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# Factors influencing intention to undergo whole genome screening in future healthcare: A single-blind parallel-group randomised trial

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ABSTRACT

*Objective.* This study investigated the effect of biased information on beliefs about, and intention to undergo, whole genome sequencing (WGS) screening; and predictors of intention.

*Methods.* A single-blind parallel-group randomised trial was conducted in Australia, in 2011. Using Excel, 216 participants with English proficiency and no genetic testing experience were randomly allocated (1:1): a *neutral* information pamphlet or a *biased* version omitting screening limitations. Measures included: screening intention; Protection Motivation Theory (PMT) constructs; consideration of future consequences (CFC); uncertainty avoidance (UA); anticipated regret (AR).

*Results.* Intention decreased from pre to post-manipulation ($p<.001$, $\eta^2=.07$, 95% CIs [4.41, 4.86], [3.99, 4.44], respectively). *Biased* participants ($n=106$) had higher response efficacy beliefs than *neutral* participants ($n=102$) ($p<.001$, $\eta^2=.04$, 95% CIs [4.80, 5.10], [4.49, 4.79] respectively), but equal intention. The model explained 36.2% of the variance in intention; response efficacy ($p<.001$), response costs ($p<.001$), self-efficacy ($p=.024$), and UA ($p=.019$) were predictors.

*Conclusion.* This is the first study investigating factors influencing anticipated WGS screening uptake. Omitting screening limitations may bias beliefs about screening efficacy and benefits. Uptake may be driven by perceived benefits and costs, self-efficacy beliefs, and uncertainty avoidance. PMT appears to be an appropriate psychosocial model for this setting.



## Introduction

Advances in clinical genomics mean that the public could soon obtain analyses of their full genetic material at an affordable price (National Health and Medical Research Council, 2010). This new generation of DNA-based health screening, whole genome sequencing (WGS) screening, will enable healthy individuals to discover their genetic susceptibility to a multitude of rare and common diseases (Wright and Kroese, 2010) with significant implications for disease prevention, diagnosis, and treatment (Health Council of the Netherlands, 2010). The future clinical usefulness of screening remains unknown, with some citing a lack of evidence that feedback about one's personalised disease susceptibility is effective in motivating risk-reducing behaviours (McBride et al., 2010). Despite these concerns, sequencing technologies are progressing fast and falling in cost (HCN, 2010), thus there is a pressing need to improve our understanding of factors that may influence uptake, to inform guidelines for screening within clinical practice and a competitive direct to consumer market (NHMRC, 2010). It is also important to consider the balance of potential benefits and harms for consumers (HCN, 2010).

There is currently a lack of psychosocial research investigating the factors that may influence WGS screening uptake and the resulting benefits and harms (Hunter et al., 2008). However, the genetic testing literature provides some insights into this area. Genetic testing interest among the general adult population is substantial though varying, with estimates ranging from 30 to 80% (Bunn et al., 2002; Braithwaite et al., 2002). Community-wide surveys (e.g., Bunn et al., 2002) reveal that interest is generally unrelated to socio-demographic factors, including age and socio-economic status. However, interest is influenced by perceived disease characteristics, and the test's predictive ability. In a university student sample there was greater interest in genetic testing for cancer than Alzheimer's disease (Frost et al., 2001), and similarly in an older adult community sample, for curable than incurable diseases (Shaw and Bassi, 2001). These findings suggest a greater perceived benefit when testing for more 'controllable' diseases (Frost et al., 2001), among both younger and older adults. There is also a preference for tests that are highly predictive of disease onset (e.g., Wolff et al., 2011), which may reflect a key motivator for testing: people's desire for increased certainty of disease risk

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(Cameron and Muller, 2009). Thus, disease and test characteristics may influence the benefits and harms of WGS screening for an individual. For example, results indicating a strong predisposition for an unpreventable disease may be beneficial (e.g., increased certainty), or harmful (e.g., increased anxiety), or both (Robertson, 2003).

Existing research also highlights an important issue for informed consent in health screening: test information needs to be balanced, and avoid overstating the benefits (Morrison et al., 2008). Jorgensen and Gotzsche (2004) found that internet-sourced information on breast cancer screening is frequently biased in favour of screening: the benefits and therapeutic effectiveness were emphasised, while reported harms were less prominent. Weller et al. (2009) suggest that screening programmes should ideally promote a balance between uptake and informed decision making, which relies on prospective screening participants being informed about, and understanding the limitations of screening (HCN, 2010). It is therefore important to examine the impact of information framing on WGS screening-related attitudes and intention; especially as the direct clinical benefits of WGS screening are currently limited (Wright and Kroese, 2010).

Social cognitive theories provide a structured framework for investigating psychosocial influences on health behaviours, including genetic testing (Etchegary, 2004). Protection Motivation Theory (PMT; Rogers, 1983) has been used to identify the predictors of a range of health behaviours, however, only one known study has applied PMT to genetic testing, specifically BRCA1/2-gene testing in a sample of low-risk women (Helmes, 2002). Despite PMT's limited use in this setting, PMT-based information interventions are found to have a greater impact on intention and behaviour than other well-known models (Webb and Sheeran, 2006). Such theory-based information provisions have been shown to strengthen beliefs about the efficacy of a diagnostic test (Brouwers and Sorrentino, 1993) and moderate genetic testing interest (Cameron and Diefenbach, 2001) in undergraduate student samples, while increasing the perceived benefits of, and intention to undertake genetic testing in an adult sample of mean age 37 years (Sweeny and Legg, 2011). This provides a means of testing the effect of information framing about the benefits and harms of WGS screening on intended uptake.

In addition to the factors specified within PMT, the genetic testing literature identifies three additional factors that could potentially influence WGS screening intentions. Anticipated regret (AR; Norman et al., 2005) following a health behaviour depends on the test outcome obtained, and is predictive of lower test-taking intentions (Frost et al., 2001). Health-related uncertainty avoidance (UA; Braithwaite et al., 2002) is predictive of increased intention to pursue genetic testing. This has been attributed to a desire to reduce unwanted uncertainty (Wolff et al., 2011), which may be problematic when WGS screening *itself* introduces uncertainty (Wright and Kroese, 2010). Consideration of future consequences (CFC; Strathman et al., 1994) refers to an individual's weighting of immediate and long term consequences of behaviour. People who prioritise long term consequences indicate more favourable attitudes toward, and likelihood to undertake health screening for adult onset diseases (e.g., Orbell and Hagger, 2006; Orbell et al., 2004). These additional factors might afford a more comprehensive understanding of WGS screening intentions (Crockett et al., 2009).

This study aimed to: (i) investigate the impact of biased versus neutral information on perceptions of WGS screening benefits, as well as intention to undergo WGS screening; (ii) determine the predictors of intention to undergo WGS screening within the PMT framework; and (iii) identify whether AR, UA and CFC provide additional predictive value for a model of WGS screening intention.

## Methods

### Participants

Participants were 231 undergraduate students recruited via The University of Sydney research participation database. Ethics approval was sought and obtained from the university's Human Research Ethics Committee. Eligibility criteria included English proficiency and no history of genetic testing. Participants received course credit.

### Trial design

This was an online-based single-blind parallel-group study with balanced randomisation (1:1) conducted in Sydney, Australia between June and August, 2011.

### Procedure

A computer-generated list of random numbers[1] randomised individual (blinded) participants to one of two parallel information framing groups: *neutral* or *biased*. After accessing the electronic questionnaire via an email link and giving consent, participants completed pre-manipulation measures, viewed their assigned information pamphlet, and then completed post-manipulation measures (Fig. 1). Conditional branching implemented the random allocation sequence. Participants were subsequently debriefed.

### Materials and measures

All developed materials and measures were piloted on undergraduate students ($N = 16$) to assess comprehensibility, appropriateness and usability, and revised according to feedback. For all attitude measures, composite scores were the item score means (relevant items reverse-scored). Higher scores indicated higher levels of the corresponding construct.

#### Neutral/biased information pamphlet

Pre-manipulation, a brief factsheet defined WGS screening and its future availability. The experimental manipulation pamphlet was developed by the authors (AF and IJ), who conducted a review of the WGS screening literature (e.g., HCN, 2010), and categorised screening-related themes according to PMT constructs. These categorised themes informed the corresponding sections of the pamphlets, which aimed to manipulate perceptions of WGS screening benefits and response efficacy. The *neutral* pamphlet gave a balanced overview of benefits, limitations and costs; the *biased* pamphlet omitted limitations while keeping all other sections identical (see Appendix A). The pamphlet was written in the second person ('you') using bullet-points; with images depicting DNA, and two young adults.

#### PMT measures

The PMT measures were developed by the authors (AF and IJ) using past research on genetic testing attitudes in a similar study population (e.g., Morrison et al., 2010). Items were rated on seven point Likert type scales, from: *very unlikely* (1) to *very likely* (7) (protection motivation); *very low* (1) to *very high* (7) (vulnerability); and *strongly disagree* (1) to *strongly agree* (7) (others).

- *Protection motivation*: One item assessed hypothetical WGS screening intention, pre- and post-manipulation.
- *Severity*: Six items assessed the perceived seriousness of having an increased risk to diseases (e.g., a treatable disease).
- *Vulnerability*: Five items assessed perceived susceptibility to diseases (e.g., neurodegenerative).
- *Response efficacy*: 14 items (adapted from Morrison et al., 2010), assessed perceived WGS screening benefits and efficacy (e.g., reduce worry).
- *Self-efficacy*: Eight items, informed by literature (e.g., Clarke and Thirlaway, 2011) assessed confidence in undertaking WGS screening despite 'obstacles' (e.g., family opposes).
- *Response costs*: 15 items (adapted from Morrison et al., 2010), assessed perceived barriers to WGS screening (e.g., jeopardise privacy).

The PMT subscales displayed moderate ($\alpha = .65$; .69; .72; severity, response costs and vulnerability respectively) to high ($\alpha = .80$; .84; self efficacy and response efficacy respectively) internal reliability in this study.

#### Consideration of future consequences (CFC)

Twelve items from Strathman et al. (1994) assessed CFC, rated on a five point Likert type scale, from: *extremely uncharacteristic of me* (1) to *extremely characteristic of me* (5). CFC showed high internal reliability ($\alpha = .85$).

[1] The Excel function [=IF(RAND()<0.5,0,1)] used for the random allocation of participants was created in consultation with a University Statistician.

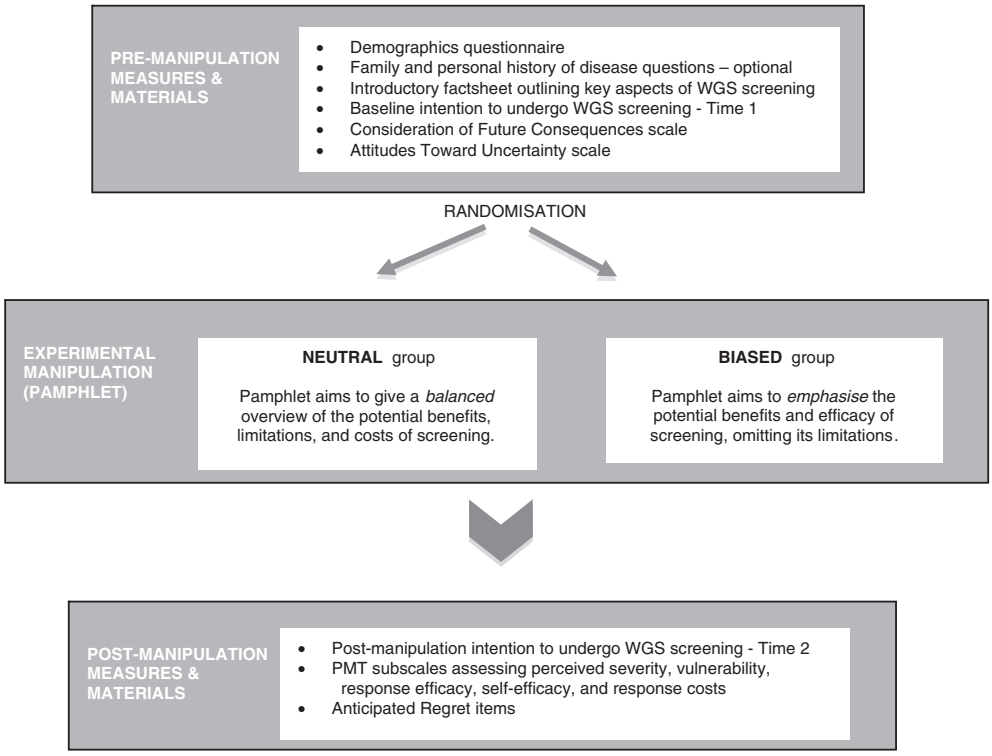


**Fig. 1.** An illustrative diagram of the main study ($N = 216$) procedure conducted in 2011 in Sydney, Australia.

*Uncertainty avoidance (UA)*

Health-related UA was assessed using the Attitudes towards Uncertainty scale (Braithwaite et al., 2002). Eight items were rated on a five point Likert type scale from: *strongly disagree* (1) to *strongly agree* (5). UA showed high internal reliability ($\alpha = .84$).

*Anticipated regret (AR)*

A seven item scale, adapted from previous research (e.g., Orbell and Hagger, 2006), assessed AR following WGS screening results (e.g., increased risk for an incurable disease). Items were rated on a seven point Likert type scale from: *strongly disagree* (1) to *strongly agree* (5). AR had high internal reliability ($\alpha = .88$).

*Demographics*

Up to 10 items (depending on applicability) assessed: age; gender; ethnicity; biological children; genetically-tested relatives; prior WGS screening knowledge.

*History of disease*

Participants indicated first- and second-degree relatives affected by six disease types (e.g., neurodegenerative disease; O'Daniel, 2010), and other conditions. Each affected first-degree and second-degree relative was assigned a value of 1 and 0.5 respectively, summed for a total score (Cameron and Diefenbach, 2001). Participants indicated personal disease history (*yes*; *no*; *no answer*).

*Statistical analyses*

Statistical Package for the Social Sciences (SPSS) version 19 was used. On family history of disease, seven outliers (3.2% of sample) were removed, following literature recommendations (Pallant, 2005). One way, between-subjects ANCOVAs (controlling family history of disease) compared the *neutral* and *biased* groups on WGS screening intention post-manipulation, perceived response efficacy, and other PMT variables. Pearson correlations tested bivariate relationships between intention and CFC, UA, AR, and the PMT variables. A hierarchical multiple regression (method: enter) tested the predictors of intention post-manipulation, with: family history of disease and experimental condition (dummy-coded) in block one; PMT variables in block two; and CFC, UA, and AR in block three. A $2 \times (2)$ mixed design ANCOVA explored pre- to post-manipulation changes in intention, with: information framing (between-subjects variable); intention (within-subjects variable); and mean-centred family history of disease (covariate). $p < .05$ was considered statistically significant.

*Sample size*

Without comparable research, a medium effect size of $f^2 = 0.15$ was assumed. A minimum of 130 participants was required, for 0.80 power and 0.05 significance level for 10 predictors (Tabachnick and Fidell, 2001).

## Results

*Sample*

Of the 231 participants recruited between June and August 2011, four withdrew for unknown reasons and nine failed to complete the survey on time, producing a 94.4% response rate. Two participants with genetic testing experience were excluded, because it was not known whether their responses were informed by past experience. Seven cases were removed due to extreme values. One participant who chose not to report their family history of disease was classified as missing data. For analyses controlling family history of disease, the final sample comprised 208 participants, with 102 randomised to the *neutral* group and 106 to the *biased* group.

*Socio-demographic characteristics*

Participants were aged 19.4 years on average ($SD = 3.32$; range: 17–42), and 61.1% were female (Table 1). A majority of participants (56.0%) self-identified as Australian; had no biological children (99.1%); were single (67.6%); and indicated no prior WGS screening knowledge (62.5%). A small percentage of participants (7.0%) reported genetically-tested relatives; most commonly for cancer ($n = 6$).

*Family and personal history of disease*

A minority of participants (17.3%) reported a personal disease history; most commonly depression ($n=11$) or asthma ($n=11$). Half of the sample (49.3%) reported at least one affected first-degree relative, and the majority (86.6%) reported at least one affected second-degree relative. Mean family history of disease was 2.24 ($SD=1.60$; range: 0–7).

*Pre- and post-manipulation measures*

The sample indicated moderate intention on average, both pre- ($M=4.63$ out of 7, $SD=1.62$, 95% CI [4.41, 4.86]) and post-manipulation ($M=4.22$, $SD=1.62$, 95% CI [3.99, 4.44]), controlling family history of disease (Table 2). Over half of participants reported being "likely" or "very likely" to undergo WGS screening pre- (59.3%) and post-manipulation (51.9%). Consideration of future consequences (CFC), uncertainty avoidance (UA), and anticipated regret (AR) were all moderate; as were PMT-based beliefs (Table 2).

*Impact of biased versus neutral information*

Post-manipulation, the sample indicated significantly *lower* intention, $F(1, 205)=15.41$, $p<.001$, $\eta^2=.07$, controlling family history of disease (Table 2). Decreases in intention were the same regardless of the pamphlet received, $F(1, 205)=0.07$, $p=.794$. In the following section, 'Intention' refers to intention post-manipulation. *Biased* participants indicated significantly *more* positive response efficacy beliefs ($M=4.95$, $SD=.75$, 95% CI [4.80, 5.10]) compared to *neutral* participants ($M=4.64$, $SD=.79$, 95% CI [4.49, 4.79]), $F(1, 205)=8.26$, $p<.001$, $\eta^2=.04$, controlling family history of disease (Table 2). There were *no* significant between-group differences on Intention or other PMT cognitions (Table 2).

**Table 1**
Comparing *neutral* and *biased* groups on socio-demographic variables, based on data collected in 2011, in Sydney, Australia.

| | Neutral[a] group | | | Biased[b] group | | | Significance | |
|---|---|---|---|---|---|---|---|---|
| | *n* | *M* | *SD* | *n* | *M* | *SD* | *F* | *p* |
| Age (in years) | 108 | 19.36 | 2.03 | 108 | 19.99 | 4.23 | 1.95 | .164 |
| | | Neutral[a] group | | Biased[b] group | | | Significance | |
| | | *n* | % | *n* | % | | $\chi^2$ | *p* |
| Gender | | | | | | | 1.95 | .163 |
| Female | | 61 | 56.5 | 71 | 65.7 | | | |
| Male | | 47 | 43.5 | 37 | 34.3 | | | |
| Ethnicity [c] | | | | | | | 0.48 | .789 |
| Australian (non-indigenous) | | 63 | 58.3 | 58 | 53.7 | | | |
| Asian | | 33 | 30.6 | 37 | 34.3 | | | |
| Other | | 12 | 11.1 | 13 | 12.0 | | | |
| Relationship status [c] | | | | | | | 0.34 | .561 |
| Single | | 75 | 69.4 | 71 | 65.7 | | | |
| In a relationship | | 33 | 30.6 | 37 | 34.3 | | | |
| Biological children | | | | | | | N/A[d] | N/A[d] |
| No | | 108 | 100 | 107 | 99.1 | | | |
| Yes | | 0 | 0 | 1 | .9 | | | |
| Relative undergone genetic testing | | | | | | | 0.65 | .422 |
| No | | 102 | 94.4 | 99 | 91.7 | | | |
| Yes | | 6 | 5.6 | 9 | 8.3 | | | |
| Previous knowledge of WGS-screening | | | | | | | 0.49 | .482 |
| No | | 70 | 64.8 | 65 | 60.2 | | | |
| Yes | | 38 | 35.2 | 43 | 39.8 | | | |

Notes:
[a] Neutral = participants receiving neutral information.
[b] Biased = participants receiving biased information.
[c] Recoded variable based on clustered categories.
[d] N/A = analysis not appropriate due to low cell count (<5 cases per cell).

**Table 2**
Comparing *neutral* and *biased* groups on pre and post-manipulation measures, based on data collected in 2011 study in Sydney, Australia.

| Variable | Neutral[a] group | | | Biased[b] group | | | Significance | |
|---|---|---|---|---|---|---|---|---|
| | *n* | *M* | *SD* | *n* | *M* | *SD* | *F* | *p* |
| Consideration of future consequences[c] | 108 | 3.19 | .61 | 108 | 3.31 | .66 | 1.92 | .168 |
| Uncertainty avoidance[c] | 108 | 3.35 | .74 | 108 | 3.45 | .78 | .86 | .354 |
| Anticipated regret[d] | 108 | 3.16 | 1.39 | 108 | 3.17 | 1.35 | .006 | .938 |
| PMT components: | 102 | | | 106 | | | | |
| Intention | | | | | | | | |
| - at baseline[c,e] | | 4.60 | 1.66 | | 4.66 | 1.60 | .07 | .792 |
| - post-manipulation[d,e] | | 4.16 | 1.71 | | 4.27 | 1.53 | .26 | .609 |
| Severity[d,e] | | 5.19 | .93 | | 5.18 | .86 | .002 | .961 |
| Vulnerability[d,e] | | 3.72 | 1.06 | | 3.81 | .94 | .54 | .462 |
| Response efficacy[d,e] | | 4.64 | .79 | | 4.95 | .75 | 8.26 | .004 |
| Self-efficacy[d,e] | | 4.15 | 1.01 | | 4.20 | 1.17 | .10 | .757 |
| Response costs[d,e] | | 4.45 | .60 | | 4.45 | .69 | <.001 | .987 |

Notes:
[a] Neutral = participants receiving neutral information.
[b] Biased = participants receiving biased information.
[c] Measured prior to experimental manipulation.
[d] Measured post-manipulation.
[e] Covariate-adjusted means (controlling for family history of disease).

*Predictors of intention to undergo WGS screening*

Factors significantly correlating with Intention (Table 3) were included in a hierarchical multiple regression, to assess the predictors of Intention. CFC was included, since it was theoretically relevant and marginally significantly correlated with Intention ($r=.13$, $p=.051$). The overall regression model was significant, $F(10, 197)=11.18$, $p<.001$, accounting for 36.2% of the total variance (Table 4). Variables entered in block one did not explain a significant proportion of variance ($R^2=.001$), nor predict Intention (Table 4). PMT variables were entered in block two, accounting for an additional 33.7% of the variance, $\Delta F(5, 200)=20.30$, $p<.001$ (Table 4). In the final model, three PMT variables made a significant unique contribution to the amount of variance explained: response efficacy ($\beta=.34$, $p<.001$), response costs ($\beta=-.25$, $p<.001$), and self efficacy ($\beta=.18$, $p=.024$) (Table 4). UA made a significant unique contribution ($\beta=.18$, $p=.019$), controlling for the effects of other variables; CFC and AR did not (Table 4). Together, UA, CFC, and AR accounted for an additional 2.4% of the total variance, *over and above* the PMT variables. This was marginally significant, $\Delta F(3, 197)=2.52$, $p=.059$ (Table 4).

## Discussion

The present findings suggest that intention to undergo WGS screening for personal disease susceptibility is likely to be moderate among young healthy adults with a limited family history of disease and familiarity with screening. This parallels other types of genetic testing (e.g., Morrison et al., 2010).

Omitting the limitations of WGS screening led to stronger beliefs about screening efficacy and benefits, but did not affect intention. For individuals expressing moderate intention, viewing cost-benefit information appears to lower screening intention *regardless* of whether the limitations are presented. These findings accord with Cameron and Diefenbach (2001), and meta-analytic findings suggesting that PMT-based information manipulations have a greater impact on cognitions than behavioural intentions (Webb and Sheeran, 2006).

The finding that omitting limitations did not affect screening intentions was unanticipated. This contrasts with Sweeny and Legg (2011), who found that viewing limitations of genetic testing weakened perceptions of both benefits *and* test taking intentions. Methodological differences may explain this, since both experimental groups viewed screening 'costs' in the present study. This was done so the manipulation targeted only a single variable (response efficacy) and because the total omission of barrier-related information was not considered

**Table 3**
Correlations between Protection Motivation Theory variables, consideration of future consequences, uncertainty avoidance, and anticipated regret, based on data collected in 2011 study in Sydney, Australia.

| Variable | Severity | Vulnerability | Response efficacy | Self-efficacy | Response costs | Consideration of future consequences | Uncertainty avoidance | Anticipated regret | Intention (post-manipulation) |
|---|---|---|---|---|---|---|---|---|---|
| 1. Severity | – | | | | | | | | |
| 2. Vulnerability | .01 | – | | | | | | | |
| 3. Response efficacy | .20** | −.07 | – | | | | | | |
| 4. Self-efficacy | −.01 | .05 | .52** | – | | | | | |
| 5. Response costs | .11 | .08 | −.22** | −.42** | – | | | | |
| 6. Consideration of future consequences | .07 | −.02 | .28** | .26** | −.19** | – | | | |
| 7. Uncertainty avoidance | .10 | .03 | .49** | .45** | −.28** | .26** | – | | |
| 8. Anticipated regret | .02 | .03 | −.48** | −.51** | .39** | −.17** | −.60** | – | |
| 9. Intention (post-manipulation) | .14* | .08 | .50** | .43** | −.36** | .13+ | .39** | .30** | – |

Notes: *$p<.05$, **$p<.001$, +$p=0.05$.

reflective of real world sources of health screening information (Jorgensen and Gotzsche, 2004). Alternatively, an increase in perceived response efficacy alone, without changing other PMT variables (increased perceived self-efficacy or decreased perceived response costs), may not have produced a sufficient global increase in coping appraisals, and thus intention to perform the health protective behaviour (Rogers, 1983). The present sample also indicated low-to-moderate likelihood of having an increased disease risk. Although not directly measured, this finding may reflect a tendency to perceive oneself as having lower personal vulnerability to health problems compared to peers (Weinstein, 1982). In accordance with PMT, weak vulnerability beliefs may have kept overall threat appraisals low in this sample, and since protection motivation relies on both threat appraisals and coping appraisals being high, increased response efficacy perceptions alone would not have strengthened screening intention. Together, these points may partially explain why the biased information pamphlet affected response efficacy but not screening intention in the present study.

**Table 4**
Hierarchical multiple regression analyses predicting post-manipulation intention to undergo WGS screening, based on data collected in 2011 study in Sydney, Australia.

| Dependent variable: Intention | | | | | | | |
|---|---|---|---|---|---|---|---|
| Independent variables | *B* | SEB | *ß* | *t* | $R^2$ | $\Delta R^2$ | $\Delta F$ |
| Model 1 | | | | | .001 | .001 | .87 |
| (Constant) | 4.15 | .22 | | 18.81 | | | |
| Family history of disease | .01 | .07 | .01 | .08 | | | |
| Information framing group | .12 | .23 | .04 | .51 | | | |
| Model 2 | | | | | .34** | .34** | 20.30** |
| (Constant) | 1.57 | 1.15 | | 1.37 | | | |
| Family history of disease | −.04 | .06 | −.043 | −.70 | | | |
| Information framing group | −.11 | .19 | −.035 | −.60 | | | |
| *Protection Motivation Theory components:* | | | | | | | |
| Severity | .17 | .11 | .10 | 1.58 | | | |
| Vulnerability | .05 | .10 | .03 | .44 | | | |
| Response efficacy | .70 | .15 | .34 | 4.66** | | | |
| Self efficacy | .25 | .11 | .17 | 2.23* | | | |
| Response costs | −.590 | .16 | −.24 | −3.70** | | | |
| Model 3 | | | | | .36** | .02+ | 2.52+ |
| (Constant) | .85 | 1.32 | | .64 | | | |
| Family history of disease | −.05 | .06 | −.05 | −.83 | | | |
| Information framing group | −.12 | .19 | −.04 | −.61 | | | |
| *Protection Motivation Theory components:* | | | | | | | |
| Severity | .15 | .11 | .08 | 1.39 | | | |
| Vulnerability | .03 | .10 | .02 | .33 | | | |
| Response efficacy | .69 | .16 | .34 | 4.30** | | | |
| Self efficacy | .26 | .12 | .18 | 2.28* | | | |
| Response costs | −.64 | .16 | −.25 | −3.88** | | | |
| *Additional factors*: | | | | | | | |
| Consideration of future consequences | −.23 | .16 | −.09 | −1.49 | | | |
| Uncertainty avoidance | .38 | .16 | .18 | 2.37* | | | |
| Anticipated regret | .16 | .10 | .14 | 1.66 | | | |

Notes:
*$p<.05$, **$p<.01$, +$p=.06$.
Regression method = enter.

PMT provided a useful theoretical framework for understanding the factors underlying WGS screening intention; almost all of the variance explained was attributable to components in PMT. All three coping appraisal variables in PMT predicted screening intention, with perceived response efficacy and costs emerging as particularly strong predictors. These findings support previous research showing that coping appraisals are the best predictors of health screening intentions (e.g., Norman et al., 2005).

In contrast to Helmes (2002), threat appraisals did not predict intention and the present PMT-based model explained a lower proportion of the variance in screening intention (36% versus 51%, Helmes, 2002). Threat appraisals may not have predicted intention because the present study used a mostly young adult sample, whose appraisals of disease severity and vulnerability may have been limited by the distal nature of disease risks revealed by WGS screening. This seems unlikely given that other studies (e.g., Morrison et al., 2010) involving young, healthy adult samples found an association between perceived personal risk and intention to undergo genetic testing for a future-onset disease. A more likely explanation comes from Sweeny and Legg (2011), who assert that threat beliefs pertain to specific disease outcomes, and thus do not make sense when screening provides feedback on multiple disease outcomes, as with WGS screening. Unidimensional measures (Norman et al., 2005) may not effectively capture threat perceptions regarding multiple diseases, thus explaining the lower predictive ability of PMT in this study.

In addition to PMT factors, screening intention was predicted by uncertainty avoidance (UA), but not anticipated regret (AR) or consideration of future consequences (CFC). As with genetic testing (e.g., Braithwaite et al., 2002), a desire to resolve health-related uncertainty appears to increase motivation to pursue WGS screening in this young healthy adult population. This is despite WGS screening being unable to provide definitive or 'certain' results (Wright and Kroese, 2010). In Wolff et al. (2011) individuals higher on UA showed increased genetic testing motivation even if they would continue to face uncertainty post-screening (50% chance of disease onset). These findings suggest that the substantial uncertainty associated with WGS screening

results may *not* detract from its appeal to people who avoid health-related uncertainty.

This study's use of a multi-item rather than a single item AR measure (Frost et al., 2001; Sweeny and Legg, 2011) may have provided a more reliable measure of the underlying construct (Pallant, 2005), but diminished its ability to predict intention. Alternatively, AR may not be highly relevant in this young asymptomatic population. Here, *anticipatory* emotions (experienced *at the time of* decision making) may play a more important role, since WGS screening requires decisions about distal future outcomes which involve risk and uncertainty (i.e., future health status, Loewenstein et al., 2001). Further, CFC may not predict health behaviours lacking a clear relationship between immediate and future consequences (Strathman et al., 1994). This applies to WGS screening, with limited and inconsistent evidence of its short and long term clinical utility (e.g., Ashley et al., 2010; McBride et al., 2010).

### *Strengths and limitations*

To the authors' knowledge, this is the first psychosocial study to examine the factors influencing anticipated WGS screening uptake. Strengths of this study include its use of an expected target population for screening: healthy young adults, who are young enough to maximally benefit from early disease-preventive interventions (HCN, 2010). Secondly, characteristics of this study's self-selecting sample may also characterise early adopters of genetic susceptibility testing (Sweeny and Legg, 2011): participants may have been more knowledgeable about genetics and genomics, more interested in screening, and more health conscious, compared to non-participants. Thus, the present findings may be of relevance to future WGS screening uptake. Thirdly, this study employed a theory-based information manipulation, which is more effective than those without a theoretical basis (Webb and Sheeran, 2006).

There are several limitations to the findings. Firstly, the unique characteristics of this relatively educated and young sample may limit the generalisability of the findings to the general population. More educated individuals demonstrate greater health knowledge and literacy (O'Neill et al., 2010) and show greater interest in genetic screening (Morrison et al., 2008). Young adults may differ in their reasons for pursuing WGS screening, hold more optimistic bias, and be less able to foresee future health consequences, since people tend to draw on their past experience of health problems when estimating their future vulnerability (Weinstein, 1987). However, the present sample reported moderate consideration of future consequences, which is comparable to older samples (Orbell et al., 2004; Orbell and Hagger, 2006). Secondly, participant attitudes and intention were assessed immediately after viewing the information manipulation, with no longer term follow up. Although this design limitation is common in experimental studies (e.g., Morrison et al., 2010), it prevents conclusions about the stability of screening-related cognitions and intention over time. Finally, screening intention may not translate into actual uptake. Since WGS screening is currently expensive with limited availability, the measurement of behaviour was not feasible.

### *Clinical implications and future research*

Future screening providers – both clinical and commercial – need to ensure that prospective WGS screening participants are informed of its limitations, as failure to disclose this information could potentially inflate perceived efficacy and benefits. Future research is needed to ascertain whether these heightened efficacy beliefs remain stable over time. Cost-benefit information appears to moderate WGS screening intention, highlighting the importance of balanced information provision in future screening programmes (Cameron and Diefenbach, 2001). Future research should determine if cost-benefit information also moderates screening intention in a more representative general population sample. A desire to resolve health-related uncertainty could be a potentially strong motivator of screening intention in this population. Therefore it is imperative that WGS screening programmes promote awareness that some screening results are only weakly predictive of a disease (O'Neill et al., 2010), dispelling any misconceptions that screening provides a means of obtaining absolute certainty regarding disease risk and future health (Braithwaite et al., 2002).

## Conclusions

This study suggests that in this population of young healthy adults, future WGS screening invitations may be driven by perceived benefits and costs, self-efficacy beliefs, and attitudes towards health-related uncertainty. Certain screening-related attitudes appear modifiable in response to available information. With the foreseeable availability of, and current interest in WGS screening, further psychosocial research is needed to guide the development of information materials, and determine which factors underlie intentions. PMT appears to be an appropriate psychosocial model for future research in this setting.

#### Conflict of interest statement

The authors declare that there are no conflicts of interest.

## Appendix A. Supplementary data

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.ypmed.2012.08.008.

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