Health professionals' and service users' interpretation of screening test results: experimental study

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Abstract

Objective To investigate the accuracy of interpretation of probabilistic screening information by different stakeholder groups and whether presentation as frequencies improves accuracy.

Design Between participants experimental design; participants responded to screening information embedded in a scenario.

Setting Regional maternity service and national conferences and training days.

Participants 45 pregnant women attending their first antenatal appointment in a regional maternity service; 40 companions accompanying the women to their appointments; 42 midwives; 41 obstetricians. Participation rates were 56%, 48%, 89%, and 71% respectively.

Measures Participants estimated the probability that a positive screening test result meant that a baby actually had Down’s syndrome on the basis of all the relevant information, which was presented in a scenario. They were randomly assigned to scenarios that presented the information in percentage (n = 86) or frequency (n = 83) format. They also gave basic demographic information and rated their confidence in their estimate.

Results Most responses (86%) were incorrect. Obstetricians gave significantly more correct answers (although still only 43%) than either midwives (0%) or pregnant women (9%). Overall, the proportion of correct answers was higher for frequencies (71%) than for presentation as percentage (41%). The data presented here are part of a larger study in which participants were randomised to one of four scenarios presented on either health (prenatal) screening or machine parts screening using presentation either as percentages or as frequencies. This paper presents the prenatal screening scenarios only, comparing responses from obstetricians, midwives, and pregnant women. Previous research has neglected the potential differences between different stakeholder groups in their interpretation of screening information that has current personal or professional relevance to them. We therefore compared responses of obstetricians, midwives, pregnant women, and their companions at an antenatal appointment.

Clinically, the impact of inaccurate estimates would be magnified if those making them were confident in them. Therefore, we also examined respondents’ confidence in their ratings.

Methods

Participants The data presented here are part of a larger study in which participants were randomised to one of four scenarios that presented information on either health (prenatal) screening or machine parts screening using presentation either as percentages or as frequencies. This paper presents the prenatal screening scenarios only, comparing responses from the frequency and percentage scenarios. We recruited participants from four stakeholder groups: pregnant women, the people accompanying them to antenatal appointments, midwives, and obstetricians. Within each group, we randomised consenting participants to antenatal appointments.

Effect sizes for presentation as frequencies versus percentages in previous studies with student samples have been large.1 Allowing for a separate analysis in each stakeholder group, 40 cases per group presented with a prenatal screening scenario

Introduction

Medicine is making increasing use of biochemical, imaging, and genetic screening tests that provide probabilistic information. Extensive psychological research has shown that most people, including health professionals, incorrectly interpret such information.1 The usual method for laboratory research has been to present probabilistic information in a scenario relating to medical screening or other hypothetical situations and ask respondents to draw a conclusion. Such research has extensively investigated the incorrect answers given in order to understand the reasoning processes that lead to them and suggests that respondents typically ignore information essential to a mathematically correct answer.

Early laboratory research suggested extreme overestimation or underestimation when respondents estimated the probability that a positive screening result indicated that the relevant condition was present. Furthermore, scenarios describing medical screening produced more overestimation than did ones describing screening of machine parts.2 More recent applied research with patients has also shown frequent misinterpretation of screening results.3

The suggestion that evolution and experience equip people better to understand probabilistic information expressed as frequencies in a population, rather than as probabilities for an individual,4 led to the practical recommendation that medical practitioners should present screening information as frequencies, perhaps pictorially.5 We therefore tested the effect of a change from presentation as percentages to presentation as frequencies on the level of correct estimates and the types of error made in response to a scenario based on screening of maternal blood serum for Down’s syndrome, which is now routinely offered to all pregnant women. Previous research has neglected the potential differences between different stakeholder groups in their interpretation of screening information that has current personal or professional relevance to them. We therefore compared responses of obstetricians, midwives, pregnant women, and their companions at an antenatal appointment.

Clinically, the impact of inaccurate estimates would be magnified if those making them were confident in them.6 Therefore, we also examined respondents’ confidence in their ratings.
gave 89% power to detect an effect size of $W = 0.50$ (which is large but smaller than those reported) at $\alpha = 0.05$. Target recruitment was therefore 80 from each participant group.

Numbers who were approached and participated in each group for the whole study were as follows: 154 pregnant women approached, 82 (54%) responded, of whom 43 received the health scenario; 166 companions approached, 80 (48%) responded, of whom 40 received the health scenario; 92 midwives approached, 82 (89%) responded, of whom 42 received the health scenario; 116 obstetricians approached, 82 (71%) responded, of whom 41 received the health scenario. We excluded from the respondent numbers above and from the analysis three pregnant women and two companions who agreed to participate and were randomised but were called in to their appointment before completing the questionnaire and three women who completed only the demographic section of the questionnaire. The analysis presented here is of responses to the health context scenarios only.

Companions included 33 partners (all men) and seven female relatives (one unknown relationship). All midwives and 25 obstetricians were women. Table 1 shows the number in each group who responded to a frequency or percentage scenario.

### Procedure

The researcher (HW) recruited all participants in person, and they completed questionnaires in her presence. She recruited health professionals at national training events or through a regional maternity service. She approached colleagues at waiting rooms for the first antenatal appointment at a regional maternity service. She recruited health professionals at national training events or through a regional maternity service, and they completed the questionnaire during breaks from work or training.

In order to randomly assign scenarios to participants, the questionnaires were placed in sealed plain A5 envelopes, which were hand shuffled by the researcher so that the sequence was completely concealed. As respondents were recruited, the researcher took the next envelope from the stack.

Questionnaires sought basic demographic information and then presented a screening scenario (box 1) that described a positive screening result to the test would actually have a baby with Down’s syndrome (that is, the positive predictive value for the test). They also rated their confidence in their answer from 1 (not at all confident) to 6 (very confident).

### Analysis

We converted responses to percentages for presentation and analysis. The correct response was 47.6% (box 2). We categorised estimates from 45.0% to 50.0% as correct. We regarded all other responses as incorrect and categorised them into overestimates and underestimates.

We compared the participant groups on the proportion of correct responses and then on the proportion of incorrect

### Table 1 Percentage (number) of respondents from each stakeholder group who provided answers that were correct, overestimates, or underestimates

<table>
<thead>
<tr>
<th>Presentation as percentages</th>
<th>Pregnant women</th>
<th>Companions</th>
<th>Midwives</th>
<th>Obstetricians</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correct</td>
<td>5 (1)</td>
<td>15 (2)</td>
<td>0</td>
<td>5 (1)</td>
<td>6 (5)</td>
</tr>
<tr>
<td>Overestimate</td>
<td>68 (15)</td>
<td>50 (10)</td>
<td>46 (10)</td>
<td>76 (16)</td>
<td>60 (51)</td>
</tr>
<tr>
<td>Underestimate</td>
<td>27 (6)</td>
<td>35 (7)</td>
<td>55 (12)</td>
<td>19 (4)</td>
<td>34 (29)</td>
</tr>
<tr>
<td>Total</td>
<td>100 (22)</td>
<td>100 (20)</td>
<td>100 (22)</td>
<td>100 (21)</td>
<td>100 (85)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Presentation as frequencies</th>
<th>Correct</th>
<th>Overestimate</th>
<th>Underestimate</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>pregnant women</td>
<td>14 (3)</td>
<td>15 (3)</td>
<td>0</td>
<td>65 (13)</td>
</tr>
<tr>
<td>companions</td>
<td>38 (6)</td>
<td>40 (8)</td>
<td>35 (7)</td>
<td>15 (3)</td>
</tr>
<tr>
<td>midwives</td>
<td>48 (9)</td>
<td>45 (9)</td>
<td>65 (13)</td>
<td>20 (4)</td>
</tr>
<tr>
<td>obstetricians</td>
<td>52 (11)</td>
<td>45 (9)</td>
<td>65 (13)</td>
<td>20 (4)</td>
</tr>
<tr>
<td>Total</td>
<td>100 (21)</td>
<td>100 (20)</td>
<td>100 (21)</td>
<td>100 (20)</td>
</tr>
</tbody>
</table>

### Box 1: Screening scenario

#### Version 1: percentages

The serum test screens pregnant women for babies with Down’s syndrome. The test is a very good one, but not perfect. Roughly 1% of babies have Down’s syndrome. If the baby has Down’s syndrome, there is a 90% chance that the result will be positive. If the baby is unaffected, there is a 1% chance that the result will be positive. A pregnant woman has been tested and the result is positive. What is the chance that her baby actually has Down’s syndrome? __________%

### Box 2: An explanation of how to derive the correct answer

- If 10 000 pregnant women were tested, we would expect 100 (1% of 10 000) to have babies with Down’s syndrome.
- Of these 100 babies with Down’s syndrome, the test result would be positive for 90 (90% of 100) and negative for 10
- Of the 9900 unaffected babies, 99 (1% of 9900) will also test positive, and 9801 will have a negative test result.
- So, out of the 10 000 pregnant women tested, we would expect to see 189 (90+99) positive test results. Only 90 of these actually have babies with Down’s syndrome, which is 47.6%.
- Therefore, 47.6% of pregnant women who have a positive result to the test would actually have a baby with Down’s syndrome.

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- Of these 100 babies with Down’s syndrome, the test result would be positive for 90 (90% of 100) and negative for 10
- Of the 9900 unaffected babies, 99 (1% of 9900) will also test positive, and 9801 will have a negative test result.
- So, out of the 10 000 pregnant women tested, we would expect to see 189 (90+99) positive test results. Only 90 of these actually have babies with Down’s syndrome, which is 47.6%.
responses that were overestimates versus underestimates. We followed significant effects by pairwise comparisons. We next compared presentation as frequencies with presentation as percentages for the proportion of correct responses in the total sample and then in each respondent group. We used Pearson χ² to make comparisons except when, for pairwise comparisons, the low proportion of correct responses led to expected cell frequencies under five; when we used Fisher’s exact test (two tailed). Finally, we report the confidence in incorrect responses for different groups.

Results
As expected, most (n = 142; 86%) responses were incorrect. Whereas the correct answer was 47.6%, most responses were close to 0% or 100%. Popular answers clustered around specific values. The two most frequent answers were 1.0% (n = 32; 19% of the sample) and 90.0% (n = 46; 27% of the sample), and these were produced by all groups and in response to both presentations.

Between group differences
Figure 1 shows the distribution of responses in each group. The groups differed in the proportion of correct answers (table 1; χ² = 20.9, df = 3; P < 0.001). Pairwise comparison showed that obstetricians were more often correct than either pregnant women (P = 0.007) or midwives (P < 0.001), and companions were more often correct than midwives (P = 0.011). The groups did not differ in the proportion of overestimates versus underestimates (χ² = 6.4, df = 3; P = 0.093).

Confidence in responses
Table 2 shows that, even among respondents who answered incorrectly, many were confident in their responses. Whereas most of the pregnant women who gave incorrect answers scored in the lower range of the confidence rating, people who were in a position to advise them were more confident. In particular, obstetricians who gave incorrect responses were generally highly confident, with a modal rating of 4 on the scale from 1 to 6. Midwives showed a bimodal distribution—although many also scored 4, a similar proportion were not at all confident.

Discussion
Probabilistic reasoning has consistently been shown to be poor, and previous research has indicated that presentation of frequencies improves understanding. In this study, a simple change from presentation as percentages to presentation as frequencies did indeed improve the accuracy of interpretation of information about screening for Down’s syndrome, but only

Table 2  Confidence ratings for participants who gave an incorrect response to the scenario, shown as percentage (number) of those responding incorrectly in each group who chose that rating

<table>
<thead>
<tr>
<th>Group</th>
<th>1: Not at all confident</th>
<th>2:</th>
<th>3:</th>
<th>4:</th>
<th>5:</th>
<th>6: Very confident</th>
<th>No response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pregnant women</td>
<td>21 (9)</td>
<td>23 (10)</td>
<td>23 (10)</td>
<td>9 (4)</td>
<td>14 (6)</td>
<td>7 (3)</td>
<td>2 (1)</td>
</tr>
<tr>
<td>Companions</td>
<td>13 (5)</td>
<td>13 (5)</td>
<td>18 (7)</td>
<td>25 (10)</td>
<td>13 (5)</td>
<td>18 (7)</td>
<td>3 (1)</td>
</tr>
<tr>
<td>Midwives</td>
<td>26 (11)</td>
<td>17 (7)</td>
<td>14 (6)</td>
<td>26 (11)</td>
<td>10 (4)</td>
<td>5 (2)</td>
<td>2 (1)</td>
</tr>
<tr>
<td>Obstetricians</td>
<td>5 (2)</td>
<td>18 (4)</td>
<td>12 (5)</td>
<td>24 (10)</td>
<td>20 (8)</td>
<td>29 (12)</td>
<td>0</td>
</tr>
</tbody>
</table>
to use decision aids such as visual presentations of risk. Effective communication of probabilistic information will need such reasoning. Indeed, some people have suggested that truly aspects of the presented information in an attempt to facilitate changing from presentation as percentages to presentation as frequencies that might facilitate understanding. This study used manipulations of only one scenario, to which the correct answer was close to 50%. Both accuracy and the proportion of overestimates and underestimates may respond to changes in the base rate, sensitivity, and specificity used in the scenario. Furthermore, presentation of information in frequency format for some combinations of these key screening test parameters would require the use of larger numbers than the 10,000 denominator used here. Future research will need to examine whether users’ difficulty in thinking about large numbers might counteract the benefits of presentation as frequencies. Finally, participation was voluntary, and clearly the study may be biased towards those who felt more comfortable with probabilistic data.

Implications for practice
Comparisons between stakeholders in screening highlight the importance of future research with user groups and non-medical professionals. Health professionals need to be aware that screening information presents difficulties to professionals and service users alike and that the erroneous conclusions being drawn by different groups may differ. Screening technologies are becoming increasingly available across many health settings, although the assumption that they are always beneficial has been disputed. The inability of the people actually using probabilistic screening information, both professionals and service users, to draw correct conclusions from it seriously challenges the usefulness of such screening in practice.

Contributors: RB had the original idea for this research, and all three authors contributed to the research design. HW collected the data. RB did the analysis and drafted the manuscript in collaboration with PS and HW. RB is the guarantor.

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Competing interests: None declared.

Ethical approval: Liverpool (Adult) Research Ethics Committee 9/1/04, reference 02/05/063A.

What is already known on this topic
Most people, including health professionals, do not draw mathematically correct inferences from probabilistic screening information

Some studies suggest that presentation as frequencies aids interpretation

What this study adds
Presentation as frequencies does not help everyone: a simple change from percentages to frequencies increased correct responses in obstetricians but not in midwives or service users

The change in presentation did change the type of errors that people made

Many respondents were very confident about their incorrect answers


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