ISBT Science Series
An affiliated publication to Vox Sanguinis

ISBT International Society of Blood Transfusion

ISBT Science Series (2016) **11**, 14–23

ORIGINAL PAPER

Public Perceptions of Pathogen Reduction Technology in the Canadian Donor Blood Supply

N. Gray,[1] K. B. Newbold,[1] S. J. Lane,[2] N. M. Heddle,[2,3] K. Webert[4,5] & J. Eyles[1,6]

[1]*School of Geography & Earth Sciences, McMaster University, Hamilton, ON, Canada*
[2]*Department of Medicine, McMaster University, Hamilton, ON, Canada*
[3]*Research and Development, Canadian Blood Services, Hamilton, ON, Canada*
[4]*Medical Office, Canadian Blood Services, Hamilton, ON, Canada*
[5]*Department of Pathology and Molecular Medicine, McMaster University, Hamilton, ON, Canada*
[6]*Centre for Health Policy, School of Public Health, University of Witwatersrand, Johannesburg, South Africa*

Background The safety of the donor blood supply has been a major public health concern to the Canadian public in the past. Multiple safety measures are in place to ensure its continued safety, including a risk-based decision-making process associated with blood-borne pathogen transmission. Pathogen reduction technology (PRT) may provide such an approach by inactivating pathogens in donated blood to prevent spread to a blood transfusion recipient. To date, no research has assessed the Canadian public's opinions of PRT, which can aid in policy development and implementation strategies.

Study Design and Methods This paper details the results of an email survey that was developed around awareness of blood system practices in Canada, opinions of PRT and health risk perceptions to the Canadian public. 1008 individuals from Ontario and Québec responded to the survey.

Results Results indicated that there is a generally low reported knowledge of PRT amongst the Canadian public. Regression analysis revealed that education, employment and prior blood donation have an effect on awareness of PRT.

Conclusions PRT is often met with mixed opinions. The majority of those surveyed agree with its use, yet many were hesitant about the chemical aspect. This also indicates minimal knowledge about PRT and may additionally be a result of the low perceived risk of blood transfusions to the Canadian public. An increase in public awareness around PRT risk may be beneficial in the future if this technology is to be implemented.

Key words: blood donation testing, pathogen inactivation, transfusion medicine

Introduction

Each year, Canadian Blood Services (CBS) and Héma-Québec (HQ) collect approximately 1·1 million volunteer whole blood donations to provide medical therapy to a wide range of patients including those undergoing surgery, chemotherapy and other medical interventions as well as patients with trauma and inherited blood disorders. Donated blood is essential for the health of many Canadians, but it carries the risk of transmitting harmful pathogens to the recipient during transfusion. The Canadian blood supply is currently very safe due to practices such as donor screening and serological testing of donated blood. However, even with these processes in place, the potential transmission of an unknown pathogen still remains since testing can only be conducted for pathogens that are already identified [1]. In the 1970s and 1980s (and prior to the implementation of screening tools), some 1000 Canadians were accidently transfused with blood contaminated with HIV and 30 000 were

Correspondence: K. B. Newbold, School of Geography & Earth Sciences, McMaster University, 1280 Main St. West, Hamilton, ON L8S 4K1, Canada.
E-mail: Newbold@mcmaster.ca

infected with hepatitis C through transfusion [2]. Although many factors contributed to this public health tragedy, a major problem was the delay in recognizing and screening for viruses that caused these infections. Subsequent to the tainted blood tragedy, a culture of zero tolerance and the precautionary principle has routinely been applied to issues of blood policy and decision-making in Canada [3]. More recently, Canadian blood suppliers have moved towards a risk-based decision-making process, with one of its principles to define a level of acceptable risk.

For these reasons, there has been a move over the past decade to develop more effective strategies to minimize the risk of transfusion transmitted infections (TTIs). At the forefront are pathogen reduction technologies (PRTs), innovations which reduce the risk of pathogens (both known and unknown) by inactivating their genetic content. Methods of pathogen inactivation for cellular blood components include INTERCEPT, which utilizes psoralens and UVA light exposure, Mirasol which utilizes riboflavin and exposure of the product to broad-spectrum UV to inactivate blood-borne pathogens [4], and exposure to ultraviolet light C alone [5].

International clinical trials to determine the safety and efficacy of PRT are currently underway in Canada and elsewhere, but the technology has not yet been approved for use in Canada. However, PRT of platelets and plasma is widely used in Europe [6–8]. In December 2014, the US Food and Drug Administration (FDA) approved the use of CERUS's INTERCEPT Blood System for platelets and plasma in the United States [8]. INTERCEPT is already used in other countries such as France, where it is used as a treatment for platelets and plasma, and Switzerland, where it is used as a treatment for platelets [9]. This technology has also been recently used on plasma donations from Ebola survivors in order to maintain protective antibodies in plasma, yet inactivate any potential pathogens donors may transmit [9].

In countries where PRT has been adopted, implementation has moved forward with little public awareness and, to our knowledge, no public discussion [10]. In 2007, a consensus conference was held in Toronto, Canada, to develop recommendations and guide decision-making about PRT. The panel recognized the potential for PRT to add an additional layer of safety to the blood supply, but pointed out that treatment of the nation's blood supply requires 'societal informed consent' [11], most likely for reasons of transparency, an important CBS and Héma-Québec principle following the Krever inquiry into the tainted blood tragedy. To this end, the panel recommended broad consultation with the public, patient and physician stakeholder groups and hospital physician and transfusion groups [11]. Health Canada has indicated that such consultation is essential to moving the regulatory process forward [1].

If PRT is to be introduced into the Canadian healthcare system, it will be valuable to first determine public perceptions and acceptance of this new technology. Despite the currently limited discourse of its potential, no research to date has surveyed the Canadian public on this issue. With a view to inform policy development for PRT, we undertook a four-phase mixed-methods study to explore public and professional stakeholder perceptions of PRT for blood products. Phase one of the research included a systematic search and review of literature related to food irradiation and genetic modification of food in order to identify relevant publications providing information on implementation and education that could be applicable to PRT to inform the development of subsequent phases. Phase two included focus groups and interviews with a range of public and professional stakeholder groups, including media, physician groups, laboratory personnel, blood suppliers, regulators and transfusion specialists. This manuscript reports on phase three – the survey of the general public to assess public knowledge and perceptions of PRT and blood safety. Respondents' socio-demographic information was collected in the survey as were personal views on health risks, hazards and technology that are associated with high and low awareness and positive and negative attitudes towards PRT. Phase four includes a draft report and recommendations.

Materials and methods

Survey

Consistent with mixed-methods, exploratory sequential design [12], the findings from a literature review [13] and focus groups and interviews with blood supply stakeholders [10] were used to inform the design and content of the public survey. The survey was developed by the research team and was piloted internally with colleagues, with feedback used to revise the survey. Overall, feedback indicated that the survey was user-friendly and took respondents an average of 15 min to complete. This study was approved by the Hamilton Health Sciences/McMaster University Research Ethics Board.

The survey consisted of 74 questions of different types including multiple choice, dichotomous, Likert scale and open-ended questions. The first section of the survey assessed blood donation and transfusion experience, perceptions of blood safety and awareness of current blood safety procedures, knowledge of and acceptability of PRT, and willingness to pay for PRT. Perceptions of benefits and risks of PRT were assessed, as were potential ethical concerns about PRT and preferred information delivery

methods. The second section focused on general health risk perception, with respondents asked to rate the severity of a range of health risks (i.e. smoking, obesity, flu, pollution, blood transfusions) on a scale from 'no' risk to 'high' risk. The third section focused on individual and societal views on health risks and included questions about individual control, expert trust and opinions on technology. Standard socio-demographic information such as age, gender, marital status, education, income and postal code was also collected.

Data collection

TNS Canadian Facts, a marketing and social research firm, was commissioned to administer the online survey between 13 and 16 August 2012. An email containing a link to the survey was sent to online panel members (age 18 years and older), a group that had agreed to be approached by TNS to participate in research studies. The survey was voluntary and anonymous and consent to participate was implied by survey completion. The survey was conducted in English and is available from the corresponding author.

Sample size was calculated using a confidence level of 95%, a confidence interval of $\pm 3\%$ and a sampling population of 120 000 (the size of the TNS panel). The response distribution for each question was estimated at 50%, and this rate gave the largest sample size to allow us to calculate the maximum sample size needed, as the exact response rate to each question could not be known. Based on this calculation, we required 1000 responses. Knowing that TNS typically had response rates of 30–35 per cent, it was estimated that 3000 individuals would need to be surveyed. In total, 1008 responses were received; 603 surveys were completed in Ontario and a further 405 in English-speaking Québec.

Statistical analysis

All data analysis was completed using JMP® (version 11.0.0) by SAS Institute Inc Cary, NC, USA. A descriptive analysis of the results was first completed. Descriptive analysis included cross-tabulations of responses by gender and province. For the cross-tabulations, answers 'don't know' or 'unsure' were either added to 'no' responses, or 'neutral' when appropriate. Response proportions between Ontario and Québec residents or between males and females that observationally diverged were tested for significance using z-tests. Statistically significant results were identified at the 0·05 level.

Responses to the set of questions regarding individual and societal views on health risks (individual control, expert trust and opinions on technology) were formed into additive scales to reduce the number of explanatory variables around risk perception. Scales were created by adding the values as follows: no risk = 1, almost no risk = 2, slight risk = 3, moderate risk = 4, high risk = 5, no answer/not sure = 3. Responses on the 5-point Likert scale were grouped based on the overall themes of individual responsibility (stress, cigarette smoking, obesity, motor vehicle accidents, household chemical products, food allergies), little individual control (industrial pollution, bacteria in foods, crime and violence, food additives, flu epidemic, climate change, GMOs, irradiated food products, nanotechnology) and respondent perceptions of healthcare risks (non-prescription drugs, blood transfusions, elective surgery, robotics in medicine, vaccines, new medical technologies, laser eye surgery, alternative health products). These groups were based on associations from risk literature [14, 15] and where the risks fell from perceived low to high risk. Risks dealing with individual responsibility were generally rated by respondents on the high-risk end [median score (out of 5) = 4·17], followed by risks with little individual control (median = 3·89), which were moderate risk, and risks associated with health care, which were generally rated as having the least risk (median = 3·67). This inductive approach meant that a factor design/analysis was not utilized.

Following the descriptive analyses, logistic regression models were built to identify the covariates of blood donation, receipt of blood transfusion and PRT awareness mediated by socio-demographic characteristics and attitudes to other types of risk. Receipt of blood transfusion is determined by the combination of two questions: Has the respondent received a blood transfusion within the past 10 years? and Has an immediate family member of the respondent received a blood transfusion within the past 10 years? These two variables were combined to create the dependent variable since the proportion of respondents who had received a blood transfusion was very low (7·2%). The questions were chosen based on their representation of different levels of awareness of the blood system. Blood donation indicates some level of awareness, while blood transfusion may indicate a higher level of awareness, while individuals who are more aware of the blood system may be more likely to have knowledge of PRT.

Socio-demographic variables were added into the model first, followed by socio-economic variables. Then, province was added, followed by the variable 'Have you ever donated blood?' except in the model of blood donation. Finally, the additive scales were included in the models. For the regressions, answers of 'don't know/unsure' became 'no' for the three dependent variables, in the same manner as they did for cross-tabulations. Declining to answer socio-demographic or socio-economic ques-

tions leads to elimination from the analysis. Statistically significant results were identified at the 0·05 and 0·10 significance levels.

Results

Sample characteristics (not shown) revealed that nearly 43% of respondents had donated blood in the past, and 23% received a blood transfusion themselves or had an immediate family member who had received a transfusion. On a scale from 1 to 10 where a value of 1 is 'not at all safe' and 10 is 'very safe', over three-quarters of the respondents rated the safety of the blood supply as 7 or higher, and almost 75% rated the safety of a blood transfusion a '7' or higher. Most respondents (typically >80%) were also aware of the various measures *currently* used to screen donors and donations, including the use of screening questions, testing for HIV/AIDS and hepatitis, and not accepting donations from people with certain medical conditions.

Although a large proportion of respondents that were aware of the various techniques currently used to ensure the safety of blood products, only approximately 26% of respondents claimed they had heard of PRT as a method to improve blood safety, and 59·2% strongly agreed or agreed with the use of PRT in the preparation of blood products. This comparatively lower awareness is perhaps not surprising given limited public discourse associated with the technique. However, around 45·3% of people agreed or strongly agreed with spending more money to prepare blood using a PRT process. In regard to blood donation, increasing age and educational attainment was generally associated with increased blood donation. Age did not appear to play an observable role with regard to receipt of blood transfusion, nor did any of the other factors. For knowledge of PRT, younger ages were more likely to claim that they were aware of PRT, and knowledge of PRT appeared to increase with education, and somewhat with income.

Table 1 reports the results of *z*-tests comparing responses between females and males and Québec and Ontario residents. Significantly, more males (47·1%) have donated blood than females (39·2%). A higher proportion of males (75·7% vs. 69·7% for females) also believed CBS or HQ take adequate safety precautions when it comes to blood products. A higher proportion of females had knowledge of all blood donation safety techniques, except knowledge of PRT (23·4%). In regard to PRT, more males reported knowledge of the technique (28·6%). More females (60·3%) than males (51·2%) were slightly bothered by PRT and more females believed certain groups (pregnant women, children, immune compromised) should not be transfused with PRT blood products as compared to males.

Examining differences between the provinces, a significantly higher percentage of Québec residents (84·3%) had heard of CBS or HQ, compared to Ontario residents (69·3%). More Québec residents (9·9%) responded as 'definitely not/unlikely' when it came to willingness to receive donated blood utilizing PRT, compared to Ontarians (5·5%). Concurrently, more Ontarians responded as 'probably/definitely' (69·3%). A higher percentage of Québec residents (16·8%) were also bothered greatly by PRT, compared to Ontarians (11·0%). Additionally, a higher percentage of Québec residents (19·0%) disagreed with a higher transfusion frequency associated with PRT than Ontarians (12·6%).

Table 2 reports the results of the logistic regression modelling the predictors of blood donation. Model 1 incorporated just the socio-demographic effects, with females, those aged 35–44 and individuals without children decreasing the likelihood of donation. Modelling the effects of socio-economic variables (Model 2) less than a postsecondary education and an income less than $15 000 a year decreases the likelihood of donation. The full model (Model 3) includes all potential covariates and reveals that females, individuals aged 25–44 and 55–64, individuals with no children and individuals with less than a postsecondary education significantly decrease the likelihood of blood donation. Individuals who rated risks involving little individual control (i.e. pollution, crime, flu, climate change) highly were more likely to have donated blood. Conversely, individuals who rated risks involving individual responsibility highly (i.e. stress, smoking, obesity) were less likely to have donated blood.

Table 3 reports the results of the logistic regression modelling the predictors of blood transfusion. While we may expect to see the likelihood of receiving transfusion increase with age, no socio-demographic factors were significant at the 0·05 or 0·10 levels (Model 1), which likely reflects the comparatively small number of respondents. In the second model (Model 2), which incorporated only socio-economic factors, some postsecondary education significantly increased the likelihood of receipt of a blood transfusion for self or a family member. In the full model (Model 3), some postsecondary education increased the likelihood of transfusion receipt, while previous blood donation decreases the likelihood. Being separated, divorced or widowed also significantly decreased the likelihood of transfusion receipt, but only at the 0·10 level of significance.

Table 4 reports the results of the logistic regression modelling the predictors of PRT knowledge. In the first model (Model 1), females and individuals aged 25–34 were less likely to have knowledge of PRT, but only at the 0·10 level. In the second model (Model 2), no current employment, part-time employment and a high school

Table 1 Response percentages for select survey questions comparing males/females and Québec/Ontario residents

Question	Male (%)	Female (%)	Québec (%)	Ontario (%)
Have you ever donated blood?				
Yes	47·1[a]	39·2[a]	41·2	43·9
No/Not sure	52·9	60·8	58·8	56·1
Have you received a blood transfusion within the last 10 years?				
Yes	7·7	6·9	8·4	6·5
No/Not sure	92·3	93·1	91·6	93·5
Have you heard of CBS or HQ?				
Yes	74·6	75·9	84·2[a]	69·3[a]
No/Not sure	23·4	24·1	15·8	30·7
Do you think they take adequate precautions to protect the safety of blood products?				
Yes	75·7[a]	69·7[a]	73·6	71·5
No/Not sure	24·3	30·3	26·4	28·5
Have you heard of the following techniques that can be used to ensure the safety of blood products?				
Screening questions				
Yes	82·9[a]	89·1[a]	85·7	86·6
No	17·1	10·9	14·3	13·4
Testing for HIV/AIDS				
Yes	87·0[a]	90·5[a]	89·1	88·7
No	13	9·5	10·9	11·3
Testing for hepatitis				
Yes	82·1[a]	85·9[a]	84·2	84·1
No	17·9	14·1	15·8	15·9
Not accepting donations from people with certain medical conditions				
Yes	79·5[a]	87·8[a]	85·9	82·6
No	20·5	12·2	14·1	17·4
Not accepting donations from people who travelled or lived in a different country				
Yes	59·9	63·5	60·3	62·9
No	40·1	36·5	39·7	37·1
Pathogen reduction techniques				
Yes	28·6[a]	23·4[a]	24·4	26·7
No	71·4	76·6	75·6	73·3
Do you agree with the use of PRT in the preparation of blood products in Canada?				
Strongly Agree/Agree	59·5	59	60·5	58·4
Neutral/Don't know/Prefer not to say	39·2	39·3	38·3	40
Disagree/Strongly disagree	1·3	1·7	1·2	1·6
Would you accept being transfused with a blood product that had been prepared using PRT?				
Definitely Not/Unlikely	7·5	7·4	9·9[a]	5·8[a]
Don't Know/Unsure	22·8	28·8	27·6	24·9
Probably/Definitely	69·7[a]	63·8[a]	62·5[a]	69·3[a]
Does the idea of adding a chemical substance in a blood product as part of the PRT process bother you?				
Bothers me a lot	11·3[a]	15·0[a]	16·8[a]	11·0[a]
Bothers me a bit	51·2[a]	60·3[a]	55·6	56·4
Doesn't bother me	37·5[a]	24·7[a]	27·6[a]	32·6[a]
Which groups should not be transfused with a PRT product? (Select all that apply)				
Pregnant women	35·8[a]	53·3[a]	40·9	48·8
Immune compromised	30·1[a]	42·7[a]	33·9	39·3
Children	28·8[a]	39·2[a]	32	36·4
If PRT was safer, but meant you had to be transfused more frequently, how much do you agree with the process?				
Strongly disagree/Disagree	13·7	16·5	19·0[a]	12·6[a]
Neutral/Don't Know/No Answer	52	54·7	51·9	54·6
Agree/Strongly Agree	34·3[a]	28·8[a]	29·1	32·8

n total = 1008.

[a]Significantly different at 0·05 significance level.

Table 2 Logistic regression results: Have you ever donated blood?

	Model 1		Model 2		Model 3	
Independent variable	**Coefficient**	***P*-value**	**Coefficient**	***P*-value**	**Coefficient**	***P*-value**
Female	−0·34	0·0095*			−0·32	0·0341*
(Ref = Male)						
Age 18–20	−0·99	0·1037			−0·86	0·1839
Age 21–24	−0·43	0·2954			−0·44	0·3636
Age 25–34	−0·30	0·2121			−0·64	0·0284*
Age 35–44	−0·41	0·0880**			−0·82	0·0051*
Age 45–54	−0·07	0·7524			−0·30	0·2651
Age 55–64	−0·31	0·1430			−0·54	0·0290*
(Ref = Age 65+)						
Single	−0·06	0·7504			−0·06	0·7780
Separated	0·09	0·6456			0·06	0·7868
(Ref = Married)						
Does not have children	−0·38	0·0224*			−0·39	0·0332*
(Ref = Has children)						
Immigrant to Canada	0·04	0·7943			0·04	0·8374
(Ref = Born in Canada)						
Not High school grad			−1·61	0·0002*	−1·78	<0·0001*
High school grad			−0·63	0·0014*	−0·76	0·0003*
Some postsecondary			−0·36	0·0283*	−0·42	0·0152*
(Ref = postsecondary grad)						
Income <15 000/year			−0·60	0·0736**	−0·36	0·3346
Income 15 000–24 999/year			0·23	0·4405	0·32	0·3151
Income 25 000–49 999/year			−0·14	0·5394	−0·12	0·6406
Income 50 000–74 999/year			0·03	0·8869	0·05	0·8338
Income 75 000–99 999/year			0·24	0·3342	0·21	0·4099
(Ref = Income >100 000/year)						
Part–time employment			−0·31	0·1348	−0·29	0·1955
Retired/Unemployed			0·01	0·9411	−0·21	0·2883
(Ref = Full–time employment)						
Ontario resident					0·05	0·7430
(Ref = Québec resident)						
Individual Responsibility					−0·33	0·0655**
Little Individual Control					0·37	0·0319*
Health care					−0·11	0·3804
RSquare	0·0209		0·0364		0·0637	
-LogLikelihood	661·04		587·79		560·75	
Whole Model *P*-value	0·0030		<0·0001		<0·0001	
n	**987**		**889**		**872**	

*$P < 0·05$.

**$P < 0·1$.

education decreased the likelihood of PRT knowledge. In the full model (Model 3), individuals with high school level educational attainment along with individuals who were employed part time were less likely to have heard of PRT. However, individuals who had donated blood and who rated healthcare risks high (i.e. moderate to high risk associated with non-prescription drugs, blood transfusions, elective surgery, and vaccines) were more likely to be aware of PRT.

Discussion

The introduction of PRT to the Canadian blood supply is a potentially transformative safety measure. Yet, despite its use in other countries, only 26% of respondents from Ontario and Québec were aware of PRT, although this is perhaps not surprising given limited public discussion about PRT. Yet, a majority of respondents agreed with the use of PRT for the preparation of blood products and

Table 3 Logistic regression results: Have you or a family member ever received a blood transfusion?

	Model 1		Model 2		Model 3	
Independent variable	**Coefficient**	***P*-value**	**Coefficient**	***P*-value**	**Coefficient**	***P*-value**
Female	0·11	0·4653			0·06	0·7414
(Ref = Male)						
Age 18–20	−0·02	0·9682			0·33	0·6235
Age 21–24	−0·21	0·6599			0·27	0·6180
Age 25–34	0·01	0·9893			0·26	0·4420
Age 35–44	−0·20	0·4835			−0·09	0·7849
Age 45–54	−0·12	0·6301			−0·006	0·9829
Age 55–64	0·10	0·6856			0·25	0·3673
(Ref = Age 65+)						
Single	−0·16	0·4781			−0·27	0·2981
Separated	−0·16	0·4664			−0·49	0·0578**
(Ref = Married)						
Does not have children	0·002	0·9919			0·02	0·9246
(Ref = Has children)						
Immigrant to Canada	−0·24	0·2234			−0·17	0·4438
(Ref = Born in Canada)						
Not High school grad			0·006	0·9886	0·0005	0·9991
High school grad			0·35	0·1099	0·31	0·1871
Some postsecondary			0·51	0·0062*	0·52	0·0064*
(Ref = postsecondary grad)						
Income <15 000/year			0·06	0·8741	0·34	0·4270
Income 15 000–24 999/year			0·45	0·1843	0·47	0·1996
Income 25 000–49 999/year			0·17	0·5534	0·19	0·5300
Income 50 000–74 999/year			0·28	0·3215	0·28	0·3270
Income 75 000–99 999/year			0·001	0·9968	−0·06	0·8415
(Ref = Income >100 000/year)						
Part–time employment			−0·11	0·6661	−0·06	0·8217
Retired/Unemployed			−0·03	0·8928	−0·05	0·8189
(Ref = Full-time employment)						
Ontario Resident					−0·16	0·3504
(Ref = Québec resident)						
Scale: Individual responsibility					−0·11	0·5732
Scale: little individual control					0·23	0·2407
Scale: Health care					−0·15	0·2817
Donated Blood					−0·25	0·0028*
(Ref = No)						
RSquare	0·0048		0·0131		0·0338	
-LogLikelihood	534·28		479·61		456·88	
Whole Model *P*-value	0·9250		0·2362		0·1950	
n	**987**		**889**		**862**	

*$P < 0·05$.

**$P < 0·1$.

would accept being transfused with blood that had been treated with PRT. However, a majority of respondents were also slightly or very bothered by the chemical aspect of PRT. People also seemed to be unsure of the benefits of PRT when it comes to transfusion frequency or economic value. Additionally, there appeared to be some hesitation regarding the universal use of PRT-treated blood products. This is coupled with a low perceived risk of blood transfusions and may indicate uncertainty towards the technology.

Overall, we would argue that there is relatively low knowledge of PRT in the Canadian public despite the 26% of the sample that indicated that they were aware of PRT as a method to improve blood safety. This proportion likely overstates awareness of the technique given the limited public discussion of PRT within Canada [10].

Table 4 Logistic regression results: Have you ever heard of pathogen reduction technology as a blood safety technique?

	Model 1		Model 2		Model 3	
Independent Variable	**Coefficient**	***P*-value**	**Coefficient**	***P*-value**	**Coefficient**	***P*-value**
Female	−0·25	0·0984**			−0·18	0·2923
(Ref = Male)						
Age 18–20	0·61	0·2787			0·88	0·1518
Age 21–24	0·60	0·1604			0·63	0·2107
Age 25–34	0·46	0·0798**			0·19	0·5584
Age 35–44	0·17	0·5264			−0·03	0·9337
Age 45–54	0·07	0·7907			−0·14	0·6440
Age 55–64	−0·34	0·1876			−0·37	0·2036
(Ref = Age 65+)						
Single	−0·16	0·4616			−0·14	0·5870
Separated	0·21	0·3191			0·12	0·6127
(Ref = Married)						
Does not have children	−0·04	0·8110			−0·11	0·5879
(Ref = Has children)						
Immigrant to Canada	−0·21	0·2637			−0·30	0·1596
(Ref = Born in Canada)						
Not High school grad			−0·32	0·4151	−0·32	0·4396
High school grad			−0·54	0·0220*	−0·53	0·0337*
Some postsecondary			−0·09	0·6156	−0·15	0·4543
(Ref = postsecondary grad)						
Income <15 000/year			0·22	0·5656	0·02	0·9638
Income 15 000–24 999/year			0·09	0·7939	0·20	0·5755
Income 25 000–49 999/year			0·19	0·4702	0·23	0·4106
Income 50 000–74 999/year			0·11	0·6612	0·18	0·5128
Income 75 000–99 999/year			−0·04	0·8780	−0·06	0·8370
(Ref = Income >100 000/year)						
Part−time employment			−0·67	0·0072*	−0·65	0·0157*
Retired/Unemployed			−0·35	0·0539**	−0·28	0·1933
(Ref = Full−time employment)						
Ontario Resident					0·01	0·9421
(Ref = Québec resident)						
Scale: individual responsibility					−0·08	0·6697
Scale: little individual control					−0·16	0·4004
Scale: Health care					0·22	0·0995**
Donated blood					0·30	0·0730**
(Ref = No)						
RSquare	0·0145		0·0179		0·0377	
−LogLikelihood	553·63		497·08		472·20	
Whole model *P*-value	0·1302		0·0531		0·0752	
n	**987**		**889**		**862**	

*$P < 0·05$.

**$P < 0·1$.

Instead, results may be biased given the tendency towards answering what is considered socially desirable in a society on a survey [16] with respondents more likely to select 'yes'. Second, the limited knowledge of PRT is reflected in the small number of variables that significantly affected knowledge of PRT, with only education, employment, prior blood donation and high-perceived healthcare risk being significant predictors of PRT knowledge. These results suggest that with more education, there may be a greater chance that an individual will have acquired knowledge of PRT. Likewise, prior blood donation may suggest more awareness of blood safety practices, such as PRT. In regard to perceived risk, higher associated risk with health care could suggest that an

individual is more aware and/or knowledgeable of healthcare practices, such as blood transfusions and their related risks.

With respect to other findings, the covariates associated with both blood donation and transfusion risk align with other Canadian survey research in this area. Men, older individuals and higher-educated individuals are more likely to be donors [17]. Similarly, ideas around blood donation have been shown to differ between different demographics and between donors and non-donors [18]. Additionally, Canadians rank the risk of blood safety low, consistent with findings published by Krewski *et al*. [19]. Likewise, females and less educated individuals often perceived risks high overall, and Québec residents often perceived risks higher than residents of other provinces [19].

The indicators did not remain consistent across the regression models. For example, prior blood donation significantly decreased the likelihood of receiving a blood transfusion. This could indicate that the populations involved in blood donation and blood transfusion are distinct. Therefore, awareness of these two aspects of the blood system may not be shared between individuals. Additionally, although those who donate blood may be more aware of PRT, they may not be those who would be most affected by its implementation.

Limitations of the analysis focus on the sample collection methodology. The sample collected was not a randomized sample of the Canadian public and was drawn from only two provinces, Ontario and English-speaking Québec. The sample was drawn from an existing survey database, so it consists of individuals whom have already taken surveys in the past. Since the survey was administered via email, it also only allowed those with current access to a computer to respond. Responses were also dependent on self-reporting.

Conclusion and future directions

There is a general lack of knowledge of PRT amongst the Canadian public, which leads to uncertainty about its place as a blood safety practice. The limited public knowledge of PRT likely reflects the limited discussion to date amongst blood providers and policy-makers. It is also unlikely that knowledge or awareness has changed in the years since data collection, with a Google Trends search of 'pathogen reduction' and 'blood safety' showing no mention of PRT. Further, 'blood safety' also demonstrated a decline in interest over time (2005–2015). The tainted blood scandal of the 1970s and 1980s may be far enough in the past for people to forget about the risks that accompany blood transfusions. Instead, blood transfusions are viewed as relatively low risk compared to other health risks to the Canadian public. This could also be due to the public's infrequent exposure to blood transfusions, as individuals may not be aware of risks for a medical procedure they have never had to undergo. However, opinions and knowledge around the safety of the blood system and PRT could easily change in the future with the implementation of PRT or the emergence of a blood safety issue that calls for increased safety of the donor blood supply. Echoing earlier findings [10], public acceptance of PRT will be largely based on its perception of its risk. In addition, strategies for gaining acceptance of PRT should focus upon information dissemination and managing the language of risk used to describe it. If Canada were to follow the direction of other nations and implement PRT for use in certain types of blood products, education of the public and healthcare professionals will be critical.

Acknowledgements

All authors participated in developing the survey and critically reviewing the manuscript. Additionally, NG analysed and summarized the data, with support from BN and JE. NG and BN took the lead writing the manuscript. SL and NH contributed written content and editorial advice.

Funding

Blood Supply and Risk Operating Grant, Canadian Blood Services, Health Canada and CIHR.

Conflict of interest

The authors declare no conflict of interest.

References

1 Webert KE, Cserti CM, Hannon J, *et al.*: Proceedings of a consensus conference: pathogen inactivation—Making decisions about new technologies. *Transfus Med Rev* 2008; **22**:1–34
2 Wilson K: The Krever Commission—10 years later. *CMAJ*, 2007; **177**:1387–1389
3 Wilson K, Ricketts MN: The success of precaution? Managing the risk of transfusion transmission of variant Creutzfeldt-Jakob disease *Transfusion* 2004; **44**:1475–1478
4 Schlenke P: Pathogen inactivation technologies for cellular blood components: an update. *Transfus Med Hemother*, 2014; **41**:309
5 Mohr H, Steil L, Gravemann U, *et al.*: A novel approach to pathogen reduction in platelet concentrates using short-wave ultraviolet light. *Blood Components* 2009; **49**:2612–2624
6 Custer B: Update on pathogen reduction technology. *ISBT Sci Ser*, 2013; **8**:80–84

7 Goodrich RP, Edrich RA, Li J, *et al.* The Mirasol PRT system for pathogen reduction of platelets and plasma: an overview of current status and future trends. *Transfus Apher Sci* **2006**; **35**: 5–17.
8 FDA Approves INTERCEPT Blood System for Plasma. (2014, December 16). Retrieved April 12, 2015 from http://www.cerus.com/Investors/Press-Releases/Press-Release-Details/2014/FDA-Approves-INTERCEPT-Blood-System-for-Plasma/default.aspx
9 Irsch J, Seghatchian J: Update on pathogen inactivation treatment of plasma, with the INTERCEPT Blood System: current state of the art of methodology, quality and clinical aspects. *Transfus Apher Sci* 2015; **52**:240–244
10 Newbold KB, Heddle NM, Lane SJ, *et al.*: Risks, benefits and the role of stakeholders in pathogen reduction technology. *Health Risk Society* 2014; **16**:547–564
11 Klein HG, Anderson D, Bernardi MJ, *et al.*: Pathogen inactivation: making decisions about new technologies. Report of a consensus conference. *Transfusion* 2007; **47**:2338–2347
12 Guest G, Fleming P: Mixed methods research. In public health research methods; in Guest G, Fleming P (eds): *Public Health Research Methods*. Washington DC, Sage Publications Inc, 2015: 58–610.
13 Heddle NM, Lane SJ, Sholapur N, *et al.*: Implementation and public acceptability: lessons from food irradiation and how they might apply to pathogen reduction in blood products. *Vox Sang* 2014; **107**:50–59
14 Lee JEC, Lemrye L, Mercier P, *et al.*: Beyond the hazard: the role of beliefs in health risk perception. *Hum Ecol Risk Assess*, 2005; **11**:1111–1126
15 Lee JEC, Dallaire C, Markon M-PL, *et al.*: 'I can choose': the reflected prominence of personal control in representations of health risk in Canada. *Health Risk Society*, 2014; **16**:117–135
16 Sjöström O, Holst D: Validity of a questionnaire survey: response patterns in different subgroups and the effect of social desirability. *Acta Odontologica*, 2002; **60**:136–140
17 Godin G, Sheeran P, Conner M, *et al.*: Factors explaining the intention to give blood among the general population. *Vox Sang*, 2005; **89**:140–149
18 Hupfer ME, Taylor DW, Letwin JA: Understanding Canadian student motivations and beliefs about giving blood. *Transfusion* 2005; **45**:149–161
19 Krewski D, Lemyre L, Turner MC, *et al.*: Public perception of population health risks in Canada: health hazards and sources of information. *Hum Ecol Risk Assess*, 2006; **12**:626–644