REVIEW

Measuring informed choice in population-based reproductive genetic screening: a systematic review

Alice Grace Ames^{1,2}, Sylvia Ann Metcalfe^{*,1,2}, Alison Dalton Archibald^{1,2,3}, Rony Emily Duncan^{2,4,5} and Jon Emery⁶

Genetic screening and health-care guidelines recommend that programmes should facilitate informed choice. It is therefore important that accurate measures of informed choice are available to evaluate such programmes. This review synthesises and appraises measures used to evaluate informed choice in population-based genetic screening programmes for reproductive risk. Databases were searched for studies offering genetic screening for the purpose of establishing reproductive risk to an adult population sample, in which aspects of informed choice were measured. Studies were included if, at a minimum, measures of uptake of screening and knowledge were used. Searches identified 1462 citations and 76 studies were reviewed in full text; 34 studies met the inclusion criteria. Over 20 different measures of informed choice were used. Many measures lacked adequate validity and reliability data. This systematic review will inform future evaluation of informed choice in population genetic screening programmes.

European Journal of Human Genetics (2015) **23**, 8–21; doi:10.1038/ejhg.2014.89; published online 21 May 2014

INTRODUCTION

Population-based reproductive genetic screening programmes offer individuals and couples without a specific family history or predisposition the opportunity to learn if they have an increased risk of having a child with a particular genetic condition or conditions in current or future pregnancies. Developments in genetic health care are constantly evolving, with screening technology becoming publicly and privately available such as multiplex panels for carrier screening, whole exome/genome sequencing and noninvasive prenatal testing.

Genetic screening guidelines recommend that ethical and psychosocial aspects of screening programmes, such as informed choice,^{1–3} are evaluated in addition to technical aspects such as analytical and clinical validity.³ Screening decisions do not always have a clear medical imperative or benefit that outweighs the potential for psychological harms for the individual.⁴ Therefore, screening programmes should not directly encourage uptake of screening or influence reproductive decision making following a screen-positive result.⁵ The decision of whether to accept screening resides with the individual and it is therefore important that the decision is informed, based on correct knowledge and free of coercion from others.^{1,3,5} Thus, the success of population genetic screening programmes should not be based solely on the uptake of screening, and it is important to evaluate whether these programmes are in fact facilitating informed choice.²

Evaluation of genetic screening programmes requires accurate, validated measures of informed choice, which is a complex, multi-dimensional construct, defined in various ways throughout the literature.^{6–12} Informed choice may literally be measured through

evaluation of knowledge and uptake of screening, to indicate whether the decision to accept or decline screening was ‘informed’. However, definitions of informed choice more commonly involve at least two elements: having a factual understanding and making a choice aligned with one’s values.^{12,13} Some definitions distinguish between choice and decision making with the inclusion of deliberation and the behavioural implementation of the decision to reflect the cognitive processes involved in decision making.^{7,10} However, underlying these various definitions is the same concept of an informed and autonomous choice.^{13,14} The complexity of measuring informed choice, because of the different ways informed choice has been defined and measured in a range of screening settings, has been recognised.^{12,14–16}

Here we present the findings of a systematic review focussing on reproductive genetic screening in the general population, where screening was used to assess risk of a genetic condition in current or future pregnancies. A variety of conditions are included such as Down syndrome (DS) and single gene disorders. Screening choices in any of these scenarios can be complex, as individuals’ choices depend on the value they place on the benefits and harms of screening. Aspects of the condition also influence the way in which screening is offered, for example, screening a fetus for DS, a genetic but not usually inherited condition, is common and offered during each pregnancy in many countries. On the other hand, population genetic screening for carrier status, which provides an individual with reproductive risk, needs only to be performed once in a person’s lifetime and so can be offered anytime, including preconceptionally or during pregnancy.

Although there have been many studies evaluating population reproductive genetic screening, this review focusses on studies that

¹Genetics Education and Health Research, Murdoch Childrens Research Institute, Parkville, Victoria, Australia; ²Department of Paediatrics, The University of Melbourne, Melbourne, Victoria, Australia; ³Victorian Clinical Genetics Services, Melbourne, Victoria, Australia; ⁴Centre for Adolescent Health, Murdoch Childrens Research Institute, Parkville, Victoria, Australia; ⁵Health Services Delivery for Adolescents, Murdoch Childrens Research Institute, Parkville, Victoria, Australia; ⁶General Practice and Primary Care Academic Centre, University of Melbourne, Parkville, Victoria, Australia

*Correspondence: Professor SA Metcalfe, Genetics Education and Health Research, Murdoch Childrens Research Institute, Royal Children’s Hospital, Flemington Road, Parkville, Victoria 3052, Australia. Tel: +61 3 8341 6309; Fax: +61 3 8341 6212; E-mail: sylvia.metcalfe@mcri.edu.au

Received 3 December 2013; revised 11 March 2014; accepted 10 April 2014; published online 21 May 2014

specifically aimed to measure informed choice. This work will inform future research aiming to evaluate informed choice in genetic screening programmes. This systematic review investigates how informed choice has been measured in population reproductive genetic screening, what variables, methods and validation procedures have been used, and what rates of informed choice have been reported in these studies.

MATERIALS AND METHODS

Databases indexing medical and psychosocial research were searched for studies from the past 30 years (1982 to September 2012), addressing informed choice in population-based genetic carrier or DS screening. The search strategy was based on: (1) genetic screening, (2) measurement, and (3) informed choice. Search terms were defined using key words and thesaurus terms specific to Medline, Embase, Cochrane Library, CINAHL, and PsycInfo databases that were searched using this strategy (see Supplementary Table 1).

Inclusion criteria

Studies were included if they met the following criteria: original research during the past 30 years; published in English; adults or pregnant women from an unselected, population-based sample; the study needed to be in the context of offering a genetic test to determine reproductive risk; the study needed to have reported on measures of informed choice obtained prospectively at the time of test offer, including uptake of screening and knowledge as a minimum requirement to evaluate informed choice. Genetic testing is defined here according to the Foundation for Genomics and Population Health as: 'a test to detect the presence or absence of, or change in, a particular gene or chromosome'; the test did not need to have been a DNA or chromosomal assay, for example, it could be a full blood examination to identify thalassaemia carriers or ultrasound screening to identify markers for DS.¹⁷

Studies were excluded if they: were reviews, opinion or commentary, letters to the editor, guidelines, or used only qualitative methodology; used a hypothetical scenario; sampled selected subgroups of the population, such as those identified in high-risk categories through first-trimester screening for DS and trisomy 18, a group affected by, or with family history of, a genetic condition, or those undergoing preimplantation genetic diagnosis as part of *in vitro* fertilisation treatment; reported fetal anomaly scans, or other tests for structural anomalies without specifically reporting on risk of DS for the pregnancy. The cited references of the included papers were searched for additional relevant titles. Corresponding authors of the included papers and experts in the field were contacted for recommendations of any additional relevant papers.

RESULTS

The review of titles and abstracts was conducted by AGA, and JE confirmed the application of the exclusion criteria in 10% of papers (see Figure 1). During data extraction, eight papers were excluded either because they measured informed choice many months after test offer^{18,19} or did not report uptake of screening.^{20–25} In total, 34 articles met the inclusion criteria; data were extracted for 33 articles as two studies reported the same data on informed choice.^{26,27} The final inclusion of papers was confirmed by the authors JE and SAM.

Summary of studies

Of the 33 studies included in the review, less than half ($n = 11$) of the studies were randomised control trials (RCTs, Tables 1–4).^{11,13,26,28–35} Twenty-two studies were prospective,^{12,28,36–55} including cross-sectional,^{41,42,49} quasi-experimental,⁵³ pilot,⁵⁰ and longitudinal study designs.⁵² Of the RCTs, five involved an information or educational intervention,^{28,29,32–34} five randomised the screening offer,^{11,13,26,30,35} and there was one decision aid trial.³¹ The 33 studies were published between 1991,⁵⁴ and 2012,³⁶ with 25 studies published between 2002 and 2012. Three studies

used the same cohort as in previous studies,^{13,39,46} in subsequent studies the sample was stratified differently,⁴⁰ different measures were applied,¹¹ and additional validation data were reported.⁴⁵ Eight studies were conducted in continental Europe,^{11,13,38,43–46,53} and 14 were from the United Kingdom.^{12,26,29,30,32–35,37,39–41,51,54} Seven studies were from Australia,^{31,36,48–50,52,55} three from the United States,^{28,42,56} and one from Taiwan.⁴⁷ Prenatal screening for DS was the most common screening programme evaluated (27 studies).^{11–13,28,29,31–35,37–40,42–49,51–53,55,56} Three studies offering population carrier screening in prenatal settings included screening single gene disorders: sickle cell disease and thalassaemia (haemoglobinopathies (Hb))^{26,41} and cystic fibrosis (CF).³⁰ Of the 33 studies reviewed, only one included partners of the pregnant women,³⁰ and one offered CF carrier screening to men as well as women.⁵⁴ Only two studies offered carrier screening to a nonpregnant population, for CF⁵⁴ and fragile X syndrome (FXS).⁵⁰

Uptake of screening varied in the DS studies from 13%⁴⁴ to 91.6%.³⁸ Six DS studies reported 100% uptake;^{42,45–49} however, these studies only included women who had accepted screening as they were recruited at their screening consultation. High rates of screening uptake were reported for prenatal Hb screening in two studies (100%⁴¹ and 90.7%²⁶). Similar uptake rates were reported in CF carrier screening in a prenatal setting (89–91%³⁰) and a preconception setting (89%, family planning clinic site).⁵⁴ However, the two preconception screening studies (CF⁵⁴ and FXS)⁵⁰ reported that uptake varied with recruitment method and site.^{50,54} Studies reporting 100% uptake, however, should not be considered representative as they either only included individuals already having screening,⁴⁷ or recruited from a site where women were presenting for prenatal screening.^{42,45,46,48,49}

MEASURES OF INFORMED CHOICE

Knowledge

As determined by the inclusion criteria, all of the 33 studies measured and reported on knowledge, a core component of informed choice. The knowledge items used in these studies measured knowledge recall, although some studies also measured perceived knowledge^{47,56} and risk accuracy.⁵⁶ Throughout these studies the type and number of knowledge items varied, and knowledge levels were not generally comparable across studies. Two validated DS knowledge scales were used in more than one study; six studies used the scale developed by Marteau *et al*.^{12,31,39,40,49,52,55} and two studies used the scale by Dormandy *et al*.^{34,44,45} whereas the other DS studies each used their own specific knowledge scale. Studies screening for single gene disorders developed condition-specific knowledge scales for FXS,⁵⁰ Hb,^{26,41} and CF.^{30,54} Knowledge results were reported in different ways using means,^{11,12,29,32,34,36,38,40,41,51–53,55,56} medians,^{26,28,35,36} dichotomised cutoffs of good knowledge,^{11,13,26,31,36,39,43–46,49,55} categories,^{32,37,45,46,48,50} and percentage of items answered correctly.^{28,30,42,47,54}

OTHER MEASURES OF INFORMED CHOICE

Measures of informed choice other than knowledge were heterogeneous, involving a variety of different aspects such as perceptions of knowledge and information,^{32,37,43,49,56} the multidimensional measure of informed choice (MMIC),^{11–13,26,31,35,36,39–41,43–46,49,52} perceptions of choice,^{32,43,49,51,56} attitudes and feelings towards screening,^{30,43,47,50,56} decisional conflict,^{11,28,31,38,56} satisfaction and decisional regret,^{11,13,28,29,32} and systematic and informed decision making.^{29,42,51}

Figure 1 Flow diagram of systematic review search results. *All corresponding authors (30) and 3 experts were contacted. Of the 21 studies identified, 19 were from corresponding authors and 2 from experts. The four studies meeting inclusion criteria were identified by corresponding authors (two) and by experts (two).

Perceptions of knowledge and information

Two studies measured perception of knowledge,^{47,56} and five studies measured perception of the information provided.^{32,37,43,49,53} Measuring participants' perception of knowledge and information is another way of assessing the quality and level of information provided in a screening study. These measures directly asked how women felt about the information provided,⁵³ and if they were provided with enough information,⁴⁹ with the purpose to inform how to present information in a meaningful way to aid participants' understanding and facilitate informed choice. One study used a single item of perceived adequacy of information as their primary outcome measure, and showed that ~60% of participants in both trial arms reported that there was adequate information to make a choice about screening.³² Another study showed informed choice was dependent on a measure of the quality of the information provided ($P < 0.001$)⁴³ and that less satisfactory information was related to the perception of the screening being compulsory rather than optional.⁴³

Multidimensional measure of informed choice

The MMIC was the most widely used measure, and was used in 17 studies,^{11–13,26,31,35,36,39–41,43–46,49,52,55} with the majority ($n = 14$) assessing informed choice in prenatal screening for DS in the United Kingdom, continental Europe, and Australia

(Table 1).^{11–13,31,35,39,40,43–46,49,52,55} The MMIC was adapted for use in population carrier screening for Hb in pregnancy by using a specific knowledge scale for Hb,²⁶ and for low literacy populations,⁴¹ as well as for FXS carrier screening in a preconception setting (Table 3).^{36,50}

The MMIC is a theory-based measure, modelling the attitudes–behaviour domain on the Theory of Planned Behaviour.⁵⁷ The MMIC is based on the definition of informed choice being 'one that is based on relevant knowledge, consistent with the decision-maker's values and behaviourally implemented'.¹² Some of the studies in this review were published before the MMIC, and hence they did not use the same terminology for defining informed choice as the authors of the MMIC.^{29,30,33,34,51}

The MMIC combines knowledge with 'value-consistency' comprising attitudes and screening behaviour into a single measure. A choice is value consistent when an individual has positive attitudes and accepts screening or has negative attitudes and declines screening. A value consistent choice becomes an informed choice when made with good knowledge. All other combinations are classified as uninformed choices.

Each continuous knowledge and attitude scale is dichotomised into 'good'/'poor' knowledge and positive/negative attitudes for which there is no commonly agreed upon acceptable standard.

Table 1 Down syndrome screening studies measuring informed choice with the MMIC

Author; reference year; geographical location of study	Study type; data collection methods; other relevant measures	Participants ^a ; recruitment rate if reported (%); place of recruitment; screening test; screening procedure	Knowledge measure, theoretical basis; no. of items, score range; response options;				Knowledge results (mean (SD)/median (IQR)); good knowledge %; other	Informed choice (MMIC) %
			Uptake of screening validation; %	good knowledge cutoff;	other	other		
Dormandy <i>et al.</i> ³⁹ 2002; England	Prospective; self-report questionnaire	1499; 89%; general hospital; second-trimester MSS (double test); 'separate' screening on return visit at 15–16 weeks, 'routine' screening at 15–16 weeks with dating scan	49%		Marteau <i>et al.</i> ¹² Michie <i>et al.</i> ⁷¹ 8, 0–8; MCQ; $\alpha = 0.62$	NR; 61–76% ^b , <i>P</i> < 0.001	44–64% ^c	
Dormandy <i>et al.</i> ⁴⁰ 2005; UK	Prospective; self-report questionnaire	1499; 89%; general hospital; second-trimester MSS (double test); 'separate' screening on return visit at 15–16 weeks, 'routine' screening at 15–16 weeks with dating scan	49 (95% CI 47–52)		Marteau <i>et al.</i> ¹² Michie <i>et al.</i> ⁷¹ 8, 0–8; MCQ; $\alpha = 0.62$	Mean = 5.3; NR	20–56% and 45– 59% ^d	
Dormandy <i>et al.</i> ³⁵ 2006; UK	Cluster randomised control trial; self-report questionnaire	982; 76%; general hospital; second-trimester MSS (triple test); 'combined' screening at 15–16 weeks with routine bloods, screening at 'separate' (optional) visit at 15–16 weeks	42.7– 45.2% ^e		Marteau <i>et al.</i> ¹² Michie <i>et al.</i> ⁷¹ 10, 0–10; MCQ; median, score > 5; $\alpha = 0.65$	Median = 6.0 (5–8) 6.0 (4–7) ^f ; 55.6–59.2% ^g	43.5%	
Favre <i>et al.</i> ⁴³ 2008; France	Prospective; self-report questionnaire; in favour of having the test; quality of information and consultation	not reported; ultrasound and prenatal diagnosis departments in hospital maternity units; first-trimester ultrasound, second-trimester MSS	74%		Michie <i>et al.</i> ⁷¹ GMC, ⁷² 10, 0–20; T/F; median, score > 10; piloted before the study	NR; 227/305 (74.4)	44.59%	
Fransen <i>et al.</i> ⁴⁴ 2010; The Netherlands	Prospective; structured interview	271; unknown number approached; community midwifery clinics, hospital outpatient clinic; first-trimester combined screening; NR	26%		Marteau <i>et al.</i> ¹² van den Berg <i>et al.</i> ¹³ 21, 0–21; T/F/U; score ≥ 15 (guess corrected midpoint); NR	NR; 115 (44)	36%	
Gourounti <i>et al.</i> ⁴⁶ 2008; Greece	Prospective; self-report questionnaire	135; 93% (90% response rate); public hospital; first- and/or second-trimester NTM and MSS (double or triple test); screening at separate visit	100% ^h		Michie <i>et al.</i> ⁷¹ Dormandy <i>et al.</i> ³⁵ translated into Greek; 10, 0–10; MCQ; median, score > 5; $\alpha = 0.64$	NR; 45	44%	
Gourounti <i>et al.</i> ⁴⁵ 2011; Greece	Prospective; self-report questionnaire; uncertainty about the choice (one item)	135; 93% (90% response rate); public hospital; first- and/or second-trimester NTM and MSS (double or triple test); screening at separate visit	100% ^h		Michie <i>et al.</i> ⁷¹ Dormandy <i>et al.</i> ³⁵ translated into Greek; 10, 0–10; MCQ; median, score > 5; $\alpha = 0.65$, forward/back translations, piloted questionnaire	NR; 46	44%	
Jacques <i>et al.</i> ⁴⁹ 2005; Australia	Cross-sectional; self-report questionnaire; perception of choice and information	202 (Q1); 202/219 (92%); obstetric and gynaecological ultrasound practices; first-trimester combined screening or ultrasound only; NR	100% ^h		Marteau <i>et al.</i> ¹² Michie <i>et al.</i> ⁷¹ 8, 0–8; MCQ; median, score > 4; measures of perception of choice and information	NR; pre-test: 112, 68.7% Post-test: 122, 74.8%	74.5%	
Marteau <i>et al.</i> ¹² 2001; England	Prospective; questionnaire and validation interview	42; not reported; hospital; second-trimester prenatal screening; screening offer at 12 weeks	76%		GMC, ⁷² Smith <i>et al.</i> ²⁴ Marteau <i>et al.</i> ⁷³ focus groups; 8, 0–8; MCQ; median, score > 4; piloted, $\alpha = 0.82$, construct validity	Mean = 4.5 (SD 2.5, 43% range = 0–8); NR	43%	

Table 1 (Continued)

Author; reference year; geographical location of study	Study type; data collection methods; other relevant measures	Participants; recruitment rate if reported (%); place of recruitment; screening test; screening procedure	Uptake of screening validation; % other	Knowledge measure, theoretical basis; no. of items, score range; response options; good knowledge cutoff; good knowledge %; other	Knowledge results (mean (SD)/median (IQR)); informed choice (MMIC) %
Nagle <i>et al.</i> ³¹ 2008; Australia	Cluster randomised control trial; self-report questionnaire; decisional conflict scale	338; 338/467 (response rate); primary care; all prenatal screening (first and second trimester combined); NR	85–87% ⁱ	Marteau <i>et al.</i> ¹² Michie <i>et al.</i> ⁷¹ 8, 0–8; MCQ; median, score >4; NR	NR; 72–88% ^k 65–76% ^l
Rowe <i>et al.</i> ⁵² 2006; Australia	Prospective, longitudinal study; self-report questionnaire	134 (Q1); 134/184; antenatal clinics (in-hospital, outreach, primary care, birth centre); second-trimester MSS; NR	62.40%	Marteau <i>et al.</i> ¹² Michie <i>et al.</i> ⁷¹ 8, 0–8; MCQ; median, score >4; $\alpha = 0.62$	Mean = 4.4 (2.0); 48.1% 37.30%
van den Berg <i>et al.</i> ¹³ 2005; The Netherlands	Randomised control trial; self-report questionnaire; decisional conflict scale, satisfaction with decision	1159; 1159/4076; midwifery and gynaecology practices; first-trimester NTM and second-trimester MSS (triple test); intervention 1: NTM offer, intervention 2: MSS offer, control group: no screening offer	44%	Information booklet; 17 (7 NTM items, 10 MSS items), 0–17; Y/N; guess corrected midpoint (Abbott's blind guessing formula), >4/7 NTM items and >6/10 MSS items; NR	NR; 83% (n = 957) 68%
van den Berg <i>et al.</i> ¹¹ 2006; The Netherlands	Randomised control trial; self-report questionnaire; deliberation (informed decision making)	962; 1330/4076; midwifery and gynaecology practices; first-trimester NTM and second-trimester MSS (triple test); intervention 1: NTM offer, intervention 2: MSS offer, control group: no screening offer	46%	Information booklet; 7, 0–7; Y/N; guess corrected midpoint (Abbott's blind guessing formula), score >5; NR	Mean = 6.4 (0.9), 84% (N = 804) 51% ^m
Wynter <i>et al.</i> ⁵⁵ 2011; Australia	Prospective; self-report questionnaire	165; 165/194 (85.1%); hospital young mothers; second-trimester MSS; NR	63.9%	Marteau <i>et al.</i> ¹² Michie <i>et al.</i> ⁷¹ 8, 0–8; MCQ; median, score >4; $\alpha = 0.68$ (Michie <i>et al.</i> ⁷¹)	Mean = 2.1 (2.0); 12.2% (20/164) 9.7%

Abbreviations: IQR, interquartile range; MCQ, multiple choice questions; MMIC, multidimensional measure of informed choice; MSS, maternal serum screening; NR, not reported; NTM, nuchal translucency ultrasound measurement; T/F, true/false response options; T/F/U, true/false/unsure response options; Y/N, yes/no items.

MMIC measuring knowledge, attitudes, and uptake of screening. Informed choice is 'good' knowledge and positive attitudes and accepted screening, or 'good' knowledge and negative attitudes and declined screening.

MSS: more details provided if specified in article.

Triple test: α -fetoprotein and β -human chorionic gonadotrophin.

First-trimester combined screening: MSS and NTM.

^aParticipants, n = valid number of questionnaires.

^bSeparate visit, 61%; combined, 76%, $P < 0.001$.

^cSeparate screening group (44%) and routine screening group (64%).

^dSouth Asian women (20%), white women (56%), disadvantaged women (45%), and socioeconomically advantaged women (59%).

^e'Combined' group (42.7%) and 'separate' group (45.2%).

^fCombined = 6.0 (5–8), separate 6.0 (4–7).

^gCombined = 59.2, separate = 55.6.

^hStudies recruiting women who had accepted screening.

ⁱComparing scores from interview; mean knowledge score: of good knowledge = 5.8 (SD 1.8, $n = 20$) of poor knowledge = 4.4 (SD 1.5) ($t(1.31) = 2.4$, $P = 0.023$).

^jControl (85%) and intervention (87%).

^kControl group (72%) and intervention group (88%), difference between groups (adjusted OR 3.43; 95% CI, 1.79–6.58).

^lControl (65%) and intervention (76%), difference = adjusted OR 2.08; 95% CI, 1.4–3.81.

^mInformed decision making.

Table 2 Down syndrome screening studies using measures of informed choice (other than the MMIC)

Author; reference year; geographical location of study	Study type; data collection methods; measures of informed choice	Participants; recruitment rate if reported (%); place of recruitment; screening test; screening procedure	Uptake of screening %	Knowledge measure, theoretical basis; number of items, score range; response options; good knowledge cutoff; validation; other	Knowledge results (mean (SD)/median (IQR)); good knowledge %; other informed choice measures
Chilaka <i>et al.</i> ³⁷ 2001; England	Prospective; self-report questionnaire; knowledge, perception of quality of knowledge	245; 82%; hospital; second-trimester MSS (double test); separate screening appointment	47%	NR; NR, 1–3; open-ended; 3 = good ^b ; NR; measures baseline and perceived knowledge	NR; 33%; 54% perceived information provided as useful; good knowledge 33%, fair knowledge 31%, poor knowledge 36%
Dahl <i>et al.</i> ³⁸ 2011; Denmark	Prospective; self-report questionnaire; knowledge, decisional conflict scale	4111; 64%; hospital; first-trimester combined screening ^c , and second-trimester ultrasound;	91.6%	Dahl <i>et al.</i> ²⁰ 15, 0–15; MCQ; NR; face and content validity, construct validity ^d	Mean = 8.6 (2.46); NR; NR
Farrell <i>et al.</i> ⁴² 2011; USA	Cross-sectional study; self-report questionnaire; knowledge, importance of decision-making factors	NR 139; 139/154 (response rate); ultrasound clinic; first-trimester screening (NTM and serum markers); NR	100% ^e	ACOG ⁷⁴ and interviews by Farrell <i>et al.</i> ⁷⁵ NR, NR; MCQ and Y/N; NR; piloted	NR; NR; 77–79.6% understood the cause of Down syndrome, 92.8% understood role of a screening test (vs diagnostic test)
Graham <i>et al.</i> ³³ 2000; Scotland	Randomised controlled trial; self-report questionnaire; knowledge	875 (baseline); 875/1050 (eligible participants); antenatal clinics at university teaching hospital; second-trimester screening including ultrasound scan at booking, serum screening, detailed anomaly scan, amniocentesis, and CVS;	'Less than 1% of parti- cipants had no test'	Miedzybrozka <i>et al.</i> ³⁰ Marteau <i>et al.</i> ⁷³ 14, 0–14; MCQ; NR; NR	NR; NR; 'High baseline knowledge of purpose of tests except for knowledge about CVS'
Hewison <i>et al.</i> ³⁴ 2001; England	Randomised controlled trial; self-report questionnaire; knowledge	NR 779; 779/1051 (response rate); maternity hospital, antenatal clinic; second-trimester MSS (triple test); return appointment for screening	64.2–64.7% ^f	Smith <i>et al.</i> ²⁴ Thornton <i>et al.</i> ⁷⁶ 12, 0–12; MCQ; NR; NR	Mean = 7.3 (2.4, intervention), 6.7 (2.6, control), small diff ($t = 3.24$, $P = 0.0005$); NR
Hwa <i>et al.</i> ⁴⁷ 2010; Taiwan	Prospective; researcher administered	193; 193/220; medical centre;	100% ^e	Marteau <i>et al.</i> ⁷³ Smith <i>et al.</i> ²⁴ Thornton <i>et al.</i> ⁷⁶ Priest <i>et al.</i> ⁷⁷ 14 (7 recall, 7 perceived), NR;	NR; NR; percentage correct items 69.7% (intervention), 64.6% (control), $P = 0.048$

Table 2 (Continued)

Author; reference year; geographical location of study	Study type; data collection methods; measures of informed choice	Participants ^a ; recruitment rate if reported (%); place of recruitment; screening test; screening procedure	Uptake of screening %	Knowledge measure, theoretical basis;			
				number of items, score range; response options; good knowledge cutoff; validation; other	Knowledge results (mean (SD)/median (IQR)); good knowledge %; other informed choice measures		
Jaques <i>et al.</i> ⁴⁸ 2004; Australia	Prospective; self-report questionnaire; knowledge	second-trimester MSS (triple test) and ultrasound; screening at same appointment	100% ^e	MCQ, perceived knowledge; 'quite well', 'somewhat', 'barely or not at all'; NR; NR; NR; 1; open-ended ^f ; whether women mentioned Down syndrome, trisomy, and/or chromosomal abnormality for prenatal screening and diagnosis; NR; NR	NR; NR; 61.3% mentioned Down syndrome		
		432; 432/461 (response rate); hospitals, rural and metropolitan; any NTM, second trimester MSS, CVS or amniocentesis; NR					
Kuppermann <i>et al.</i> ⁵⁶ 2006; USA	Prospective; self-report questionnaire, or researcher administered oral questionnaire; knowledge of Down syndrome and testing outcome, testing awareness (perceived knowledge, decision uncertainty), attitudes (value of testing, faith and fatalism, health-care system distrust)	819; 1065/1668; clinics and practices; any prenatal screening and testing use; NR	84.6–88.2% ^h	NR; NR; 3, 0–6, perceived risk ⁱ , 2 items, 0 (no risk)—1 (very high risk); NR; NR	Mean (SE) = 3.7 (0.1) (aged <35) 4.5 (0.1) (aged >35); NR; NR; per- ceived DS-affected fetus risk = 0.2 (0.01), perceived procedure-related miscarriage = 0.4 (0.01); decision uncertainty 3.1 (0.1) 3.3 (0.1), perceived understanding 5.1 (0.1) 5.9 (0.1) ^j		
		496 (T1); 54% (588/1080) (consented to participate); university hospitals and medical centres, obstetrics clinics; any prenatal screening and testing use; NR					
Kuppermann <i>et al.</i> ²⁸ 2009; USA	Randomised control trial; researcher administered questionnaire; knowledge, decisional conflict scale, decisional regret scale, satisfaction with decision-making involvement	720 (Q1); 1332 (approached); teaching hospital antenatal clinic;	81%	Goel <i>et al.</i> ²² literature review, focus groups; 10, NR; 5-point Likert scale; NR; piloted	Median (range, group) = 70 (0–100, control) 80.0 (10–100, intervention); NR; percent items correct 64.7 (con- trol) 79.5 (intervention), Cohen's $d = 0.73$, $P < 0.001$; mean decisio- nal conflict score within normal range 1–2 weeks after screening (interven- tion: 19.1 (0–56.9), control: 20.9 (0–71.6), $P = 0.21$ Mean = 8.8 (2.0)—9.0 (2.0); decision-making score, range 0–17, higher scores are more systematic; mean = 4.4 (3.7)—4.8 (3.6) ^k		
Michie <i>et al.</i> ²⁹ 1997; England	Randomised control trial; self-report questionnaire; knowledge, decision-making process, satisfaction with decision making			NR; 11, 0–11; MCQ;			

Table 2 (Continued)

Author; reference year; geographical location of study	Study type; data collection methods; measures of informed choice	Participants ^a ; recruitment rate if reported (%); place of recruitment; screening test; screening procedure	Uptake of screening %	Knowledge measure, theoretical basis:		
				number of items, score range; response options; good knowledge cutoff; validation; other	Knowledge results (mean (SD)/median (IQR)); good knowledge %; other informed choice measures	
Michie <i>et al.</i> ⁵¹ 1999; England	Prospective; self-report questionnaire; knowledge, systematic decision-making scale	second-trimester MSS; NR	81%	NR; $\alpha = 0.71$ Smith <i>et al.</i> ²⁴ 11, 0–11; MCQ; NR; $\alpha = 0.71$;	Mean = 7.9 (2.2)—8.5 (2.5) ¹ ; systematic decision-making mean score: screened: 4.3 (3.5), no screening: 5.7 (3.7)	
		not reported; antenatal clinic, teaching hospital; second-trimester MSS; NR		Information provided; 10, 0–10; NR; NR; NR		
O' Cathain <i>et al.</i> ³² 2002; Wales	Cluster randomised control trial; self-report questionnaire; knowledge, perceived adequacy of information, satisfaction with infor- mation and how choices were made, sufficient discussion with health pro- fessionals, women's preferences for involvement in decision-making	6452; 6452/10 070 (eligible); maternity units; any prenatal screening tests for Down syndrome; NR	79% ^m		Mean = 3.35 (1.61) 3.99 (1.57) ⁿ ; 56–58% of the control groups and 58–59% of intervention groups had enough information	
Stefansdottir <i>et al.</i> ⁵³ 2010; Iceland	Quasi-experimental; self-report questionnaire; knowledge, information preferences	379; 379/400 (response rate); prenatal clinics, city, and rural areas; first-trimester combined screening ^o ; NR	64–68% ^p	NR; 4, 0–8; Y/N and open-ended; NR; NR	Mean = 4.1, (control = 3.7 (n = 237), intervention = 4.8 (n = 142), $P < 0.001$	

Abbreviations: CVS, chorionic villus sampling; MSS, maternal serum screening; NR, not reported; NTM, nuchal translucency ultrasound measurement.

MSS: more details provided if specified in article.

Double test: α -fetoprotein and free β -human chorionic gonadotrophin.

Triple test: oestrol, β -human chorionic gonadotrophin, and α -fetoprotein levels.

^aParticipants, n = valid number of questionnaires.

^bGood knowledge classified if participants understood 'the condition was known to be a chromosomal abnormality associated with significant mental disability and structural abnormalities', score range: -1 = misinformed, 0 = poor, 2 = fair, 3 = good knowledge.

^cDown syndrome combined risk assessment: MSS (double test), age, and NTM.

^dFace and content validity: items evaluated by obs + gyn consultants, scores approached normal distribution, construct validity: item characteristic curves of probabilities of a correct answer according to the knowledge score for each item.

^eStudies recruiting women who had accepted screening.

^fIntervention (64.2) and control (64.7).

^gContent coding of open-ended questions: 'mentioned Down syndrome' = any response mentioning the terms above 'did not mention Down syndrome' = 'comments such as 'everything was fine', 'any abnormality in the baby', or made general comments about the baby being fine or healthy'.

^hAge < 35 years (84.6) and age > 35 years (88.2).

ⁱPerceived risk (10 cm visual analogue scale, from 'no risk' to 'very high risk').

^jDecision uncertainty 3.1 (0.1, aged > 35 years) and 3.3 (0.1, aged < 35 years), range 1–7; perceived understanding 5.1 (0.1, aged < 35 years) and 5.9 (0.1, aged > 35 years).

^kWhere intervention groups 1, simple information leaflet; 2, information leaflet with decision tree; 3, simple information leaflet and video; 4, information leaflet with decision tree and video. Mean knowledge scores (SD): 1, 9.0 (2.0); 2, 8.8 (2.0); 3, 8.8 (2.0); 4, 9.0 (1.9). Mean decision-making scores (SD), range 0–17, higher scores are more systematic: 1, 4.8 (3.6); 2, 4.4 (3.7); 3, 4.6 (3.4); 4, 4.5 (3.5).

^lNot screened: 7.9 (2.5) and screened: 8.5 (2.2).

^mUptake, control group: TO = 70, T1 = 79; intervention group: TO = 84, T1 = 79.

ⁿMean knowledge scores (TO, T1): intervention group (TO, T1): antenatal, 3.74 (1.43), 3.99 (1.75), prenatal, 3.3 (1.65), 3.53 (1.64). Control group (TO, T1): antenatal, 3.79 (1.52), 3.79 (1.52), postnatal, 3.37 (1.62), 3.35 (1.61).

^oFirst-trimester combined screening: NTM, MSS for free β -human chorionic gonadotrophin, and pregnancy-associated plasma protein A.

^p64 (control) and 68 (intervention).

Table 3 Population carrier screening studies measuring informed choice with the MMIC

Author; reference year; geographical location of study; condition screened	Study type; data collection methods	Participants ^a ; recruitment rate if reported (%); place of recruitment; screening test; screening procedure	Uptake of screening %	Knowledge measure, theoretical basis; number of items; score range; response options; good knowledge cutoff; validation; other	Knowledge results (mean (SD)/median (IQR)); good knowledge %; other	Informed choice (MMIC) %
Ames <i>et al.</i> ³⁶ 2012; Australia; fragile X syndrome	Prospective; self-report questionnaire	241; 285/309 (92%); family planning clinic, preconception screening; blood test; return visit	11%	Metcalfe <i>et al.</i> ⁵⁰ Delphi, focus groups; 9, 0–9; T/F/U; score > 6/9; $\alpha = 0.70$, construct validity (modified Delphi, factor analysis)	Mean = 6.6 (2.0), median = 7 (5–8); 71%	27%
Brown <i>et al.</i> ²⁶ 2011 and Dormandy <i>et al.</i> ²⁷ 2010; UK; sickle cell and thalassaemia	Partial factorial cluster randomised control trial; self-report questionnaire	464; 68%; primary care, prenatal screening; blood test; (i) primary care parallel, (ii) primary care sequential, (iii) secondary sequential ^b	90.7%	GMC, ⁶⁸ Dormandy; ⁴¹ 10, 0–10, MCQ; score > 5; $\alpha = 0.66$	Median = 4 (3–6); 34.7%	30.6%
Dormandy <i>et al.</i> ⁴¹ 2007; UK; sickle cell and thalassaemia	Cross-sectional study; self-report questionnaire, semistructured interview	79; 90%; antenatal clinic; NR; NR	100%	Houts <i>et al.</i> ^{78,79} guidelines; ⁸⁰ 12, 0–12; pictorial (simplified questions), MCQ; sample median, score > 5; $\alpha = 0.79$ (simplified), 0.80 (standard)	Mean = 4.9 (3.2, simplified) 5.3 (3.2, standard) diff $t = 3.3$, $P = 0.001$, NR difference –11 to +19%	51% (standard measure), 54% (simplified measure, 95% CI difference –11 to +19%)

MMIC: multidimensional measure of informed choice, measuring knowledge, attitudes, and uptake of screening; Informed choice = 'good' knowledge and positive attitudes and accepted screening.

^aParticipants, n = valid number of questionnaires.^b(i) Primary care parallel: screening offered to woman and baby's father at first pregnancy confirmation in primary care; (ii) Primary care sequential: screening offered to woman at first pregnancy confirmation in primary care, father screened if mother is a carrier; (iii) Secondary sequential: screening offered to woman at first midwife appointment in community-based secondary care, baby's father screened if woman is a carrier.

Table 4 Population carrier screening studies using other measures of informed choice

Author; reference year; geographical location of study; condition screened	Study type; data collection methods; and measures of informed choice	Participants ^a ; recruitment rate if reported (%); place of recruitment; screening test; screening procedure	Uptake of screening %	Knowledge measure, theoretical basis; number of items, score range; response options; good knowledge cutoff; validation; other		
				Knowledge results (mean (SD)/median (IQR)); good knowledge %; other measures of informed choice		
Metcalfe <i>et al.</i> ⁵⁰ 2008; Australia; fragile X syndrome	Prospective, pilot; self-report questionnaire; knowledge, attitudes, uptake	318, 77% (327/426); family planning clinic, preconception screening; blood test; return visit	20%	Modified Delphi, focus groups; 10, 0–10; T/F/U; score > 7; construct validity (modified Delphi)	Mean = 6.8 (SEM 0.1); 63.2; attitudes scores, negative (< 7) 5.4%, intermediate (7–12) 42%, positive attitudes (> 12) 52.5%	
Miedzybrodzka <i>et al.</i> ³⁰ 1995; Scotland; cystic fibrosis	Randomised control trial; self-report questionnaire; knowledge, attitudes towards screening	2002 (1641 stepwise, 361 couple screening); not reported; maternity hospital antenatal clinic, prenatal screening; mouth wash; stepwise or couple screening ^b	89–91% ^c	NR; 4; Y/N/M and MCQ; NR; NR	NR; NR; 77–89% items correct; 33% support for CF screening in antenatal clinics, 84% would recommend it to a friend, 91% would ask for further testing of their fetus if the couple were carriers, 73% indicated they would not have a termination if their baby had CF	
Watson <i>et al.</i> ⁵⁴ 1991; UK; cystic fibrosis	Prospective; self-report questionnaire; knowledge	340 (GP clinic), 374 (family planning clinic); 340/513 (GP clinic) 374/431 (family planning clinic); primary care, preconception screening; buccal swab; opportunistic or invitation letter ^d	10–87% ^e	NR; NR; NR; NR	NR; NR; 77% had heard of CF, 35% knew CF was inherited, 44% knew there was no cure, 18% knew carriers do not need a family history of CF	

Abbreviation: Y/N/M, yes/no/maybe response options.

^aParticipants, n = valid number of questionnaires.

^bStepwise screening: screening of the woman in the first instance, then screening of her partner if a carrier is detected. Couple screening: sampling both partners, but only screening both samples if a carrier is detected, only returning a positive result if both are carriers.

^cCouple testing (89) and stepwise (91).

^dOpportunistic: offering opportunistic screening to everyone attending two GP clinics and at the family planning clinics. Invitation letter (and leaflet): sent to a stratified random sample of the target population from the practice's register.

^e10 (invitation letter), 66 (GP clinic), and 87 (opportunistic, family planning clinic).

Good knowledge was defined in various ways using the median¹² and a guess-corrected midpoint.¹³ Validation of the 'good' knowledge cutoff was generally lacking, with only two studies validating the cutoff using interview data.^{12,41}

Informed choice varied for DS screening from 9.7%⁵⁵ to 74.5%.⁴⁹ In prenatal Hb carrier screening, 30.4–50% were classified as having made an informed choice.^{26,41} Low rates of informed choice were generally because of poor knowledge. In preconception carrier screening for FXS, only 27% of participants were classified as having made an informed choice.³⁶ In this setting, uninformed choices were due to low value consistency, largely because screening required people to return for a separate appointment to have blood taken, resulting in women having positive attitudes towards screening but not attending the return appointment to provide the blood sample for screening.⁵⁰

Perception of choice

Five studies incorporated measures of participants' perception of their choice about the screening test.^{32,43,49,51,56} When screening is offered as part of 'routine' care, it can be interpreted by participants as being compulsory. However, ideally, screening should be offered in a way that promotes autonomy; being free from coercion. Assessing the subjective perception of choice is one way of assessing the degree of autonomy that individuals exercised when making their choice.

The items measuring perception of choice varied across studies; four studies used a single item,^{32,43,49,56} and one study included a single item within a systematic decision-making scale.⁵¹ All items asked women, in different ways, whether they thought the screening was optional, or who should make their choice about screening.

In prenatal screening for DS, almost half (46%) of women thought screening was routine,⁴⁸ and most (82%) thought it was compulsory.⁴³ However, most women reported believing that the choice should lie with the individual offered screening.⁵⁶ Perceptions of choice are likely to be context specific; for example, in countries where screening is funded by the government or is socially accepted, testing might be seen as part of 'routine' care.^{38,46}

Attitudes and feelings towards screening

Of the 33 studies, 5 used an attitudes scale different from that used in the MMIC,^{30,43,47,56} or the same scale but used independently of the MMIC.⁵⁰ These studies used a variety of different items within the attitudes measures; three studies used various items regarding participants' general feelings towards screening,^{30,50} and whether or not the participant was in favour of DS screening.⁴³ One study measured a broad range of attitudes and values towards screening such as 'faith or fatalism'.²⁸ Two studies also measured participants' acceptance and values relating to screening, termination of pregnancy, and having a child with the condition being screened.^{30,56} One study did not report the items or results of the attitudes measure.⁴⁷

Attitudes regarding screening are particularly important to measure as it has been argued that screening choices ought to be aligned with the morals and values of the individual.³ These measures however need to be more consistent and validated within the sample population.

Decisional conflict

The decisional conflict scale (DCS) was used to evaluate participants' feelings regarding the choice outcome in five studies; four RCTs^{13,28,31,38} and an adapted version was used in one prospective study.⁵⁶ The DCS was designed as a general scale, not for a particular condition, and validated with health-care consumers deciding about

hypothetical scenarios of influenza vaccination and breast cancer screening.¹⁰ The scale comprises five subscales (information, values clarity, support, uncertainty, and effective decision) measuring the outcome of how an individual feels about a health-related decision, rather than evaluating whether the decision was an informed one. Decisional conflict is defined as 'a state of uncertainty about the course of action to take' that can occur when decisions are difficult, resulting in decisions that are not effective, and where an individual may feel uncertain about their decision. Rather, an effective decision is defined as one that is 'informed, consistent with personal values and acted upon'.¹⁰ Decisional conflict is important in informed choice evaluation because it directly measures participants' perspectives of how certain they feel about the decision and their perceived autonomy in making the decision.

Results can be compared across the studies as the DCS is a standardised measure on a scale of 0–100 with validated cutoff scores for low decisional conflict (scores <25) and increased decisional conflict (scores >37.5).¹⁰ Decisional conflict was reported within the normal range in two studies (mean ranging from 1.65 to 23.9)^{28,31} with another study also demonstrating a relationship between low decisional conflict and high levels of knowledge (OR = 1.31, 95% CI, 1.26–1.37, $P < 0.001$).³⁸

Satisfaction with decision and decisional regret

Five studies measured satisfaction with decision or decisional regret.^{13,28,29,32,50} Satisfaction and decision regret scales are explicit measures of how people feel about their choices,⁴ and can be used to measure the outcome of decision making.^{4,58} An informed decision may lead to better outcomes⁵⁹ such as increased satisfaction, or low regret with the decision.^{4,10,60} Decision regret can be defined as 'remorse or distress over a decision' that can stem from 'knowledge that the choice made was nonoptimal'.⁴ Decision satisfaction and regret, however, are not the same as making an informed choice; someone may have low satisfaction but have made an informed choice.⁵⁹

Two studies used scales of decision satisfaction,^{13,29} one study used the decision regret scale,²⁸ whereas two others used individual items to measure satisfaction with how the choices were made.^{32,50} In studies where satisfaction with screening choices was measured, most women were very satisfied with their choices,²⁹ and did not regret their decisions.^{28,50} One study showed significantly higher satisfaction scores in people making informed decisions compared with uninformed decisions ($t = 4.9$, $P < 0.001$, $t = 2.1$, $P < 0.05$).¹³

Measures of systematic decision making

Three studies used measures of systematic, informed decision making.^{11,29,51} According to a rational decision-making perspective, an informed decision needs to involve a systematic process of weighing up the advantages and disadvantages of the choice, that is, deliberating, as well as the decision being informed in order to have the best outcome.⁷ Informed decision making is differentiated from an informed choice, where the former involves the process of deliberation. Decisions that are not systematic are often made using mental short cuts or heuristics that can lead to biases in decision making and poorer quality decisions.⁶¹ To account for this aspect of decision making, an 18-item systematic decision-making scale was developed,^{29,51} and a 6-item deliberation scale was used with the existing MMIC.¹¹ These measures have been well validated,⁵¹ indicating that each accurately measures the systematic decision-making construct. However, these scales have not been widely used to date.

DISCUSSION

This systematic review evaluated how informed choice has been measured in population reproductive genetic screening. Studies offering population genetic screening should endeavour to measure informed choice as well as uptake of screening.² The studies identified in this review demonstrate the array of methods used to measure informed choice in population reproductive genetic screening. Our findings highlight well-validated measures, and also some limitations and inconsistencies in evaluating informed choice in this setting.

The concept of informed choice is a multidimensional construct and has been defined in a number of ways.^{11,12,32,33,48} Measuring knowledge is integral for informed choice evaluation, yet there has been little development and validation of knowledge measures. A heterogeneous range of knowledge items were used in the studies reviewed. Even the reporting of validated knowledge scales varied within DS screening where there has been much development of informed choice measurement.^{12,31,39,40,46,49}

There are no agreed thresholds or minimum standards for the knowledge an individual is required to have to make an 'informed' choice. As such, a variety of methods were used to classify participants as having 'good enough' knowledge for an informed choice. This is problematic because when good knowledge is defined differently, it is not possible to compare the proportion of informed choice across studies. Some measures, such as the MMIC, required the scales to be dichotomised. Dichotomising continuous scales into binary or categorical data has been criticised and is not recommended by some editorial guidelines.⁶²

The authors of the MMIC drew on work by O'Brien-Pallas, integrating the definition of informed choice with the theoretical perspective of rational behaviour.^{57,63} The MMIC has been validated and applied widely in DS screening,^{11–13,31,35,39,40,43,44,49,52,55} and now has been used in Hb^{26,41} and FXS carrier screening.³⁶ In nonpregnancy screening, the construct validity of the value-consistency domain needs to be validated because in nonpregnancy carrier screening individuals do not need to make a decision when offered screening, rather they may defer the decision to another time in their life.^{36,64} Therefore, the MMIC needs to be further explored and undergo validation in screening settings other than prenatal screening.

Another approach to encapsulate the informed choice construct is to use the DCS with a knowledge measure. The DCS is a well validated measure¹⁰ used in five studies measuring informed choice.^{13,28,31,38,56} Incorporating a knowledge scale as well, perhaps using 'good' knowledge, combined with a low decisional conflict could be one way of defining informed decision making. This way, participants' perspectives of whether they made an informed and free choice, and whether they were supported, are taken into consideration. These aspects are similar to other concepts such as the perception of choice and satisfaction, yet more research and agreement is needed to determine how these measures should be used and how they relate to evaluating informed choice.

When using the MMIC, or any measure out of its original context, the limitations of the measure need to be recognised until the measure has been validated within the new setting. The MMIC has been criticised for oversimplifying informed choice into a binary variable, potentially incorrectly classifying choices that are informed.^{52,65} The MMIC also does not take into account the cognitive processes involved in making a decision, such as deliberation.^{7,11} Although there are limitations to the MMIC, as for any measure, the MMIC remains the only single, multidimensional measure of informed

choice for genetic screening. The MMIC is a relatively short instrument to administer and easy to use, with many published studies detailing how to apply and interpret the measure. However, the MMIC does require a knowledge measure that is specific to the condition being tested.

In the future, a knowledge measure may need to address the general phenotype (multiple congenital anomalies, developmental delay, reduced life expectancy, and so on),⁶⁶ rather than be condition specific. With multiplex genetic technologies now enabling screening for multiple conditions,⁶⁷ measuring informed choice with condition-specific knowledge scales is problematic. With this technology becoming available directly to consumers, there is a need for more research about informed choice in the general population, and outside the prenatal context. There is also a need for ongoing evaluation and publication of informed choice in existing programmes, with implementation of changes where needed to facilitate informed choice. Moving forward, qualitative and mixed methods studies could be used to help understand informed choice in genetic screening and further inform how best to measure informed choice in the future.

Although we have applied rigorous systematic review methods, there are some limitations to this study. As informed choice is defined in a number of ways, it was difficult to develop a search strategy to locate all studies for this review. The search terms may not have included every definition and possible way that informed choice could be indexed in the databases. To account for this, we used citation tracking and contacted corresponding authors and experts in the field, and this yielded 13 additional relevant papers. The studies identified in the review came from a limited number of countries; almost half of the studies (14/33) were from the United Kingdom where informed choice is a key component of prenatal screening guidelines,⁶⁸ and where the widely used measure, MMIC, was developed. Informed choice may be a component of guidelines and the evaluation of screening programmes in other countries, but the evaluations may not be published and hence not included in this review. Because of the heterogeneity of included studies, we were only able to conduct a narrative synthesis. However, our review has highlighted important challenges for this field of research and suggests the need for further work in the area especially with the expansion of carrier screening and noninvasive prenatal screening.^{69,70}

The focus of this review was on the measurement tools used in population genetic screening for reproductive risk. For this reason the review did not include guidelines or qualitative studies. However, qualitative studies are important for exploring how individuals offered screening perceive informed choice. In fact, qualitative research could contribute to understanding issues of informed choice evaluation such as what is good knowledge, and whether individual's perceptions of informed choice reflect how informed choice is measured. This approach could be especially useful for new screening programmes that have not been evaluated.

This review has highlighted that there is no gold standard for evaluating good knowledge or informed choice in population reproductive genetic screening. Knowledge and autonomy are key aspects of informed choice; it is important to define what is important for participants to understand when accepting or declining screening and for individuals to understand that screening is optional and their own personal choice. A dearth of studies involving future fathers and partners suggests more research is needed to better understand their role, and women's perspectives about this in making choices about screening. There are a variety of informed choice

measures with variable quality that would benefit from further development and evaluation. Results of informed choice evaluations must be presented in a meaningful way to indicate the programme's efficacy to facilitate informed choice. Particular attention ought to be directed towards addressing how 'good' knowledge and informed choice are defined and measured from the outset of a screening programme.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

ACKNOWLEDGEMENTS

We thank Pho Chua, librarian at the Royal Children's Hospital, for her assistance. We acknowledge the funding enabling this research from the Murdoch Childrens Research Institute, Australian Postgraduate Award, and the Victorian Government's Operational Infrastructure Support Programme.

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