What type of information is trusted by whom? A multilevel analysis of the stability of the information source-trust association for blood transfusion

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ABSTRACT

BACKGROUND: It has been suggested that transfusion information from scientific sources (vs. popular sources) is seen as more trustworthy and that interventions should consider using scientific styles. Before such suggestions can be implemented, it is necessary to know if this science source-trust link is observed across different sociodemographic groups and psychological characteristics. A large-scale field-based study examining the importance of sociodemographics and psychological characteristics on the source-trust link was conducted.

STUDY DESIGN AND METHODS: A large field-based experiment (the Euro Blood Substitutes Project) was conducted on four different samples (the general public, blood donors, patients, and health experts) in the UK and The Netherlands (total n = 3935). Questions examined levels of trust about sources of transfusion medicine, various aspects of knowledge, and demographic data.

RESULTS: People differentiated between scientific and popular sources, with scientific sources perceived as more trustworthy. General trust in transfusion medicine was higher for those who believe that they or scientists were knowledgeable about transfusion medicine or genetic modification (GM). This suggests that people do not differentiate in their subjective knowledge between GM and transfusion medicine. This science trust-source relationship was moderated by a variety of demographic (e.g., younger people were more likely to trust scientific sources) and psychological (e.g., those who rate science as knowledgeable were more trusting of scientific sources) factors.

CONCLUSION: The trust-source link is not stable and communications should be targeted to the specific population samples for which they will be most effective; scientifically styled information will be particularly effective for communicating information within certain populations.

Peoples' decisions to both donate blood or accept a transfusion are influenced by their perceptions of risk or safety associated with donation or transfusion [1-3] with increased perceptions of risk associated with reduced acceptance.[1,4] One important factor linked to perceptions of risk is perceived trust.[5,6] Indeed perceived trust is also a key factor contributing to people's confidence in commercial products that, like transfusion, are associated with some degree of risk (e.g., food safety).[7] Importantly the evidence suggests that perceived trust in regulators is of particular importance in this regard.[7] Similarly within the context of transfusion medicine it has been shown that levels of trust vary as a function of different sources of information, with medical and scientific sources trusted more than popular sources of information.[8] Taken together the above evidence implies that transfusion medicine information from scientific sources should be perceived as more trustworthy. As well as potentially reducing perceptions of risk, engendering a sense of trust is in itself important for patients.[7] However, the stability of the relationship between source of information (scientific versus popular) and perceptions of trust (i.e., the source-trust link) is an important consideration that has not previously been explored. Stability of the transfusion source-trust link refers to the extent to which this general pattern (more trust ascribed to scientific sources of information on transfusion) is observed across various sociodemographic groups (age, sex, socioeconomic status, etc.) and for different psychological factors (e.g., knowledge).[9-12] If it is not stable, interventions that attribute information to different sources will need to be targeted at specific populations. The central goal of this article is to examine the source-trust link, and the stability of this link, within a large population-based representative sample.

Moderators of trust and the source-trust link

Demographic factors

A number of demographic differences influence levels of trust.[9,10] For example, people's level of trust tends to increase with age[11,12] and this suggests that the source of information may be less important for older populations. However, evidence regarding the direction and extent of differences relating to sociodemographic factors such as gender, income, or education is mixed.[13] There are also differences in levels of general trust between nationalities. The United Kingdom is characterized as a low to medium trust society while many other European countries (including The Netherlands), in particular Nordic countries, are higher-trust societies.[14]

Knowledge

Knowledge is a multifaceted construct encompassing personal knowledge, beliefs about others' knowledge, and knowledge structure.[15,16] Personal knowledge refers to what people objectively know (e.g., via multiple choice questions) or subjective knowledge in terms of what they think they know (e.g., via self-reports).[15] Personal knowledge is important in determining judgments of trust[3,8] with subjective knowledge, rather than objective knowledge, being related to judgments of trustworthiness: those who believe they are more knowledgeable about a hazard exhibiting higher levels of trust.[3,8]

Belief in others' knowledge is also a key determinant of risk perceptions.[17] Of importance is the extent to which people believe that scientists are knowledgeable about a topic.[17] Trust is likely to be lower when people believe scientists are contradicting themselves and when experts disagree with each other.[18,19] While scientific sources of information are generally the most trusted, this may only be the case when people believe that scientists are knowledgeable. Therefore, if the current level of scientific understanding is perceived as being low, then scientific sources are likely to be rated as less trustworthy.[20,21]

Knowledge structure, rather than being about facts, refers to the way in which people cognitively represent their knowledge.[16] For example, knowledge about family may be stored and represented differently from knowledge about the geography of North America, but less differently than knowledge about friends. Thus people are more likely to make errors recalling information about friends and family than family and geography. A recent study of the knowledge structure relating to blood transfusion showed that people represented blood transfusion and genetic modification (GM) products similarly as low risk (e.g., compared to smoking) and as not well understood by the general public.[22,23] Thus, in terms of the structure of their knowledge, people distinguish little between blood transfusion and GM products. This cognitive overlap was further investigated in this study by asking participants to report their own knowledge and their beliefs in scientists' knowledge about transfusion and GM. If there is conceptual overlap then it would be predicted that both transfusion and GM-related questions should show a high correlation and a similar pattern of association with trust and the source-trust link.

Information framing

Finally the way that information is presented or framed influences how people respond to it.[24,25] In this study we manipulate whether the information focuses on either 1) blood transfusion/donation from donors and modified artificial sources (domain specific) or 2) GM procedures in general (domain general). The transfusion versus GM distinction was adopted to examine the conceptual overlap between transfusion and GM.[22,23] That is, does specific information on blood donation help people to separate their cognitions on transfusion from those on GM? This would be evidenced for example if those exposed to transfusion information were more trusting of transfusion products while GM products are generally not trusted. Furthermore, previous research finds that messages tailored to a target group are more effective than generic messages.[26,27] However, there is no research regarding the effectiveness of messages that provide domain-specific versus general information regarding the topic under investigation.

Hypotheses and aims

We have five main questions within this study:

1. Are some sources of information perceived as more trustworthy than others?

- It is predicted that scientific sources will be seen as more trustworthy than nonscientific sources.

2. Are there individual differences in levels of trust?

- It is predicted that older people will be more trusting as will experts.

3. Is the source-trust link moderated by demographic and psychological factors?

- It is predicted that this relationship will be stronger when either self-reported knowledge is high or perceptions in scientific knowledge are high.

4. Do people distinguish knowledge about transfusion from GM knowledge?

- It is predicted that there will be strong associations between knowledge about transfusion medicine and GM.

5. Will domain-specific (transfusion) information lead to higher levels of trust than general (GM) information?

- It is predicted that specific information will lead to higher levels of trust.

MATERIALS AND METHODS

The current study utilizes data obtained from the Euro Blood Substitutes Project, a large multinational program of research that examined a variety of factors relating to donor blood and blood substitutes (see http://www.eurobloodsubstitutes.com for further details[4]). The data reported here is from a field-based experiment conducted in both the United Kingdom and The Netherlands. Part of this project examined levels of trust in a range of different sources with regard to blood transfusion/donation. This study examined trust in blood transfusion/donation information within a large random sample of the UK population and a database of survey candidates in Holland. As well as a sample of the general public, data were gathered within three additional target groups with an interest in transfusion medicine: blood donors, patients, and health experts. All respondents were randomly assigned to receive one of two conditions, specific blood donation/transfusion information, or general GM information, to examine the impact of this information on responses. (A no-information control was also included in the UK sample only. These subjects were excluded from these analyses.) To date, this is the largest study to have examined trust in information regarding transfusion medicine within different groups in such a comprehensive manner. Materials and method were approved by the local ethical review board.

Survey instrument

The following variables were assessed.

Estimates of trust: Survey questions examined a range of evaluative dimensions relating to transfusion medicine. Those of specific concern for the purpose of this study are questions that focused on trust. Questions asked participants to rate nine different sources of information in terms of trustworthiness of information about blood transfusion/donation. These sources were chosen to cover the range of different informational media and are similar to those used in previous research.[8,28] Donation and transfusion were grouped together as previous work shows that people treat them almost synonymously.[3] The specific questions and the format of their presentation are detailed in the appendix.

Subjective knowledge: Participants' subjective knowledge was assessed in terms of their self-reported knowledge and their perception of scientists' knowledge about GM and blood donation/transfusion. The specific questions and the format of their presentation are detailed in the appendix.

Objective knowledge: Participants also answered two multiple-choice questions that were designed to examine levels of knowledge about blood donation/transfusion; these comprised the objective knowledge measure (see appendix). Questions were chosen from a battery of questions used within a previous study[8] as those that displayed high variance between participants and were therefore best able to distinguish between different levels of knowledge.

Participant data

Across groups, a total of 3935 responses were sampled; this included 1646 British responses and 2289 Dutch responses. Participants from the general public were recruited by sending out questionnaires with a stamped addressed reply envelope to individuals. In the United Kingdom, 12,000 questionnaires were randomly distributed and 1065 responses were received, which (after those that had been returned as address unknown were subtracted) provided a response rate of 9.1%. In The Netherlands, 6000 questionnaires were sent to a database of potential survey candidates and 1153 responses were received providing a response rate of 19.3%.

The blood donor samples were recruited in person at donor centers and community-based donor sessions within the United Kingdom and The Netherlands. In the United Kingdom, 416 blood donors were recruited (72.0% response rate), and in The Netherlands, 767 blood donors were recruited (76.7% response rate). Patients were recruited in person in hospitals by medical staff and research nursing staff. In the United Kindgom, 99 cardiac and orthopedic patients were recruited (46% response rate), and in The Netherlands, 246 cardiac and orthopedic patients were recruited (100% response rate). The health experts were recruited in person in hospitals in the United Kingdom and were recruited by post in The Netherlands. Altogether, 66 health experts were recruited in the United Kingdom (66% response rate) and 123 health experts were recruited in The Netherlands (12.3% response rate).

Demographic data for the full sample are presented in Table 1. The general public sample contains slightly more women compared to the overall populations which are 51.4% female in the UK and 50.5% female in The Netherlands.[29] Demographics also vary somewhat between sample groups. Donors were younger than the general population, patients were older than the general population, and health experts tended to be young to middle-aged, with a high level of education and a high level of income.

TABLE 1. Demographic data split by nationality and sample group*

	Public		Donors		Patients		Experts	
Demographic	**UK**	**N**	**UK**	**N**	**UK**	**N**	**UK**	**N**
Sex								
Male	39.4	47.3	36.1	66.1	50.5	48.8	26.7	75.7
Female	60.6	52.7	63.9	33.9	49.5	51.2	73.3	24.3
Age (years)								
≤20	7.6	1.5	6.0	0.7	0	2.4	0	0
21-30	14.7	12.0	10.3	9.6	1.1	9.3	49.2	0.9
31-40	17.0	15.5	23.0	14.8	2.2	16.1	35.6	16.2
41-50	36.0	20.7	25.4	24.8	9.8	25.9	13.6	42.3
51-60	22.8	21.9	25.8	34.7	21.7	17.1	1.7	37.8
61-70	1.5	14.6	9.5	15.4	33.7	16.6	0	2.7
71-80	0.2	11.2	0	0	27.2	12.2	0	0
>80	0	0.1	0	0	4.3	0.5	0	0
Income (£)†								
≤10,000	25.7	15.3	27.5	9.1	28.0	14.7	1.7	0
10,001-20,000	29.3	37.8	39.4	23.3	28.0	32.7	22.4	0
20,001-30,000	20.6	28.8	21.2	38.6	28.0	32.1	58.6	2.0
30,001-40,000	11.6	11.4	9.3	18.8	8.0	7.7	13.8	3.0
>40,000	12.7	6.8	2.6	10.2	8.0	12.8	3.4	95.0
Education (years)								
<16	37.7	19.1	54.0	18.1	28.6	23.3	1.8	0
16-18	24.7	14.6	22.1	16.0	28.6	15.3	23.2	0
>18	37.7	66.3	23.9	65.9	42.9	61.4	75.0	100

* All statistics are stated as percentages of the total sample.
† Income is quoted in pounds and is an approximation of earnings in The Netherlands.
UK = United Kingdom; N = The Netherlands.

Data analysis
Of the overall sample of 3935, a total of 748 participants stated that they did not read the accompanying experimental information or did not respond to the question asking them if they had read this information. These subjects were excluded (we cannot assess the effect of information if it was not read) as were those in the United Kingdom no-information control

group, leaving a usable sample of 3187.

The analysis plan was to first explore the hypothesis that the nine sources of information conformed to two factors representing scientific and popular sources as identified by others.[8] This was examined using a mixture of exploratory analysis using principal components followed by confirmatory analysis using confirmatory factor analysis (CFA). A mixture of exploratory and confirmatory analyses was used, because while other studies have reported a distinction between scientific and popular sources, not all studies have used the same sources and it was felt that it was necessary to explore this distinction and then confirm it. This is a standard cross-validation procedure in the literature.[30] Given the large sample attained for this study, the sample was randomly split into two equal samples. The exploratory analysis was conducted on the first sample and the confirmatory procedures on the second.

The nine individual estimates of trust are nested within individuals who differ in terms of framing information received, demography, and psychology and as such multilevel modeling (MLM) is the appropriate statistical analytic approach for these data.[31,32] It is not appropriate to analyze hierarchically nested data of this type with standard regression procedures as these require aggregation and, as such, within-subjects and between-subjects errors are confounded. This leads to biased estimates of standard errors, reduced statistical power, and a variety of biases with respect to data interpretation (e.g., ecologic fallacy). There are a number of detailed descriptions of the rationale behind MLM for those who require more detail.[31-34] Furthermore, MLM allows for moderation effects of individual difference variables (framing information received, demographics, and psychology) on the source-trust relationship to be examined in a way that cannot be achieved with standard ordinary least-squares regression. As such, it is ideally suited to explore the specific hypothesis about the source-trust relationship proposed in this article. For example, it means that it is possible to examine if the strength of the relationship (slope) between trust and source of communication (e.g., scientific or popular) varies as a function of Level 2 variables (i.e., examining cross-level interactions). For example, this approach allows the examination of whether the source-trust relationship is stronger for younger participants.

MLM analyses were carried out using HLM6 software.[31] The Level 1 variables were the within-subjects indices of source of information and trust estimates with the Level 2 variables consisting of the between-subjects demographics and psychological variables. None of the Level 1 and Level 2 categorical and nominal variables were centered. Level 2 variables that were measured on a continuous scale (e.g., self-stated knowledge about blood donation/transfusion or GM products) were grand mean centered.[32] Within information frame, domain-specific information was coded as 1 and domain general information as 2. For nationality, Britain was coded as 1 and The Netherlands as 2 and for gender, males were coded as 1 and females as 2. Sample groups were coded in order of expertise from least to most knowledgeable about blood (as determined by a panel of health experts) so codes were general public = 1, patients = 2, blood donors = 3, and health experts = 4. Data were modeled using robust standard errors and all tests were two-tailed. The MLM model development followed recommendation by others with the Level 1 model significant effects (in this case the source-trust association) initially established. After this a saturated Level 2 model was specified, which consists of all the Level 2 variables predicting the mean level of trust (Level 1 intercept scores) and moderating the source-trust relationship (Level 1 slope estimates). Nonsignificant effects from this saturated model were removed and a final model was estimated. Both unstandardized and standardized coefficients—calculated using formulae from Hox[35]—are reported.

Data exclusions, missing data, and imputation strategy

Data of the type collected here are liable to result in a degree of missing data.[36] As such, analytic strategies need to be adopted that allow for missing values to be estimated so that complete data analytic techniques can be applied.[36] Of the variety of techniques available it has been recommended that multiple imputation (MI) procedures are adopted.[36-38] MI techniques are based on the analyses of multiple complete data sets with different plausible values for missing points computed based on a prior distribution and including noise. These multiple values allow for uncertainty in value estimation to be included. Each of the multiple data sets is analyzed and the resulting parameter coefficients and standard errors aggregated to produce a final model estimate.

Within a multilevel model, however, it is necessary to consider the fact that there is missing data at two levels. Gibson and Olejnik[39] have presented convincing data that for Level 2 data, listwise deletion is the most appropriate technique for dealing with missing data. However, with Level 1 data MI strategies should be considered. However, the number of imputed data sets required is based on the proportion of missing data.[38-41] The number of MI data sets required is based on the relative efficiency (RE) of the MI estimates,[38] where RE is determined as follows: $RE = (1 + \gamma/m)^{-1}$, where γ is the proportion of missing data and m is the number of MI data sets. An RE of 0.95 is considered sufficient.[38] Therefore, we used this formula to calculate the number of imputed data sets we would require. Finally, it has been argued that if less than 10% of the data are missing and no more than 10% of data are missing for a single variable, then single imputation (SI) is sufficient.[42]

Full information maximum likelihood (FIML), implemented in LISREL 8.7, was used to deal with missing data when conducting the CFA. FIML is the appropriate procedure for dealing with missing data for CFA producing more accurate results than other techniques for dealing with missing data.[43]

RESULTS

Principal components and confirmatory factor analyses

Of the sample of 3187 participants, 127 recorded no responses on any of the nine sources of information and these were excluded from the subsequent analysis. An additional 84 participants failed to respond to between five and eight of the nine questions, thus having at least 50% of their individual information missing. These were also removed leaving 2976 participants. This final sample had 0.8 of the responses missing indicating a SI would be sufficient. Indeed the RE of a SI was 0.99. The sample of 2976 was randomly split into two equal-sized samples of 1488.

A principal components analysis with varimax rotation was applied to the nine sources of information for blood information to the first random sample of 1488 participants. This sample had 0.7% missing data and a SI had an RE of 0.99. Therefore, missing data was imputed using a single expectation-maximization procedure. The Bartlett's test of sphericity ($\chi^2 = 18613.25$, $p < 0.001$) and the KMO measure of sampling adequacy (0.87) indicated that these data were factorable. The Scree test indicated that a two-factor solution was optimal with two eigenvalues greater than 1 (accounting for 65.6% of the variance). Items were defined as describing a factor if they loaded above 0.40 on a factor.[44] Two main factors emerged (see Table 2), one representing popular sources of information and the other representing scientific sources. Ratings for government sources cross-loaded on the two factors (loaded greater then 0.40 on both factors with a difference between the loading of less than 0.20).[44] These analyses suggested that it was possible to classify eight sources as clearly belonging to either a scientific or popular source (the cross-loading for government sources meant it was not clear which type of source—science or popular—they represented). To confirm this, CFA procedures were applied to the second random sample or 1488 participants.

TABLE 2. Exploratory and confirmatory factor analytic models*

	Exploratory analysis		**Confirmatory analysis**		
Source	**Popular**	**Scientific**	**Popular**	**Scientific**	**Error variance**
Radio	0.84†	0.20	0.86†‡		0.29†‡
Television	0.84†	0.25	0.83†‡		0.31†‡
Newspapers	0.81†	0.16	0.79†‡		0.38†‡
Magazines	0.79†	0.22	0.80†‡		0.36†‡
Friends	0.69†	0.06	0.58†‡		0.67†‡
Internet	0.58†	0.33	0.59†‡		0.65†‡
Government	0.54†	0.41†	0.42†‡	0.20†‡	0.70†‡
Scientists	0.15	0.90†		0.91†‡	0.18†‡
Medical	0.22	0.88†		0.79†‡	0.38†‡

* Figures presented are standardized coefficients that indicate factor loadings, which are the extent to which trust judgments load on the popular or scientific source factors. Large coefficients indicate stronger loadings.

† Sources that are designated as loading onto a factor.

‡ $p < 0.01$.

A two-factor confirmatory model was specified in LISREL 8.7, using FIML. The six items identified from the exploratory analysis as representing the popular sources were specified to load on one factor and the two items representing the scientific sources were specified to load on the other factor. For these items no cross-loadings were specified on the nontarget factor. The item representing the government sources was specified to load on both factors (this represents the cross-loading identified in the exploratory analysis). Factor error variances and loadings were set as free and the latent science and popular factors specified as correlated. The analysis was based on the covariance matrix derived from the nine sources questions. This model showed a reasonable fit to these data (FIML χ^2 (25) = 260.9, $p < 0.001$, root mean square error of approximation [RMSEA] = 0.08) and better fit than a model where the government item loaded only on the popular (FIML χ^2 (26) = 315.3, $p < 0.001$, RMSEA = 0.086) or only on the scientific (FIML χ^2 (26) = 416.3, $p < 0.001$, RMSEA = 0.11) factors. The model was also better fit than a single factor model (FIML χ^2 (26) = 1149.7, p < 0.001, RMSEA = 0.17). It has been argued that the RMSEA should be 0.6 or less to indicate a good fit.[45] For the best fitting target model this was 0.08. However, the model modification index suggested that specifying a single correlated error would improve the fit to this acceptable level. When this was specified it did not alter the pattern of factor loadings. The loadings for this final model (FIML χ^2 (24) = 160.9, p < 0.001, RMSEA = 0.06) are shown in Columns 4 to 6 of Table 2 and indicate that each item loaded significantly on its target factor and that the government questions significantly cross loaded. As such, six items were taken as purely defining popular sources and two items as purely defining scientific sources. For the first random sample (used in the exploratory analysis) both the popular ($\alpha = 0.88$) and the scientific ($\alpha = 0.82$) scales were reliable; the two scales were also reliable in the second random sample (0.88 and 0.83, respectively). Similarly for the overall sample the scales were reliable (popular sources $\alpha = 0.88$; scientific sources $\alpha = 0.83$). Therefore, in the subsequent MLM analyses six items were coded as representing popular sources and two items as representing scientific sources.

Predictors of trust of GM and blood information

Missing data analysis

With respect to Level 2 missing data (e.g., framing information received, demographics, or psychological variables) for the MLM, the data for 965 participants was *listwise* deleted. An additional 36 participants were eliminated at Level 1 as they recorded no trust score data and an additional 11 participants were eliminated who had no trust score data on either popular or scientific sources. These subjects were removed for having extensive levels of data missing at Level 1 and we felt that it was justified to remove the complete data set as these missing data are likely to be for systematic reasons rather than due to random error. This leaves a reduced sample of 2175 subject with potentially 17,400 Level 1 data points. There was a small amount of missing Level 1 data across all of the eight trust estimates (varying from 0.5% to 2.3% across the sources) with an overall missing rate of 1%. This means to achieve a RE of 0.95 or greater would require one imputed data set. Also as less than 10% of the data are missing and no more than 10% are missing for a single variable, this would support the conclusion of using a SI.[42] Scores for each of the missing sources were imputed using an estimation-maximization algorithm. Thus the final data set had 2175 subject (Level 2 data sets) and 17,400 Level 1 data points.

Associations among knowledge measures

Means, standard deviations (SDs), and correlations between the Level 2 variables are shown in Table 3. Participants perceived scientists as more knowledgeable about both GM ($t(2174) = 50.2$, $p < 0.001$, $d = 1.46$) and transfusion medicine ($t(2174) = 59.3$, $p < 0.001$, $d = 1.59$) than they were themselves. This is what would be expected and provides some initial validity for these measures.

TABLE 3. Associations between the Level 2 variables (n = 2175)

Variable	Mean (SD)	(1)	(2)	(3)	(4)	(5)
Objective knowledge (1)	1.03 (0.65)	1				
Self-reported knowledge						
GM (2)	2.97 (1.31)	0.012	1			
Transfusion (3)	3.75 (1.53)	0.043*	0.389†	1		
Perceived science knowledge						
GM (4)	4.97 (1.42)	−0.008	0.078†	0.097†	1	
Transfusion (5)	5.89 (1.13)	0.022	0.002	0.240†	0.465†	1

* $p < 0.05$.
† $p < 0.001$.

There is a small association between objective knowledge about transfusion and self-reported knowledge about blood donation. This again provides some additional validity for this subjective knowledge index. A PCA with varimax rotation on the four subjective knowledge measures indicated a two factor solution (two eigenvalues greater than 1 accounting for 71.8% of the variance with a KMO of 0.48 and Bartlett's test of sphericity of 1060.2, p < 001) with the two self-reported knowledge measures loading on one factor (loadings, 0.86 and 0.84) and the two measures of perceived science knowledge loading on the other factor (loadings, 0.85 and 0.81). There were no cross-loadings. This suggests that people's perceptions of their own knowledge and scientist knowledge are distinct. However, as observed previously, participants do not distinguish between their subjective knowledge of transfusion medicine and GM.

Multilevel models

The following initial MLM was used to test the relationship between source of information (0 = popular and 1 = scientific) and ratings of trust. The initial model was specified with the following equation.

$$\text{Trust} = \beta_{00} + \beta_{10}\,(\text{source of information}) + r_0 + r_1\,(\text{Source}) + e. \quad (1)$$

Within Equation 1, trust is the within person variation in reported trust for the eight different sources of information, β_{00} is the intercept term providing the mean level of trust across the eight sources, and β_{10} is a slope estimate indicating whether the information source (scientific or popular) alters levels of trust. The terms $r_0 + r_1$ (Source) + e specify the error terms for the intercept, slopes, and models, respectively.

The results of this model indicated that the estimates of trust were significantly different from zero ($\beta_{00} = 4.15$, $p < 0.0001$). There was a significant positive association between source and trust estimates ($\beta_{10} = 1.8$, $p < 0.0001$). This indicates that trust increases by just under 2 units when the source is scientific as opposed to when it is popular.

The next models examined the extent to which the average level of trust (Level 1 intercept) and the source-trust association (Level 1 slope) varied as a function of Level 2 between-subjects factors (framing information received, demographic, and psychological variables). Having excluded nonsignificant variables from the saturated model the following final MLM was estimated. Note that information frame was a nonsignificant variable and was removed from analyses.

$$\begin{aligned}\text{Trust} = {} & \beta_{00} + \beta_{01}(\text{income}) + \\ & \beta_{02}(\text{Subjective knowledge of GM}) + \\ & \beta_{03}(\text{Subjective knowledge of blood} \\ & \text{transfusion/donation}) + \\ & \beta_{04}(\text{Beliefs about scientists' knowledge of GM}) + \\ & \beta_{05}(\text{Beliefs about scientists' knowledge of blood}) + \\ & \beta_{10}(\text{source}) + \beta_{11}(\text{sample group} * \text{source}) + \\ & \beta_{12}(\text{age} * \text{source}) + \beta_{13}(\text{income} * \text{source}) + \\ & \beta_{14}(\text{Subjective knowledge of GM} * \text{source}) + \\ & \beta_{15}(\text{Beliefs about scientists' knowledge of} \\ & \text{blood} * \text{source}) + r_0 + r_1(\text{Source}) + e. \end{aligned} \tag{2}$$

Within this model the coefficient β_{00} (Equation 2) represents the mean value for trust across the sources and individuals and the coefficients β_{01} to β_{05} indicate the extent to which mean levels of trust concerning blood transfusion/donation are moderated by demographic/psychological factors. The coefficient β_{10} represents the mean value for the association (slope) between sources of information (science or popular) across individuals and the coefficients β_{11} to β_{15} describe the extent to which this slope is moderated by demographic/psychological factors. These coefficients are central to the source-trust stability hypothesis and represent the cross level interactions of the source-trust association. The terms $r_0 + r_1$ (Source) + e specify the error terms for the intercept, slopes, and models, respectively. The coefficients for this model are presented in Table 4.

TABLE 4. MLM of trust for information regarding blood transfusion/donation

Effect	Symbol	Unstandardized coefficient	Standardized coefficient	p Value
Mean level of trust (intercept)	β_{00}	4.33	4.33	<0.001
Income	β_{01}	−0.06	−0.05	<0.001
Self-rated knowledge				
GM	β_{02}	0.05	0.04	<0.001
Transfusion	β_{03}	0.05	0.05	<0.001
Perceived scientist knowledge				
GM	β_{04}	0.06	0.05	<0.001
Transfusion	β_{05}	0.12	0.09	<0.001
Source-trust association (slope)	β_{10}	1.81	0.50	<0.001
Sample group*	β_{11}	0.09	0.06	<0.001
Age (banded into eight 10-year groups)	β_{12}	−0.06	−0.05	<0.001
Income	β_{13}	0.06	0.05	<0.001
Self-rated knowledge—GM	β_{14}	−0.09	−0.08	<0.001
Perceived scientist knowledge—transfusion	β_{15}	0.14	0.10	<0.001

* Sample groups were coded in order from least to most perceived knowledge: general public = 1, patients = 2, blood donors = 3, health experts = 4.

Examination of the impact of Level 2 variables on the overall mean levels of trust indicated that lower income, higher subjective ratings of knowledge about blood donation/transfusion, and GM products, as well as an increased belief that science is knowledgeable about GM products and blood transfusion/donation, were associated with greater reported levels of trust in all sources of information. These results indicate again that participants do not distinguish knowledge about transfusion and GM as all the assessments are positively associated with levels of trust. Examining the standardized coefficients indicates, however, that perceptions of scientists' knowledge about transfusion have a slightly stronger effect on trust than perceptions of scientists' knowledge about GM.

The first thing to note is that the slope (β_{10}) representing the source-trust link remains significant and positive, indicating that scientific sources of information are rated as significantly more trustworthy than popular sources. The cross-level interactions indicated that there was variability in the source-trust association. Specifically, scientific sources were more likely to be rated as trustworthy by experts, younger people, those with a higher level of income, and those who believe that science is knowledgeable about blood donation/transfusion. Those who rated their own knowledge of GM technology as high were less likely to trust scientific information about blood. It is interesting to note that with regard to the source-trust link the effects of transfusion and GM knowledge are different in that self-rated knowledge about transfusion and beliefs about scientific knowledge about GM did not impact this relationship.

DISCUSSION

Engendering a sense of trust is important for consumer confidence in a product.[7] With respect to transfusion medicine, the results reported here clearly demonstrate that people trust scientific sources of information more than popular sources. This confirms in a large population-based study observations reported previously in smaller-scale studies.[6,8,28] This article advances our understanding of the relationship between trust and source of information by showing that it is not stable but is moderated by a variety of demographic and psychological factors. This finding is the main contribution of this article and has a number of key practical implications for risk communication for transfusion medicine. Specifically information from scientific sources may engender a sense of trust in the blood transfusion process for some people (e.g., younger people, those with a higher income, blood donors, patients) more than others and for people with key psychological characteristics (e.g., those who believe that science is knowledgeable about blood transfusion). Conversely those who believe that they are knowledgeable about GM technology are less likely to trust scientific sources.

Theoretical implications

Confirming previous findings, the results show that subjective rather than objective knowledge was associated with levels of trust. The results extend this by further showing that subjective knowledge moderates the effect of source of information.[8,22] A sense of subjective well-being and positive affect may account for why subjective rather than objective knowledge is associated with perceived trust. There is evidence that trust is associated with a positive sense of well-being.[46-48] People also subjectively feel that they know more than they actually do which is associated with a sense of confidence—again a positive sense of self.[49] Instilling positive emotions has also been shown to increase people's sense of trust.[50] Taken together this implies that the sense of positive well-being associated with subjective knowledge and trust may act to link these constructs together. This leads to the testable hypothesis that positive affect mediates the link between subjective knowledge and perceived trust. The same hypothesized link would be absent for objective knowledge as such information may be stored with partial independence from emotions.[51]

Again, consistent with previous findings, participants did not distinguish transfusion medicine knowledge from GM knowledge in terms of the prediction of general trust and the correlations between knowledge measures. Previous work suggests that this may be because both are associated with a perceived risk and a sense that people are relatively unknowledgeable about them.[22,23] It may also be that both involve some form of biologic manipulation. Donor blood may be "modified" before its clinical use and it is the idea of modification—regardless of the type of modification—that matters. This is something that future research should consider. It would be worth further identifying the dimensions people use to make distinctions between GM and transfusion medicine as this would better inform future risk communications.

Implications for risk communication

These findings can usefully feed into the design of communications. Interestingly our framing manipulation did not have a significant impact on perceptions, contrary to previous research examining other types of framing manipulations.[24-27] This implies that the manipulation of framing in terms of topic specificity (blood vs. GM) is not an effective method of altering the persuasiveness of communications. This may reflect the finding, supported here, that people have a high degree of conceptual overlap between blood transfusion and GM products. However, this does not preclude that other framing techniques might be effective.[52,53]

Engendering a sense of trust is important for confidence in a product and the results here show that people trust scientific sources the most. This basic finding would imply that any information designed to be advertised and aimed at the general population would benefit from being described as derived from scientific sources. However, the results reported here go one step further and show that greater trust in scientific sources of information about transfusion medicine does not hold for everyone. This has two major implications: communications should 1) target information at specific groups and 2) impact psychological factors to facilitate the reception of messages.

With respect to targeting we found, for example, that younger individuals were more likely to trust information from scientific sources. Thus, when recruiting younger blood donors, for instance, or discussing the pros and cons of a transfusion procedure with younger patients, information likely to be received as more trustworthy would be presented as derived from scientific sources. The same would be true for different income levels, as groups with higher income were more likely to trust scientific sources. Information presented in a less formal and scientific manner and reflecting more popular sources may be more useful among older groups. Here, personal stories (of the type they may hear from friends/relatives) may be worthy of consideration.

With regard to psychological factors, the transfusion-GM conceptual overlap was not observed for moderation of the source-trust link as it was for the prediction of trust in general. The results showed that increased belief in the level of scientific knowledge about transfusion medicine lead to people being more trusting of scientific sources of information; however, beliefs in one's own knowledge about GM attenuated this relationship. One possibility for this attenuation is the proposition that people who think they are knowledgeable about GM are more distrusting of science. Thus one possible way to strengthen a belief in science would be to present information that highlights consensus among experts (where it exists), the reliability of findings, and the successes of interventions.

Care needs to be taken with developing potential interventions as described to ensure that the message is clear and of the appropriate reading age, and that numerical information is presented in such a way that recipients of the information are able to understand it.[54,55] However, we caution that the above are only suggestions regarding intervention design and the suggestions should be fully evaluated in small-scale experimental and field-based studies to test their effectiveness and acceptability and identify any potential negative effects for different demographic groups.

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CONFLICT OF INTEREST

There is no conflict of interest for any of the authors.

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APPENDIX: SPECIFIC QUESTIONS AND THE FORMAT OF THEIR PRESENTATION

1. Trustworthiness questions

	Newspapers	Television	Friends	Magazines	Scientists	Medical sources including blood donor services	Radio	Internet	Government sources
How trustworthy is blood donation/transfusion information? 1 = untrustworthy 7 = extremely trustworthy	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7

2. Subjective knowledge questions

	GM products	Blood donation/ transfusion
What would you estimate your knowledge of this subject is? 1 = No knowledge 7 = extremely knowledgeable	1 2 3 4 5 6 7	1 2 3 4 5 6 7
How much do you think science knows about this subject? 1 = No knowledge 7 = extremely knowledgeable	1 2 3 4 5 6 7	1 2 3 4 5 6 7

3. Objective knowledge

a. What is the most common blood group in the UK? (circle your answer)

O B AB A

b. Approximately how many whole-blood donations are collected in the UK each year? (circle your answer)

1 million 3 million 5 million 7 million