

**BLOOD TYPE AND
BLOOD DONATION BEHAVIORS:
AN EMPIRICAL TEST
OF PURE ALTRUISM THEORY**

Shusaku Sasaki
Yoshifumi Funasaki
Hirofumi Kurokawa
Fumio Otake

May 2018

The Institute of Social and Economic Research
Osaka University
6-1 Mihogaoka, Ibaraki, Osaka 567-0047, Japan

Blood Type and Blood Donation Behaviors: An Empirical Test of Pure Altruism Theory

Shusaku Sasaki^{1,*}, Yoshifumi Funasaki², Hirofumi Kurokawa³, Fumio Otake⁴

^{1,*} Corresponding author: Faculty of Economics, Keio University, Postdoctoral Research Fellow of Japan Society for the Promotion of Science (PD), ssasaki.econ@gmail.com

² Graduate School of Economics, Osaka University, tge020fy@student.econ.osaka-u.ac.jp

³ Faculty of Policy Studies, Doshisha University, Postdoctoral Research Fellow of Japan Society for the Promotion of Science (PD), hirofumi.96kawa@gmail.com

⁴ Graduate School of Economics, Osaka University, otake@econ.osaka-u.ac.jp

Abstract

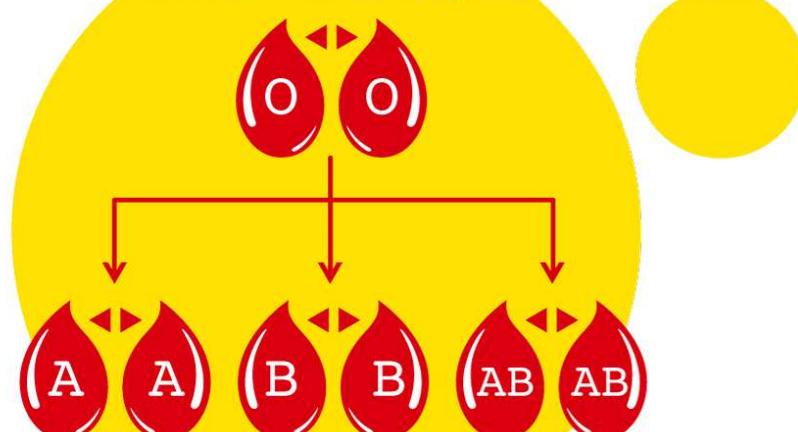
We examined whether the knowledge that your private donation has a large number of potential recipients causes you to give more or less. We found that the people with blood type O are more likely to have donated blood than those with other blood types, by using a Japan's nationally representative survey. This association was found to be stronger in a subsample of individuals who knew and believed that blood type O can be medically transfused into individuals of all blood groups. However, we found that blood type O does not have any significant relationship with the other altruistic behaviors (registration for bone-marrow donation, intention to donate organs, and the making of monetary donations) and altruistic characteristics (altruism, trust, reciprocity, and cooperativeness). After further analyses, we confirmed that the wider number of potential recipients of blood type O donations promoted the blood-donation behaviors of the people with this blood type.

Keywords: *ABO blood group, blood donation, group size, public good, pure altruism, behavioral economics*

JEL Classification Codes: I10, D64, C30

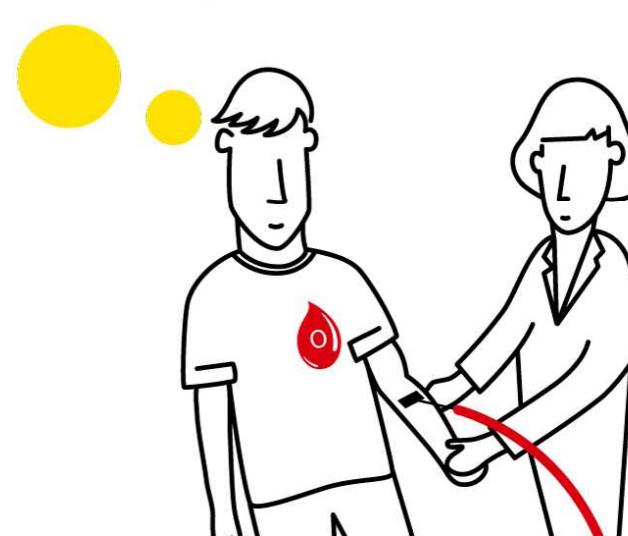
Graphical abstract

The blood type O can be medically transfused into individuals of all blood groups.



The blood types A, B, and AB can only be transfused into individuals of the same blood group.

“People with the blood type O are „more likely to have donated their blood.



Introduction

Pure altruism is well known in economics as one major driver of providing several forms of public good: charitable giving, volunteering, and blood donations¹. Andreoni has defined that an individual with pure altruism increases their personal utility when the utility level of others rises^{2,3,4}.^a For example, in blood donations, when a certain amount of blood is transfused to a person who needs it, the recipient of the blood becomes pleased. In this situation, a purely altruistic individual feels happier as a result of the recipient's pleasure. An interesting point here is that a rise in their purely altruistic utility does not depend on who gives the blood to the recipient. They simply feel happy, not only when they, themselves, donate enough of their blood to a recipient to improve his/her health, but when they know that the other blood donors also donate as well.

If your privately-provided public good has a large number of potential recipients, does it influence your behavior of providing the public good? Imagine that a natural disaster has occurred and that you are planning to donate one box of crayons to a child in

^a Andreoni writes the utility function of a purely altruistic individual in the following way: $u_i(\pi_i, \pi_o)$, where π_i is the payoff of the individual and π_o is that of the other individual. The function includes not only the individual's payoff but also the other's payoff. Therefore, their utility is affirmatively correlated with the other's payoff.

the affected area. In this case, the number of people who have the possibility to receive the box of crayons, the potential recipients, is the total number of children in the area. On the other hand, if you decide to make a monetary donation, the number of potential recipients increases, because such a monetary donation can be delivered not only to children but to adults. Thus, different forms of public goods have different numbers of potential recipients.

Does the knowledge that your private donation has a large number of potential recipients cause you to give more or less? This study considers this question, seeking to determine the answer by empirically examining how blood type affects blood-donation behaviors. The range of blood transfusion recipients differs widely across blood type, and this unique feature facilitates a natural experiment for our investigation.

More precisely, individuals with the blood types A, B, or AB can provide transfusions only for those with the same blood type. In this sense, these three types of blood are a local public good, as the benefit is limited to a particular area or population⁵. A suitable analogy to this is a city library, to which only city residents have access. In contrast, O type blood can be medically transfused to individuals of all blood groups, as

mentioned in the guidelines of the Ministry of Health, Labor and Welfare in Japan^{6,b}.

Thus, blood type O represents a local public good with a broader range of blood transfusion recipients than the other blood types, as shown in Figure 1.

[Insert Figure 1 here]

Blood type O's unique usability naturally means that it has a much larger number of potential recipients than the other blood types. Here we assume for our investigation that the probability of people requiring a blood transfusion (e.g., the likelihood of their encountering an accident) is identical for each individual and that the quantity of transfused blood is also identical for each individual, on average. Furthermore, we assume that people recognize potential recipients of their blood as members of the same group and that they experience their personal utility gain from these members' happiness if they have purely altruistic motivation.

Under these assumptions, widening the range of blood transfusion recipients means increasing the number of group members who require a blood transfusion; thereby

^b In "Guidelines on Implementation of Transfusion Therapy", The Ministry of Health, Labor and Welfare mentions the following: when there is no time to clarify the blood type of a patient due to hemorrhagic shock, when there is no determination reagent for blood type at emergency, or when it is difficult to clarify the blood type for any other reasons, a red O type blood concentrate for which a cross-matching test has not been conducted can be used.

increasing the total quantity of transfused blood and, as a consequence, increasing the social surplus.^c

Andreoni theorized how behaviors concerning the provision of a public good are influenced by the increase in social surplus due to the increase in the number of people (n) receiving the benefits of the public good⁷. First, a positive (income) effect occurs: as the number of recipients (n) increases, the provided good generates more social benefits, and people become more likely to provide the public good. Second, a negative (crowding out) effect occurs: as the number of donors also increases, the same social benefit can be attained at a lower cost, and people become less likely to provide the public good. Although Andreoni showed in a laboratory experiment that the income effect exceeds the crowding out effect⁷, in the case of blood donation behaviors, identifying which effect dominates depends on empirical analysis.

This study's purposes are as follows: (1) we investigated the differences in blood-donation behaviors between the people with blood type O and those with other blood types; and (2) if we were able to identify a different pattern of blood donation behavior

^c We rewrote the basic utility function of a purely altruistic individual in the following way: $u_i(\pi_i, n\pi_o)$, where n is the number of group members. The purely altruistic utility gain changes, as its number n changes.

from the people with blood type O, we investigated whether the cause of such behavior was due to the fact that blood type O is a public good with a larger number of potential recipients than the other blood types.

The literature empirically has indicated the possibility that stimulating non-altruistic motivation promotes an individual's blood donation behavior^{8,9,10}. However, these results have not demonstrated the non-existence of a blood donation behavior caused by purely altruistic motivation. Also, if some proportions of purely altruistic blood donors were provided with a non-altruistic incentive, it could impede their blood donation behavior¹¹. Taking these results into account, it is essential to directly test whether pure altruism motivates an individual's blood donation behavior.

Methods

Data Description

To conduct our investigation, we used a dataset from a nationally representative survey conducted in Japan, called the Preference Parameters Study of Osaka University (PPSOU)¹². This survey has been conducted annually since 2003. In the first wave in

2003, a nationally representative sample of individuals aged 20 to 69 was obtained by using two-stage stratified random sampling. In the current study, specifically, we have focused on 1,311 responses provided by the 2017 PPSOU survey, which included data concerning the respondents' blood type and blood donation behavior.^d The data that supports the findings of this study is available from Institute of Social and Economic Research at Osaka University upon reasonable request.^e

Using a Japanese sample for this analysis provides some essential advantages. First, our Japanese sample, including both blood donors and non-blood donors, generally knew their own blood type (over 99.0%); this is not the case in many other countries. Second, it is well known in Japan that blood type O can be medically transfused into individuals of all blood groups; in fact, 74.0% of our sample recognized this fact. Third, the distribution of Japanese people's blood groups is well-dispersed. If almost all members of the sample had a single particular blood type, we would not have been able to investigate our research question. According to the Japanese Red Cross Tokyo

^d Although the survey has added a sample in order to make it more nationally representative, the concern remains that the 2017 sample deviates from that. When introducing the descriptive statistics, we were able to assess whether our sample was significantly different from a Japan's official statistics or not.

^e Contact information is here, http://www.iser.osaka-u.ac.jp/survey_data/eng_application.html.

Metropolitan Blood Center, the distribution of blood groups across Japan (approximate value) is A: O: B: AB = 4: 3: 2: 1¹³. As the distribution of blood groups in our sample is 39.0% for blood type A, 30.4% for O, 21.1% for B, and 9.6% for AB, the distribution of blood groups in our sample is consistent with the distribution across Japan. Fourth, we can ignore any possible effects caused by people with Rh negative blood, because the proportion of Japanese people with Rh negative blood is quite small, approximately 0.5%. This feature allows us to focus on a simple relationship diagram, where individuals with blood type O Rh positive are able to provide transfusions for those with Rh positive in all blood groups. Rh negative blood is a kind of universal blood, which can be transfused to individuals with Rh positive blood. If the proportion of people with RH negative blood were larger in Japan, the relationship diagram relating blood transfusion subjects would have been more complicated, and the predicted effect of blood type O would also have been more complicated.

In addition, using the PPSOU dataset enabled us to investigate (and reject) the possibility that other mechanisms could explain our results. One major concern is that preferences and psychological characteristics may differ across blood groups, which

would cause different patterns of blood-donation behaviors. For example, people with blood type O are likely to donate their blood, possibly because they have more altruistic personalities when compared to people with other blood types. Several psychological studies have already rejected the validity of this concern for samples from several countries, including Japan^{14,15,16,17}; however, some people in Japan still believe that blood-type determines preferences and psychological characteristics in this regard, and holding such a belief might unconsciously characterize the preferences and psychological characteristics of such individuals.

By using the PPSOU dataset, we were able to address the above concern directly. The PPSOU survey is based on the concepts of behavioral economics, and the survey purpose is to identify the validity of the conventional economics assumptions that people are rational and seek to maximize their utility. Consequently, this survey collects unique information, including respondents' preference parameters and psychological personalities and attributes, in addition to their basic socio-economic characteristics. In our analysis, we investigated the effect of blood types on blood-donation behavior after

controlling for such characteristics, and then we checked whether these characteristics differ across blood groups.

Furthermore, we sought to reconfirm the advantages of using the PPSOU dataset by comparing it with a dataset used in a related study. To the best of our knowledge, only one empirical study by Wildman and Hollingsworth¹⁸ analyzed the relationship between blood type and blood donation behaviors, using the blood donation dataset of the Australian Red Cross. As a main finding, the authors reported that Australian blood donors with type O had a lower frequency of blood donations.

We recognize that their study is entirely novel in being the first to investigate how possessing blood type O affected blood-donation behavior. Nevertheless, it is worthwhile to readdress this question with our PPSOU data, from other viewpoints in addition to the viewpoint that the association between blood type and blood-donation behaviors can differ across countries. First, Wildman and Hollingsworth's dataset does not include information concerning preference parameters and psychological attributes and, therefore, it is difficult to examine other potential reasons for their results directly. For example, the authors suggested in their interpretations that non-altruistic motivation drives Australians'

blood-donation behaviors. However, as Andreoni describes⁷, a similar result can be found when the negative crowding out effect surpasses the positive income effect, and if so, pure altruism shaped the Australians' blood-donation behaviors. Second, their sample contains only blood donors, which might generate a sample-selection problem. If our expected mechanism is verified, people with both blood type O and relatively low levels of altruism may still donate their blood. Furthermore, in this case, the altruistic level would also be low in blood donors with type O, and if psychological attributes, such as altruism, are not controlled, the blood type O dummy variable might be a proxy variable of the lower altruistic level.

Again, our Japanese survey respondents consisted of both blood donors and non-blood donors. In addition, the survey collected information concerning respondents' behavioral economics preferences and psychological attributes. These features enabled us to avoid a potential sample-selection problem and to test whether pure altruism and a large number of potential recipients motivate an individual's blood donation behavior, after dealing empirically with the possibility that other explanations may also be valid.

Empirical Strategy

Variables and model specifications

We used a simple model specification for analysis, as shown in equation (1):

$$\text{Blood donation}_i = \alpha + \text{Blood types}'_i \beta + z'_i \gamma + u_i \quad (1)$$

where α represents a constant term, and u represents an error term.

The dependent variable, *Blood donation*, explains respondent i 's blood-donation behavior. More precisely, we employed the following two dependent variables: the first represents respondents who have donated blood at least once within the past few years, and the second represented those who had donated blood once or more within the past year. Since these two variables are binary, we used logistic regression for the estimation. In addition, we applied to the estimation a sampling weight and robust standard errors clustered at the prefecture level.

The main independent variable, *Blood types*, expressed respondent i 's blood type. These were dummy variables; for example, the dummy-coded variable of blood type O was coded as a “1” if a respondent i 's blood type is O and was coded as a “0” for the other blood types. This dummy-coding was done for each of the blood types. Here, note

that respondents cannot select their blood type in a biological sense, and *Blood types* are exogenous variables. Therefore, we can determine the starting point of the effect from blood types to blood donation behaviors, when using a cross-sectional dataset and a simple logistic regression model.

As for covariates, we added z to the model. We used these to control the effects of socio-economic status, health status, and preferences and psychological characteristics. In the next subsection labeled “descriptive statistics,” we discuss the information in more detail.

Our analysis procedure was as follows: First, we performed equation (1) with a full sample, clarifying the relationship between blood types and blood-donation behaviors. If a different pattern of blood-donation behaviors was found for people with blood type O, we then investigated whether such a result is generated because blood type O is a public good with a wider population of potential recipients than the other blood types. For this latter analysis, we performed equation (1) by using subsamples. Here the full sample was divided into two groups: one group containing those who knew and believed that blood type O could be medically transfused into individuals of all blood groups, and

another group containing individuals who did not. We then investigated whether the estimated parameter of blood type O was statistically significant from zero in the former group but not the latter. If so, it would have directly supported that people with blood type O donate their blood differently as a result of the large number of potential recipients.

Descriptive statistics

[Insert Table 1 here]

Table 1 shows descriptive statistics regarding our sample's blood-donation behaviors, blood types, and covariates. From this table, it can be seen that 11.7% of our sample have donated blood at least once within the past few years and that 5.5% have done so once or more within the past year. According to the website of the Japanese Red Cross, 5.6% of the Japanese population donated blood in 2016¹⁹, which is a similar percentage to that shown in our sample. Also, as we have already mentioned in Section 2, the distribution of blood type across Japan is consistent with that in our sample.

In addition, Table 1 introduces the sample's variables in regard to socio-economic status, health status, and preferences and psychological characteristics. Note that the

lowest age in our sample is 27 years old, which is due to the fact that the PPSOU is a panel survey, meaning that it has surveyed the same respondents since the first wave in 2003. Therefore, our sample does not include any members of the general population's 16–26 age group, who can legally donate blood. Nevertheless, the rate of blood donation among younger generations is showing a declining trend and, at present, people in their forties are the primary blood donors. In addition, the oldest age in our sample is 70 years old, as 69 years old is the oldest age at which people in Japan can donate blood. Thus, our sample includes those who were 69 years old or younger the year before our survey (2016). As a consequence, we advanced 1,311 responses from the 2017 PPSOU survey to the analysis phase. See Appendix for more details of questions and variables in particular of health status, preferences, and psychological characteristics.

Results

Basic Results

[Insert Table 2 here]

This section considers the relationships between blood types and blood-donation behaviors. Table 2 shows the basic results of our performance of equation (1) using the full sample. In all the columns (1) to (4), the estimated parameter of the blood type O dummy variable was positive and statistically significant, which indicates that people with blood type O were more likely to have donated blood at least once within the past few years than were people with other blood types. In particular, column (4) shows that they were especially more likely to have done so than people with blood type A, whose blood donation behaviors were similar to those of people with blood types B or AB. These findings are consistent with one prediction of Andreoni's theory⁷; in these cases, the positive income effect overcomes the negative crowding-out effect. When evaluating the marginal effect, the likelihood to have donated blood within the past few years was 4.0% (5.0%) higher in the people with blood type O than in people with the other blood types (in particular, the people with blood type A).

These results remained stable also when using another dependent variable, which represented respondents who had donated blood once or more within the past year. In addition, estimations using the probit regression model and the linear probability model produced similar results.

Interestingly, column (8) shows that the people with blood type AB were more likely to have donated blood once or more within the past year than were people with blood type A. Although this finding might be confusing at first glance, it also can be interpreted by considering Andreoni's theory⁷, which indicates that, in the case of a decrease in the number of potential recipients, the income effect becomes negative and the opposite effect to crowding out occurs. Therefore, it is possible that when the opposite effect prevails over the negative income effect, the people with blood type AB are more likely to have donated blood. When the group size is small, donors might think that they are among a few who are able to donate blood to a small number of the recipients. However, since this tendency is not observed in column (4), it does not seem to be robust. Thus, we found that the people with blood type O donated their blood differently than did people with the other blood types, as we expected. Following our analysis

procedure, the second step was to investigate whether they did so because blood type O is a public good with a wider population of potential recipients than the other blood types.

[Insert Table 3 here]

Table 3 shows the results of performing equation (1) with the subsamples. The results reveal that the blood type O dummy had a statistically and significantly positive impact on blood-donation behaviors only for the subsample of individuals who knew and believed that blood type O can be medically transfused into individuals of all blood groups (columns (1) to (4)). In contrast, columns (5) to (8) show dissimilar results when we used the other subsample, who did not know and believe this statement. These findings directly supported that the people with blood type O are likely to donate their blood because of the number of potential recipients.

Further Results

This section examines (and rejects) the other possible explanations for our results. In so doing, we further confirm our interpretations of the results. First, we arrest the concern that people with blood type O are more likely to donate their blood because they have

more altruistic personalities. We wish to restate that our model specification included covariates related to preferences and psychological characteristics, including altruism and considered their potential differences across blood groups: however, it is possible that these covariates failed to sufficiently control for the differences. If unobserved altruistic factors remained after controlling the covariates and if the blood type O dummy was a proxy variable for the factors, the blood type O dummy should have had a statistically and significantly positive effect not only on blood-donation behaviors but also on the other altruistic behaviors.

[Insert Table 4 here]

Table 4 presents results that negate the first concern. Rows (1) to (8) show that the blood type O dummy had no effect on any other altruistic behaviors, including registering for bone-marrow donation, organ-donation intention, and making monetary donations. In addition, after controlling for several socio-economic and health status variables, and the other psychological characteristics aside from the dependent variable, we did not find any statistically significant relationship between blood type O and any altruistic

characteristics. These findings deny the validity of the explanation that the people with O blood type have naturally stronger altruistic tendencies.

Second, we addressed the concern that people with blood type O are more likely to donate blood because they are healthier than people with other blood types. In fact, medical studies have reported that the risks of contracting diseases indeed differ between blood groups^{20,21}. Our model specifications included, and controlled for, variables that captured the respondents' current health conditions; however, these variables might have failed to represent differences in terms of congenital or chronic health conditions. Consequently, to address this concern, we performed equation (1) after excluding respondents who reported, "I have donated blood, but I have not donated within the past few years because of my health," or "I want to donate my blood, but I cannot because of my health." The results are shown in Table 5. As these results are robustly similar to those previously obtained, we can suppose that this second concern is not a significant factor.

[Insert Table 5 here]

The third concern is that the people with blood type O may be more likely to donate their blood because blood type O is more in demand than other blood types. For

example, blood-donor centers might frequently make requests that people with blood type O donate blood. To consider a (possible) difference in demand in this regard, we controlled for information relating to the inventory ratio of stocks of each blood type in each respondents' prefecture. When the inventory ratio of stocks of a particular blood type is low in a prefecture, it is likely that the blood-donor centers in the area make requests that people with that blood type donate their blood. In 2012, the Ministry of Health, Labor and Welfare in Japan published weekly reports concerning the inventory ratios of stocks of blood types for all prefectures²² and, using this information, we created variables relating to the annual averages and standard deviations of these inventory ratios of stocks in each respondent's prefecture.

[Insert Table 6 here]

Table 6 shows that O blood type's parameter remained positive and statistically significant even after controlling for information concerning the inventory ratio of stocks for each blood group. Therefore, this third concern is not crucial.

The fourth and final concern is that people with blood type O Rh-negative may be more likely to donate blood, and this behavior consequently shapes our results. It is well

known that the blood type O Rh-negative is quite rare and, therefore, people with this blood type might think that provided donations of this blood type are also rare. This rarity could make them more likely to donate their blood to others within the same group. Consequently, this has the potential to negate our hypothesis.

It is unlikely that the above concern is valid, although our survey did not capture whether a respondent had Rh positive or negative blood and we cannot directly control its effect in our estimations. According to the Japanese Red Cross Tokyo Metropolitan Blood Center, only 0.15% of the Japanese population has O Rh-negative blood (a proportion of 1:670 people)²³. Therefore, our blood type O sample included very few people with blood type O Rh-negative. Even if there were such individuals in the sample, their proportion is likely to have been extremely small (i.e. approximately up to 2 people in the sample), meaning they would not have greatly influenced our estimation results. As an illustration, we shall imagine that there existed 2 people with blood type O Rh-negative, and both have donated their blood. Even after excluding the two observations, the ratio of blood donors among the people with blood type O is 14.6%, which is almost indifferent from that in the full sample (15.1%).

Discussion

Using the data from a nationally representative survey conducted in Japan, the Preference Parameters Study of Osaka University, we found that people with blood type O are more likely to have donated blood at least once within the past one or more years than those with other blood types. This association is strongly observed in a subsample containing individuals who knew and believed that blood type O can be medically transfused into all blood groups. However, we do not find any further significant relationship between blood type O and other altruistic behaviors, including registration for bone-marrow donation, intention to donate organs, and the making of monetary donations. Moreover, we did not find any relationship between blood type O and altruistic personality and characteristics, including altruism, trust, reciprocity, and cooperativeness. After additional analyses, we can confirm that the wider number of potential recipients of blood type O donations promotes the blood-donation behaviors of people with this blood type.

Our findings are consistent with one prediction of Andreoni's theory⁷. In the case of blood donation, when the number of potential recipients increases, a positive income effect prevails over a negative crowding out effect. Our study adds to existing literature

unique field evidence concerning the relationship between group size and public goods provision. Furthermore, our findings can aid charities' fundraising or volunteer-recruiting activities; if such nonprofit organizations announce that a large number of people require a multitude of new donors or volunteers, it is likely that the numbers of donors and volunteers will increase.

REFERENCES

1. Bekkers, R., & Wiepking, P. A literature review of empirical studies of philanthropy: Eight mechanisms that drive charitable giving. *Nonprofit and Voluntary Sector Quarterly* **40**(5), 924–973 (2011).
2. Andreoni, J. Giving with impure altruism: Applications to charity and Ricardian equivalence. *Journal of Political Economy* **97**(6), 1447–1458 (1989).
3. Andreoni, J. Impure altruism and donations to public goods: A theory of warm-glow giving. *The Economic Journal* **100**(401), 464-477(1990).
4. Andreoni, J. An experimental test of the public-goods crowding-out hypothesis. *American Economic Review* **83**(5), 1317–1327 (1993).
5. Berglas, E., & Pines, D. Clubs, local public goods and transportation models: A synthesis. *Journal of Public Economics*, **15**(2), 141–162 (1981).
6. Ministry of Health, Labor and Welfare. Guidelines on implementation of transfusion therapy.
<http://www.mhlw.go.jp/stf/seisakunitsuite/bunya/0000065580.html>. (2017)
(accessed August 21, 2017).

7. Andreoni, J. Giving gifts to groups: How altruism depends on the number of recipients. *Journal of Public Economics* **91**, 1731–1749 (2007).
8. Ferguson, E., Farrell, K., & Lawrence, C. Blood donation is an act of benevolence rather than altruism. *Health Psychology* **27(3)**, 327 (2008).
9. Lacetera, N., Macis, M., & Slonim, R. Will there be blood? Incentives and displacement effects in pro-social behavior. *American Economic Journal: Economic Policy* **4(1)**, 186-223 (2012).
10. Lacetera, N., Macis, M., & Slonim, R. Economic rewards to motivate blood donations. *Science* **340(6135)**, 927-928 (2013).
11. Mellström, C., & Johannesson, M. Crowding out in blood donation: was Titmuss right?. *Journal of the European Economic Association* **6(4)**, 845-863 (2008).
12. Osaka University. Preference parameters study of Osaka University. http://www.iser.osaka-u.ac.jp/survey_data/eng_panelsummary.html. (2017). (accessed November 24, 2017).

13. Japanese Red Cross Tokyo Metropolitan Blood Center. Glossaries: Blood type ABO. <https://www.tokyo.bc.jrc.or.jp/tmpfile/yougo/detail1.html>. (2017) (accessed August 14, 2017).

14. Cramer, K.M., & Imaike, E. Personality, blood type, and the Five-Factor Model. *Personality and Individual Differences* **32**, 621–626 (2002).

15. Nawata, K. No relationship between blood type and personality: Evidence from large-scale surveys in Japan and the US. *The Japanese Journal of Psychology* **85(2)**, 148–156 (2014).

16. Rogers, M., & Glendon, A. I. Blood type and personality. *Personality and Individual Differences* **34**, 1099–1112 (2003).

17. Wu, K., Lindsted, K. D., & Lee, J. W. Blood type and the five factors of personality in Asia. *Personality and Individual Differences* **38**, 797–808 (2005).

18. Wildman, J. & Hollingsworth, B. Blood donation and the nature of altruism. *Journal of Health Economics* **28**, 492–503 (2009).

19. Japanese Red Cross. The transitive graph in the rate of blood donation
http://www.mhlw.go.jp/file/05-Shingikai-11121000-Iyakushokuhinkyoku-Soumuka/0000109388_4.pdf. (2017) (accessed October 30, 2017).

20. He, M. et al. ABO blood group and risk of coronary heart disease in two prospective cohort studies. *Arteriosclerosis, Thrombosis, and Vascular Biology* **32(9)**, 2314–2320 (2012).

21. Wolpin, B. M., et al. ABO blood group and the risk of pancreatic cancer. *Journal of the National Cancer Institute* **101(6)**, 424-431 (2009).

22. Ministry of Health, Labor and Welfare. Weekly reports concerning the inventory ratios of blood stocks.
<http://www.wam.go.jp/gyoseiShiryou/detail?gno=862&ct=030040140>. (2014) (accessed December 14, 2017).

23. Japanese Red Cross Tokyo Metropolitan Blood Center. Glossaries: blood type Rh.
<https://www.tokyo.bc.jrc.or.jp/tmpfile/yougo/detail31.html>. (2017) (accessed October 30, 2017).

Acknowledgements

We use the data from the Preference Parameters Study of Osaka University, which is conducted as part of the 21st Century Center of Excellence Program “Behavioral Macrodynamics Based on Surveys and Experiments” (2003-2007), the Global Center of Excellence Program “Human Behavior and Socioeconomic Dynamics” (2008-2013), and the Grants-in-Aid for Scientific Research (S) Humanities and Social Sciences (Social Sciences) “Behavioral-Economic Analysis of Long-Run Stagnation (15H05728)” (2016-).

In addition, in preparing this paper, the authors are financially supported by the Japan Society for the Promotion of Science (17J07242). The funders had no role in study design, data collection and analysis, decision to publish or preparation of the manuscript.

Author Contributions

S.S., H. K., and F. O. designed the research. S.S. and Y. F. analyzed the data and wrote the paper. All authors discussed the results, edited the manuscript, and approved the current draft of the paper.

Competing Interests

The authors declare no competing financial interests.

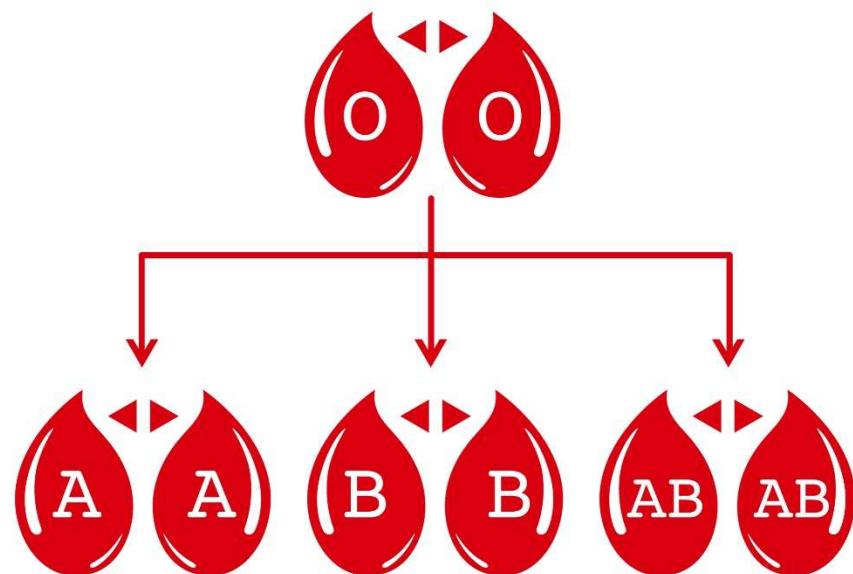
Corresponding author

Correspondence to Shusaku Sasaki

TABLES & FIGURE

Figure 1. Difference in the number of transfusion subjects for each blood group.

The blood type O can be medically transfused into individuals of all blood groups.



The blood types A, B, and AB can only be transfused into individuals of the same blood group.

Table 1. Descriptive statistics.

Variables name	Mean	S.D.	Min	Max
Number of observations = 1,311				
1. Blood-donation behaviors				
Have donated blood at least once <u>within the past few years</u> (dummy)	0.117	0.321	0	1
Have donated blood once or more <u>within the past year</u> (dummy)	0.055	0.228	0	1
2. Blood type				
Blood type A (dummy)	0.390	0.488	0	1
Blood type O (dummy)	0.304	0.460	0	1
Blood type B (dummy)	0.211	0.408	0	1
Blood type AB (dummy)	0.096	0.295	0	1
3. Socio-economic status				
Age	54.062	10.155	27	70
Female (dummy)	0.533	0.499	0	1
Spouse (dummy)	0.806	0.395	0	1
Household income levels (10,000 yen)	641.571	397.895	50	2,100
Educational years	13.298	2.039	9	21
4. Health status				
Body Mass Index (BMI)	22.864	3.379	13.333	44.983
Subjective health status	3.326	0.920	1	5
Mental illness	2.620	0.838	1	5
5. Preferences and psychological characteristics				
Behavioral economics preferences (1): Time discounting factor	0.883	0.225	-1.837	1.126
Behavioral economics preferences (2): Absolute risk aversion	0.00002	0.00006	-0.00040	0.00013
Psychological index (1): General trust	3.208	0.718	1	5
Psychological index (2): Altruism	3.792	0.659	1	5
Psychological index (3): Positive reciprocity	3.737	0.526	1	5
Psychological index (4): Negative reciprocity	2.286	0.787	1	5
Psychological index (5): Conformity	2.906	0.870	1	5
Psychological index (6): Social norm	4.339	0.950	1	5
Psychological index (7): Religious beliefs	1.661	1.031	1	5
Psychological index (8): Belief in fortune-telling based on blood-types	2.794	0.968	1	5
Big 5 personality traits (1): Extraversion	8.146	2.485	2	14
Big 5 personality traits (2): Agreeableness	10.081	1.775	3	14
Big 5 personality traits (3): Conscientiousness	8.116	2.090	2	14
Big 5 personality traits (4): Neuroticism	7.847	2.036	2	14
Big 5 personality traits (5): Openness to experience	7.792	2.112	2	14

Note: See Appendix for more details of questions and variables in particular of health status, preferences, and psychological characteristics.

Table 2. Basic results (1).

Logistic regression (coefficient)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent variable:	I have donated blood at least once within the past few years				I have donated blood once or more within the past year			
Blood type:								
Blood type O	0.397** (0.201)	0.398* (0.208)	0.497** (0.217)	0.507** (0.253)	0.400* (0.237)	0.397 (0.248)	0.468** (0.223)	0.573** (0.264)
Blood type B				-0.043 (0.298)			-0.075 (0.467)	
Blood type AB				0.143 (0.250)			0.707** (0.296)	
Covariates:								
Socio-economic status	×	×	×	×	×	×	×	×
Health status		×	×	×		×	×	×
Preferences and psychological attributes			×	×			×	×
Number of observations	1,311							

Note: *** p < 0.001, ** p < 0.05, and * p < 0.1. The baseline in columns (1)-(3) and (5)-(7) is blood type A, B, or AB. The baseline in columns (4) and (8) is blood type A. When evaluating the marginal effect, the likelihood to have donated blood within the past few years was 4.0% (5.0%) higher in the people with blood type O than in people with the other blood types (in particular, the people with blood type A).

Table 3. Basic results (2).

Logistic regression (coefficient)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent variable:	I have donated blood at least once within the past few years		I have donated blood once or more within the past year		I have donated blood at least once within the past few years		I have donated blood once or more within the past year	
Blood type:								
Blood type O	0.576** (0.267)	0.609** (0.309)	0.584* (0.314)	0.767** (0.360)	0.401 (0.544)	0.243 (0.589)	-0.042 (0.366)	-0.074 (0.427)
Blood type B		0.021 (0.379)		0.138 (0.457)		-0.321 (0.382)		-0.394 (0.686)
Blood type AB			0.189 (0.373)		0.867* (0.458)		-0.270 (0.499)	0.285 (0.917)
Subsample:								
Number of observations		970					341	

Note: *** p < 0.001, ** p < 0.05, and * p < 0.1. The baseline in columns (1)(3)(5)(7) is blood type A, B, or AB. The baseline in columns (2)(4)(6)(8) is blood type A. All the model specifications include covariates of socio-economic status, health status, and preferences and psychological attributes.

Table 4. Further results (1).

Number of observations = 1,311		Independent variable: Blood type O
Dependent variable: Other altruistic behaviors		
(1)	I have registered as a bone-marrow donor.	-0.149 (0.424)
(2)	I have registered as a bone-marrow donor, or I want to register as a bone-marrow donor, but I have not yet.	0.106 (0.220)
(3)	I have registered as a bone-marrow donor, I want to register as a bone-marrow donor, but I have not yet, or I want to register as a bone-marrow donor, but I cannot register because of my age or health	-0.018 (0.148)
(4)	I have signed an organ-donation consent form.	-0.356 (0.221)
(5)	I have signed an organ-donation consent form, or I have a will, but I have not signed it yet.	-0.050 (0.203)
(6)	Entire monetary donations for the past year	-5,135.761 (4,702.118)
(7)	Monetary donations to disaster aid	-162.781 (468.406)
(8)	Monetary donations to religious groups	-8,245.690 (8,418.801)
Dependent variable: Altruistic characteristics		
(9)	Altruism	-0.066 (0.043)
(10)	Trust	-0.044 (0.065)
(11)	Positive reciprocity	0.041 (0.033)
(12)	Cooperativeness (a Big 5 personality trait)	-0.011 (0.124)

Notes: *** p < 0.001, ** p < 0.05, and * p < 0.1. Since the dependent variables in rows (1) to (5) are binary, we estimate these equations, using logistic regression. For the experience of monetary donations in rows (6) to (8), the original question items are as follows: "not making a donation", "1 yen ~ 5,000 yen", ..., "500,000 yen ~ 1,000,000 yen", "1,000,000 yen or more". Therefore, when the dependent variable is experience of monetary donation, we estimate these equations, using interval regression. The altruistic characteristics in rows (9) to (12) are ordinal variables whose values are 5, 4, 3, 2, and 1. Therefore, we regard them as continuous variables and estimate these equations.

Table 5. Further results (2).

Logistic regression (coefficient)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent variable:	I have donated blood at least once within the past few years		I have donated blood once or more within the past year		I have donated blood at least once within the past few years		I have donated blood once or more within the past year	
Blood type:								
Blood type O	0.499** (0.208)	0.495** (0.242)	0.454** (0.225)	0.530** (0.268)	0.483** (0.217)	0.475* (0.251)	0.419* (0.222)	0.507** (0.258)
Blood type B		-0.104 (0.289)		-0.158 (0.460)		-0.096 (0.278)		-0.125 (0.450)
Blood type AB			0.175 (0.269)		0.724** (0.315)		0.133 (0.266)	0.721** (0.321)
Excluded respondents:								
	We excluded the respondents who answered: "I have donated blood before, but I have not donated within the past few years because of my health."				We excluded the respondents who answered: "I have donated blood before, but I have not donated within the past few years because of my health," or "I want to donate blood, but I cannot because of my health."			
Number of observations	1,077				930			

Note: *** p < 0.001, ** p < 0.05, and * p < 0.1. The baseline in columns (1)(3)(5)(7) is blood type A, B, or AB. The baseline in columns (2)(4)(6)(8) is blood type A. All the model specifications include covariates of socio-economic status, health status, and preferences and psychological attributes.

Table 6. Further results (3).

Logistic regression (coefficient)	(1)	(2)	(3)	(4)	(5)	(6)	I have donated blood		I have donated blood				
							Dependent variable:			at least once		once or more	
							within the past few years					within the past year	
Blood type:													
Blood type O	0.474**	0.487**	0.471*	0.462*	0.453*	0.587**	(0.213)	(0.205)	(0.243)	(0.237)	(0.241)	(0.271)	
Blood type B			-0.088			0.034			(0.291)			(0.479)	
Blood type AB			0.063			0.681**			(0.244)			(0.282)	
Additional covariates:													
Annual average of the inventory ratio of stocks of blood groups for each respondent's prefecture	×	×	×	×	×	×							
Annual standard deviation of the inventory ratio of stocks of blood groups in each respondent's prefecture		×	×			×							
Number of observations	1,311												

Note: *** p < 0.001, ** p < 0.05, and * p < 0.1. All the model specifications include covariates of socio-economic status, health status, and preferences and psychological attributes. The baseline in columns (1)(2)(4)(5) is blood type A, B, or AB. The baseline in columns (3)(6) is blood type A.

APPENDIX: Questions and variables

The following are survey questions for capturing respondent's health status, preferences, and psychological characteristics. We add explanations for how we created the variables from the answers (if necessary).

1. Health status

a) *BMI*: What is your height and weight?

Height: _____ centimeters, Weight: _____ kilograms

Note: We calculated out the indicator of BMI, using the following equation:

$$\text{BMI} = \text{Weight in kilograms} \div (\text{Height in meters})^2$$

b) *Subjective health status*: How would you describe your current health status: Is it

excellent, very good, good, fair, or poor?

1. Excellent
2. Very good
3. Good
4. Fair
5. Poor

c) *Mental illness:* How true for you is each of the following statements? Answer for each on a scale from 1 to 5, where “1” means “it is particularly true for you” and “5” means “it doesn't hold true at all for you.”

- I have been feeling stressed lately
- I have been feeling depressed lately
- I haven't been sleeping well lately
- I have been feeling lonely lately

Note: First, we reconstructed the answers on the opposite scale from 1 to 5, where “1” means “it doesn't hold true at all for you” and “5” means “it is particularly true for you.” Second, we calculated out the indicator of mental illness, by summing up the answers for the four statements and dividing the value by 4.

2. Preferences

a) *Time discounting factor:* Suppose that you are to receive money from someone. You can either choose to receive the money today, or 7 days from today, but the amounts will be different. Compare the amounts and dates below in Option “A” and Option “B,” and indicate which option you prefer for each of the nine choices.

Option A		or	Option B		Which <u>ONE</u> do you prefer?	
Receive today			Receive 7 days from today		Option A	Option B
JPY 3,005			JPY 3,014		A	B
JPY 3,003			JPY 3,297		A	B
JPY 3,008			JPY 3,037		A	B
JPY 3,000			JPY 3,000		A	B
JPY 3,005			JPY 5,951		A	B
JPY 3,009			JPY 3,068		A	B
JPY 3,001			JPY 3,119		A	B
JPY 3,002			JPY 2,996		A	B
JPY 3,008			JPY 3,011		A	B

Notes: As similarly in previous studies¹, we asked the respondents to choose between two options, “A” and “B.” For example, we asked them to choose between “A”—receiving today JPY 3,005, and “B”—receiving in 7days JPY 5,951. From each situation, we obtained response data, which revealed the switching point, where each respondent switched his or her choice from option “A” to “B.” At the switching point, the today’s option is equivalent to the delayed option.

We calculate out time discounting factor using the following way. We first take the average of the two monetary amounts for Option A at the point of switching from Option B to Option A. Second, we divide the numerator by the average of the two monetary amounts for Option B at the switching point.

b) *Absolute risk aversion:* Suppose that there is a “speed lottery” with a 50% chance of winning JPY 100,000 (USD 1,000). If you win, you receive a prize right away. If you lose, you receive nothing. How much would you spend to buy a ticket for this lottery? Choose Option “A” if you would buy the ticket at that price, or choose Option “B” if you would not.

Price of the “speed lottery” ticket	Which <u>ONE</u> do you prefer?	
	Option A (buy the “speed lottery” ticket)	Option B (DO NOT buy the “speed lottery” ticket)
JPY 10	A	B
JPY 2,000	A	B
JPY 4,000	A	B
JPY 8,000	A	B
JPY 15,000	A	B
JPY 25,000	A	B
JPY 35,000	A	B
JPY 45,000	A	B
JPY 50,000	A	B

Notes: we use answers for a hypothetical question related to a speed lottery and measure a respondent’s risk tolerance from absolutely risk neutral to absolutely risk averse. This approach to elicit risk aversion using a hypothetical lottery is also taken by previous studies^{2,3,4}.

Specifically, this question asks respondents about their willingness to pay (π_1) for a hypothetical lottery with a 50 percent chance of winning JPY 100,000 (USD 1,000) or nothing otherwise. Since the expected value of the lottery is JPY 50,000

(USD 500), we interpret this to mean that a respondent whose π_1 is lower than the expected value is more risk averse. We calculate the indicator of absolute risk aversion using the following equation:

$$\text{Absolute Risk Aversion} = \frac{50,000 - \pi_1}{0.5(0.5 \times 100,000^2 - 2 \times 0.5 \times 100,000 \times \pi_1 + \pi_1^2)}$$

3. Psychological characteristics

a) *Altruism, trust, and belief in fortune-telling based on blood-types:* To what extent do you agree with each of the following statements? Answer on a scale from 1 to 5, where “1” means “you agree completely” and “5” means “you disagree completely.” Of course, you may choose any number in between.

- *Altruism:* I feel happy when I do a good deed that I think benefits others (such as picking up trash in a park)
- *Trust:* In general, most people are trustworthy
- *Belief in fortune-telling based on blood-types:* A person’s blood type indicates their character

Note: For our analysis, we reconstructed the answers on the opposite scale from 1 to 5, where “1” means “you disagree completely” and “5” means “you agree completely.”

b) *Reciprocity, conformity, social norm, and religious beliefs:* How true for you is each

of the following statements? Answer for each on a scale from 1 to 5, where “1” means

“it is particularly true for you” and “5” means “it doesn't hold true at all for you.”

- *Positive reciprocity 1:* If someone does me a favor, I am prepared to return it
- *Positive reciprocity 2:* I go out of my way to help somebody who has been kind to me before
- *Positive reciprocity 3:* I am ready to undergo personal costs to help somebody who helped me before
- *Negative reciprocity 1:* If somebody offends me, I will offend him/her back
- *Negative reciprocity 2:* If somebody puts me in a difficult position, I will do the same to him/her
- *Negative reciprocity 3:* If I suffer a serious wrong, I will take revenge as soon as possible, no matter what the cost
- *Conformity:* Behaving similarly to people around me makes me feel comfortable
- *Social norm:* I never cut into a line of people
- *Religious beliefs:* I am deeply religious

Note: We reconstructed the answers on the opposite scale from 1 to 5, where “1”

means “it doesn't hold true at all for you” and “5” means “it is particularly true for

you.” In addition, we respectively calculated out the indicator of positive or negative reciprocity, by summing up the answers for the three statements and dividing the value by 3.

c) *Big 5 personality traits:* Please circle ONE applicable number next to each statement to indicate the extent to which you agree or disagree with that statement. You should rate the extent to which the pair of traits applies to you, even if one characteristic applies more strongly than the other.

I see myself as;	Disagree Strongly	Disagree Moderately	Disagree A Little	Neither Agree Nor Disagree	Agree A Little	Agree Moderately	Agree Strongly
A: Extraverted, enthusiastic	1	2	3	4	5	6	7
B: Critical, quarrelsome	1	2	3	4	5	6	7
C: Dependable, self-disciplined	1	2	3	4	5	6	7
D: Anxious, easily upset	1	2	3	4	5	6	7
E: Open to new experiences, complex	1	2	3	4	5	6	7
F: Reserved, quiet	1	2	3	4	5	6	7
G: Sympathetic, warm	1	2	3	4	5	6	7
H: Disorganized, careless	1	2	3	4	5	6	7
I: Calm, emotionally stable	1	2	3	4	5	6	7
J: Conventional, uncreative	1	2	3	4	5	6	7

Notes: The Big 5 personality traits are a unifying framework comprising five basic characteristics: *extroversion, agreeableness, conscientiousness, emotional stability, and openness to experiences.* The 2017 PPSOU survey included the questions of Ten Item Personality Inventory (TIPI), which was developed by Gosling, Rentfrow, and Swan⁵, and was translated into Japanese by Oshio, Abe, and Cutrone⁶.

REFERENCES FOR APPENDIX

1. Harrison, G.W., Lau, M.I., & Williams, M.B. Estimating individual discount rates in Denmark: A field experiment. *American Economic Review* **92**(5), 1606–1617. (2002).
2. Cramer, J.S., Hartog, J., Jonker, N., & Van Praag, C.M. Low risk aversion encourages the choice for entrepreneurship: An empirical test of a truism. *Journal of Economic Behavior & Organization* **48**(1), 29–36. (2002).
3. Hartog, J., Ferrer-i-Carbonell, A., & Jonker, N. Linking measured risk aversion to individual characteristics. *Kyklos* **55**(1), 3–26. (2002).
4. Guiso, L., and Paiella, M. The role of risk aversion in predicting individual behaviors. CEPR Discussion Paper No. 4591. Available at SSRN: <https://ssrn.com/abstract=608262> (2004).
5. Gosling, S. D., Rentfrow, P. J., & Swann, W. B., Jr. A Very Brief Measure of the Big Five Personality Domains. *Journal of Research in Personality* **37**, 504–528. (2003).
6. Oshio, A., Abe, S., & Cutrone, P. Development, Reliability, and Validity of the Japanese Version of Ten Item Personality Inventory (TIPI-J). *The Japanese Journal of Personality* **21**(1), 40–52. (2012).