* 1998 Jan;50(2):233–45.