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The social contagion of prosocial behaviour: How neighbourhood blood donations influence individual donation behaviour

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A B S T R A C T

Life-saving transfusions and numerous other medical treatments are enabled by a minority of people that donate blood. But why do some people repeatedly engage in such prosocial behaviour, especially when it is costly to themselves? This study examines to what extent social contagion within neighbourhoods – changing behaviour in response to the behaviour of others – affects repeated blood donation behaviour. We draw on longitudinal survey and register data from a representative sample of blood donors in the Netherlands from 2007 to 2014 (N = 15,090). Using a panel data model and an instrumental variable approach, we find that donors are positively affected by donations made by other donors living in their neighbourhood. This effect does not seem to be mediated by normative or informational social influence. Exploratory analysis further attributes this finding to social contagion within donor couples. Our study contributes to the literature on repeated blood donation behaviour, and can inform retention strategies of blood banks.

1. Introduction

Blood donations save lives by enabling transfusions and numerous other routine medical treatments (Healy, 2000; Slonim et al., 2014). For donors, however, they are costly in terms of time and potential inconveniences. Because of that, blood donations are often considered an ideal-typical example of prosocial behaviour. In many countries, blood donors make up less than five percent of the age-eligible population, and the majority of donations therefore come from few people that continuously donate over the course of their life (Masser et al., 2008; Piersma et al., 2017, 2019; Piliavin, 1990).[1]

Why do some people repeatedly engage in prosocial behaviour even when this behaviour is costly to themselves? Two strands of literature have made important progress towards answering this question.

First, studies aiming to explain real-world (i.e., non-experimental) prosocial behaviour provide a comprehensive picture of individual-level determinants of repeated prosocial behaviour, such as resources (Wilson and Musick, 1997) and the development of a role-identity (Piliavin et al., 2002). With few exceptions (e.g., Cimaroli et al. (2012); Merz et al. (2017); Piersma et al. (2021)), however, most of these studies are individual-centred and do not account for the physical or social context of behaviour (Bekkers and Wiepking, 2011; Irwin and Simpson, 2013; Piersma et al., 2017).

A second strand of the literature has focused on contextual conditions that allow prosocial behaviour to be sustained over time, and has so far mainly drawn on laboratory experiments. These studies of collective action have demonstrated the importance of the social context for prosocial behaviour to persist over time (Simpson and Willer, 2015). For example, prosocial behaviour can be sustained over time if social norms can be enforced through rewards and punishments. Another key result has been that individuals keep contributing to public goods if they believe that others do so as well, and reduce their contribution if they believe others will no longer contribute (Chaudhuri, 2011; Thöni and Volk, 2018). This is evidence for social contagion, broadly defined as a

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[1] Systems for collecting blood are diverse. Countries in the Global North (including the Netherlands) largely rely on voluntary and non-remunerated donations where donor and recipient remain anonymous to each other. Countries in the Global South more frequently rely on remunerated donations and sometimes on family-replacement systems (Slonim et al., 2014). See Healy (2000) for a discussion of how the proportion of blood donors in the population is affected by countries' collection regimes.

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process where individuals change their behaviour in response to the behaviour of others.[2] Social contagion of prosocial behaviour can be both a blessing and a curse: donors might be encouraged to keep donating as long as others do as well, but might also reduce their contributions because they perceive that others do not contribute. Many health behaviours have been shown to be affected by social contagion, ranging from smoking and health screenings to suicidality (Christakis and Fowler, 2013; Haas and Schaefer, 2014; Mueller and Abrutyn, 2015). However, despite the accumulating evidence for the social contagion of prosocial behaviour from experimental studies, it remains unclear to what extent social contagion affects real-world prosocial behaviour and blood donation in particular.

The limited attention to social contagion might be a crucial oversight given the insights into its importance from studies of collective action. At the same time, many theoretical models underlying studies of real-world prosocial behaviour have developed individual-level measures for individuals exposure to social influences. The Theory of Planned Behaviour (TPB) (Ajzen, 1991), which has been the dominant theoretical basis for empirical studies explaining blood donation behaviour (Masser et al., 2020), predicts that all contextual influences are mediated by individuals attitudes and intentions (Sniehotta et al., 2014). The concepts developed within the TPB framework and its extensions can therefore be useful to assess *how* social contagion might affect prosocial behaviour.

In this study, we link insights from both strands of the literature: studies taking an individual-centred approach to the analysis of repeated real-world prosocial behaviour and studies with a focus on the social context of prosocial behaviour. Our first goal is to assess to what extent social contagion influences repeated blood donations. The second goal is to test potential underlying mechanisms of social contagion, such as normative or informational social influence (Deutsch and Gerard, 1955; White et al., 2009). In the following, we review the relevant literature and derive hypotheses about the social contagion of blood donations.

Social contagion of repeated blood donations implies that individuals change their donation behaviour according to the donation behaviour of others. But who might be relevant others? In laboratory experiments on social contagion, individuals are typically assigned to small artificial groups composed of a few other individuals whose behaviour is directly observable (Thöni and Volk, 2018). In the real world, however, social influences operate through social networks and social relations (Christakis and Fowler, 2013; Ruppel et al., 2022). It is therefore the *social environment* that is of importance for social contagion to work. A large literature on neighbourhood effects has shown that neighbourhoods, particularly smaller scale geographical areas, are relevant social contexts for behaviour (Galster, 2012; Petrović et al., 2019; Pinkster and Völker, 2009). For the Netherlands, it has also been shown that small scale administrative areas can capture neighbourhood effects (Veldhuizen et al., 2013). To test the implications of laboratory experiments on social contagion for real-world prosocial behaviour, an obvious choice to capture the social environment is therefore the neighbourhood. At the same time, not all of individuals' social networks map into neighbourhoods. For example, Völker et al. (2007) have shown that among people drawn from a representative sample of neighbourhoods in the Netherlands, about 20% of the members of a social network were also neighbours. The local orientation of social networks also varies by ethnic background and socio-economic status (Pinkster and Völker, 2009). In addition, certain types of social relations are more likely to be observed within neighbourhoods. For example, family members are more likely to live in the same neighbourhood than friends or colleagues.

Furthermore, it has been shown that the strength of social contagion of prosocial behaviour increases with social proximity (Dimant, 2019). From the domain of charitable giving, there is evidence that married couples often make joint decisions about whether and how much to donate to charity through 'cooperative bargaining' (Andreoni et al., 2003; Einolf et al., 2018; Yörük, 2010; Mesch et al., 2022). Blood donations are ultimately individual contributions, but it is likely that decisions about whether and how often to donate are nevertheless coordinated with close social contacts. Given that family members and especially partners have a higher (compared to other social contacts) likelihood to live in the same neighbourhood and a high social proximity to the focal individual, we might expect them to be among the stronger sources of social influence within neighbourhoods – a question that we will return to in our exploratory analysis.

The only existing empirical evidence for social contagion among blood donors that we are aware of comes from Bruhin et al. (2020), who show that invitations to donate blood sent to pairs of donors living at the same address (many likely to be couples) are about 70% more effective in soliciting donations than invitations sent to isolated donors. However, it is unclear to what extent social contagion influences *repeated* blood donation, and whether social contagion extends to the broader social context of neighbourhoods. Drawing on the comprehensive theoretical and empirical work on social contagion in prosocial behaviour, we hypothesise:

Hypothesis 1. The higher the number of blood donations by others, the higher the individual's number of blood donations.

Hypothesis 1 is at the core of our theoretical framework depicted in Fig. 1. To tackle the question through which psychological mechanisms social contagion might work, we conceptualise potential mechanisms along the lines of two distinct forms of social influence, namely normative and informational social influence (Deutsch and Gerard, 1955; Frey and Meier, 2004; van Teunenbroek et al., 2020).

1.1. Normative social influence

Normative social influence can be defined as 'an influence to conform with the positive expectations of another' (Deutsch and Gerard, 1955, p. 629). Below, we argue that donations by others can create such expectations through three channels: influence on subjective norms about blood donation, influence on the likelihood of forming an identity as a blood donor, and influence on moral norms about blood donations.

1.1.1. Subjective norms

Subjective norms reflect to what extent individuals believe that others expect them to show a specific behaviour (Ajzen, 1991). While there is ample evidence that subjective norms about blood donations affect individuals' blood donation behaviour (Bednall et al., 2013), it is unclear how subjective norms about blood donation are formed and related to others' donation behaviour. Suggestive evidence for such a relationship comes from White et al., (2009), who show that subjective norms for recycling behaviour are related to perceptions about recycling

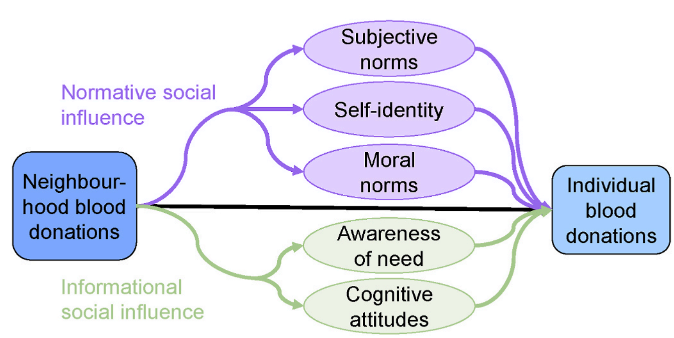

Fig. 1. Theoretical model of mechanisms underlying social contagion of blood donations.

[2] Related terms in adjacent literature are conditional cooperation, peer effects, social influence, or third-party influence.

behaviour of others. Thus, we expect that subjective norms about blood donations are also derived from others *actual* donation behaviour. We hypothesise that:

Hypothesis 2. The positive effect of donations by others on individual blood donations is mediated by individuals' subjective norms about blood donations.

1.1.2. Self-identity

Sociological and social psychological theory emphasise social self-identities next to individual identities (Stryker and Burke, 2000; Turner, 1978). Theoretical accounts argue that a self-identity emerges as others identify an individual with a specific role (Charng et al., 1988; Grube and Piliavin, 2000; Turner, 1978), and is made salient in contexts where social relations are tied to this self-identity (Charng et al., 1988; Stryker and Burke, 2000). These processes of group and role identification are more likely to take place in social contexts where other people are actively engaged in blood donation behaviour (Charng et al., 1988; Irwin and Simpson, 2013; Piliavin, 1990). Self-identity as a blood donor, in turn, is an important predictor of repeated blood donations (Bednall et al., 2013; Masser et al., 2008). We therefore hypothesise that:

Hypothesis 3. The positive effect of the donations by others on individual blood donations is mediated by individuals' self-identity as a blood donor.

1.1.3. Moral norms

Moral norms can be understood as the internalisation of social norms (Armitage and Conner, 2001; Gintis et al., 2003). Moral norms for behaviour can be constructed in a specific context, activated for example by receiving a request (Piliavin and Libby, 1986). In addition, Lindström et al. (2018) have shown that individuals perceive prosocial behaviour as more morally obligatory the more commonly they observe it. Being among other active blood donors might therefore increase individuals' moral norms about blood donations. In turn, because the violation of moral norms incurs costs, e.g., in the form of guilt, higher moral norms about prosocial behaviour should increase repeated prosocial behaviour (Gintis et al., 2003). This has also been shown for the case of blood donations (Masser et al., 2008). We hypothesise that:

Hypothesis 4. The positive effect of donations by others on individual blood donations is mediated by individuals' moral norms about blood donations.

1.2. Informational social influence

Informational social influence happens when one accepts 'information obtained from another as evidence about reality' (Deutsch and Gerard, 1955, p. 629), which can lead to attitude change (Wood, 2000). Below, we outline that awareness of need for blood donations and cognitive attitudes about blood donations might be derived from the donation behaviour of others, and in turn affect blood donation behaviour.

1.2.1. Awareness of need

Awareness of need has been identified as central factor motivating charitable giving (Bekkers and Wiepking, 2011; van Teunenbroek et al., 2020), and awareness of need for blood donations is among the most frequently self-reported motivations for donating blood (Ferguson et al., 2020). Theoretically, the effect of donations by others on an individual's awareness of need might be positive or negative. A positive relationship follows from the assumption that donations by others make the need for prosocial behaviour apparent in the first place (Schervish and Havens, 1997). A negative relationship follows from models of pure altruism (Becker, 1974), impure altruism (Andreoni, 1990), and diffusion of responsibility (Darley and Latane, 1968), where own and others' contributions are largely seen as substitutes in addressing a given need. Tsvetkova and Macy (2014) have linked these two perspectives by showing that contributions by others initially increase own contributions, and decrease own contributions once they are fairly common. Because only a small proportion of adults in the Netherlands donate blood, donations by others should increase rather than decrease awareness of need for blood donations. We therefore hypothesise that:

Hypothesis 5. The positive effect of donations by others on individual blood donations is mediated by individuals' awareness of need for blood donations.

1.2.2. Cognitive attitudes

Cognitive attitudes refer to 'the degree to which a person has a favorable or unfavorable appraisal of the behaviour in question' (Ajzen,

Table 1
Summary statistics of study measures.

	Mean or %	Min	Max	SD	SD betw.	SD within
Individuals' donation attempts	3.579	0	16	3.985	3.666	1.564
Donation attempts per inhabitant	0.102	0	3	0.150	0.135	0.068
Invitations to donate per inhabitant	0.231	0	3.8	0.295	0.262	0.138
Male	45.1%	0	1			
Income	3.826	1	7	1.573	1.573	0
Age	48.285	19.587	68.498	11.441	11.265	2.000
Working hours	26.715	0	95	15.619	14.549	6.127
ln(working hours + 1)	2.845	0	4.564	1.347	1.245	0.559
Having children	76.2%	0	1			
Individuals' invitations to donate	7.254	0	35	6.615	5.957	2.878
ln(Individuals' invitations + 1)	1.624	0	3.584	1.117	1.009	0.479
Previous donations	28.891	0	147.647	22.285	22.285	0
Permanently deferred	7.4%	0	1			
Subjective norms	0.002	−1.940	1.866	0.884	0.820	0.331
Self-identity	0.002	−3.718	2.267	0.932	0.884	0.295
Moral norms	0.003	−2.219	2.189	0.903	0.856	0.287
Awareness of need	0.007	−4.840	1.147	0.809	0.760	0.275
Cognitive attitudes	0.005	−7.690	0.836	0.788	0.690	0.381
Generalized social trust	−0.002	−3.790	2.510	0.855	0.852	0.068
Altruism	0.003	−3.945	2.114	0.883	0.830	0.302
Self-efficacy	−0.002	−5.369	1.027	0.949	0.804	0.504
Affective attitudes	0.001	−3.338	1.855	0.940	0.865	0.370

Abbreviations: SD betw. = standard deviation of variable between individuals. SD within = standard deviation of variable within individuals over time.
Descriptive statistics for attitudinal measures (Subjective norms - Affective attitudes) are predicted factors scores based on the measurement model (see Table 2). For these measures, higher values indicate more of the measured construct.

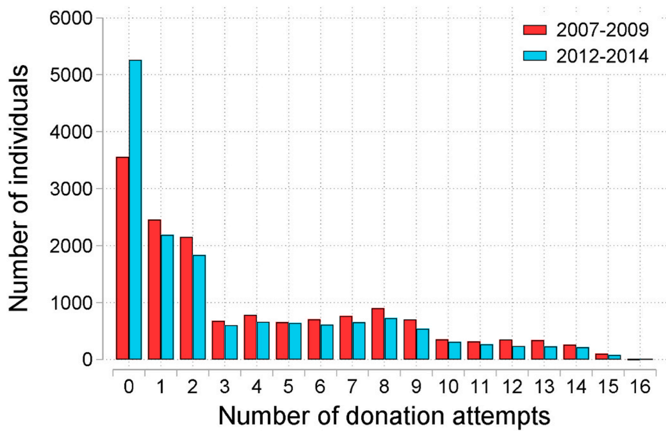

Fig. 2. Histogram of the count of the individuals' whole blood donation attempts in 2007–2009 and 2012–2014, N = 15,090.

1991, p. 188). Several studies have shown that cognitive attitudes about blood donation positively affect the donation behaviour of current donors (Bednall et al., 2013). According to the TPB, cognitive attitudes are determined by expectations about the outcome of performing the behaviour (Ajzen, 1991). These expectations might be impacted by the prosocial behaviour of others, e.g., whether performing the behaviour is seen as something positive or worthwhile. For example, the donation behaviour of others might be perceived as a 'quality signal' for the cause of blood donations, indicating that a cause is worth enduring personally costly behaviour, or less costly than initially thought (Frey and Meier, 2004; van Teunenbroek et al., 2020). We hypothesise that:

Hypothesis 6. The positive effect of the donations of others on individual blood donations is mediated by individuals' cognitive attitudes about blood donations.

2. Data and methods

Our two main data sources are the Donor InSight study (DIS; see Timmer et al. (2019) for information on collection procedures) and the Dutch Donor Registry (Sanquin, 2020). DIS is a longitudinal survey among a representative sample of the Dutch blood donor population in 2007–2009 (DIS-I, N = 31,338) and 2012–2013 (DIS-II, N = 34,826, of whom 22,132 (63.6%) also participated in DIS-I). The Dutch Donor Registry contains routinely collected data on individuals' blood donations, invitations to donate, donor addresses, and demographics. Sanquin is the only organisation that collects blood in the Netherlands. The Dutch Donor Registry therefore provides complete data on all blood donations within the study period, regardless of whether an individual participated in DIS or not.

2.1. Sample

22,132 individuals participated in both DIS waves. To focus on donors, we exclude 2983 participants who never made a donation since 2007. We further exclude 1645 participants (7%) who donate blood plasma (with a much higher possible donation frequency) instead of whole blood, 1281 participants (6%) who started donating after the start of the study period in 2007, and 1133 participants (5%) who were too old to donate (older than 70). Our analyses thus draw on a sample of 15,090 blood donors observed in both 2007–2009 and 2012–2014.

2.2. Variables

Table 1 provides descriptive statistics for the study variables. Table S1 in the Supplementary Material shows a correlation matrix of study variables. Below, we describe the central study measures in more detail.

2.2.1. Whole blood donation attempts

Our dependent variable (DV) is the individual's number of whole blood donation attempts in 2007–2009 and in 2012–2014, as registered in the Donor Registry.[3] The number of donation attempts provides a measure of *repeated* prosocial behaviour within each period. Aggregating the behavioural data for these three-year periods further keeps the behavioural measure of prosocial behaviour closely related to the socio-demographic and attitudinal measures obtained through the survey. Fig. 2 shows a histogram of the number of whole blood donation attempts in the two periods (2007–2009 and 2012–2014). On average, donors made 3.93 donations in the first and 3.23 donations in the second period. The most notable difference is that the proportion of people making no donation attempt increased from about 24% in the first period to about 35% in the second period.

2.2.2. Donation attempts per inhabitant

To capture the donation behaviour of other donors in the neighbourhood, we use the number of other donors' donation attempts per inhabitant within the focal donor's six-digit postcode. Importantly, this measure does therefore not include the number of donation attempts by the focal donor themself. The six-digit postcodes of the Netherlands are small-scale geographical units that were originally derived from walking routes of postmen. There are approximately 430,000 postcodes, and the ones in our sample have an average of 58 inhabitants (Median = 50, Min = 5, Max = 1240). The number of inhabitants per six-digit postcode is provided by Statistics Netherlands (Centraal Bureau voor de Statistiek (CBS)). We use the number of inhabitants on 1 January 2010 to create the variable for the first period, and the number of inhabitants on 1 January 2014 for the second period.

2.2.3. Mediators

The measures of subjective norms about blood donation, self-identity as a blood donor, and moral norms about blood donation are based on scales commonly used in (extensions of) the TPB (Ajzen, 1991), adapted to the blood donation context in previous work (Charng et al., 1988; Merz et al., 2017; Veldhuizen et al., 2011). They were measured using a five-point Likert scale ranging from 'completely disagree' to 'completely agree'. Table 2 shows the items used to measure these constructs. Item 1 of subjective norms additionally included 'does not apply, I do not have a partner' as a response option, which was recoded to 1 (completely disagree), to reflect that these individuals are not subject to influence by partners. To measure awareness of need for blood donations, we use responses to the two questions given in Table 2, also measured on a five-point Likert-type scale. Cognitive attitudes towards blood donation were elicited using a semantic-differential scale, where respondents fill out a five-point rating option based on the bipolar adjective pairs given in Table 2.

2.2.4. Covariates

Our models include donor age in years, sex (0 = female, 1 = male), having children (0 = no, 1 = yes), working hours per week, monthly net income in seven categories, overall number of blood donations before 2007, being permanently deferred (0 = no, 1 = yes), donation invitations, generalised social trust (GST), altruistic values, self-efficacy, and affective attitudes towards blood donation as covariates. These variables have been found to affect blood donation behaviour (Bednall et al., 2013; Piersma et al., 2017, 2019; Merz et al., 2017), and might be confounders of the relationship between own and others donations if

[3] Compared to successful donations, donation attempts better capture individuals' prosocial behaviour, that is, presenting at the blood bank to make a donation, irrespective of cases where donors had to be deferred from making a donation for medical reasons.

Table 2
Confirmatory factor analysis of attitudinal measures.

	Period 1		Period 2	
	λ	S.E.	λ	S.E.
Subjective norms about blood donation ($CR_{t1} = 0.708$, $CR_{t2} = 0.706$)				
'My partner thinks I should continue giving blood as long as my health allows it.'	0.631	0.006	0.644	0.006
My family and friends think that I should continue giving blood as long as my health allows it.'	0.841	0.007	0.828	0.007
Self-identity as a blood donor ($CR_{t1} = 0.688$, $CR_{t2} = 0.699$)				
'Being a blood/plasma donor is an important part of who I am.'	0.686	0.005	0.699	0.005
'Being a blood donor means more to me than just giving blood.'	0.638	0.005	0.648	0.005
'I would feel sorry if I could no longer give blood.'	0.629	0.004	0.633	0.005
Moral norms about blood donation ($CR_{t1} = 0.735$, $CR_{t2} = 0.723$)				
'I feel morally obliged to give blood.'	0.514	0.005	0.511	0.005
'I would feel guilty if I did not give blood.'	0.791	0.004	0.775	0.004
'Not giving blood is actually against my principles.'	0.759	0.004	0.747	0.004
Awareness of need for blood donations ($CR_{t1} = 0.525$, $CR_{t2} = 0.535$)				
'My blood is needed.'	0.728	0.008	0.695	0.008
'I have the feeling that it would not matter if I gave blood.' [reverse coded]	0.454	0.007	0.508	0.007
Cognitive attitudes towards blood donation ($CR_{t1} = 0.548$, $CR_{t2} = 0.585$)				
'I find giving blood …				
negative – positive	0.647	0.008	0.617	0.007
good – bad [reverse coded]	0.432	0.007	0.536	0.007
meaningless – worthwhile.'	0.525	0.007	0.543	0.007
Generalized social trust ($CR_{t1} = 0.523$, $CR_{t2} = 0.528$)				
'In general, most people can be trusted.'	0.566	0.007	0.578	0.007
'You can not be careful enough when you are dealing with other people.' [reverse coded]	0.624	0.007	0.620	0.007
Altruistic values ($CR_{t1} = 0.709$, $CR_{t2} = 0.711$)				
'I'd rather work for my own well being than for that of others' [reverse coded]	0.433	0.006	0.431	0.006
'I try to work towards the wellbeing of society.'	0.549	0.005	0.555	0.005
'I am not very interested in helping others' [reverse coded]	0.417	0.006	0.424	0.006
'It is important to me that I help others.'	0.720	0.005	0.719	0.005
'I think it is important to help the poor and the needy.'	0.719	0.005	0.716	0.005
Self-efficacy ($CR_{t1} = 0.899$, $CR_{t2} = 0.872$)				
'If I wanted to, I would be able to continue giving blood as long as my health allows it.'	0.727	0.004	0.763	0.004
'When I receive an invitation to give blood, I consider it a matter of course to do so.'	0.715	0.004	0.677	0.004
'I am planning to continue giving blood as long as my health allows it.'	0.858	0.002	0.800	0.003
'I will continue to be a blood donor until it is no longer possible for me to donate.'	0.834	0.003	0.664	0.004
'When I receive an invitation from the blood bank, I automatically go to give blood.'	0.639	0.004	0.654	0.004
I think that I will continue to give blood as long as my health permits it.'	0.846	0.002	0.809	0.003
Affective attitude towards blood donation ($CR_{t1} = 0.868$, $CR_{t2} = 0.883$)				
'I find giving blood …				
pleasant – unpleasant [reverse coded]	0.775	0.003	0.809	0.003
annoying – enjoyable	0.907	0.002	0.920	0.002
unappealing – appealing.'	0.799	0.003	0.805	0.003

Abbreviations: λ = standardized factor loading; S.E. = standard error; CR = composite reliability estimate.
RMSEA = 0.046; CFI = 0.851; TLI = 0.836.

they also affect others' blood donation behaviour, for example because of homophily in social relations. The number of donation invitations and individuals' working hours were log-transformed to better meet the linearity assumption of the Poisson model (see Supplementary Material S1.4). Details of the measurement of attitudinal variables can be found in Table 2, and details on the measurement of the remaining covariates are given in the study's preregistration available at https://osf.io/wjyvg.

2.3. Methods

There are two main concerns of endogeneity when estimating the effect of others' donations on the focal individual's donations. The first is that the donations by others might be correlated with unobserved time-constant heterogeneity between donors that also affects their donation behaviour. To address this concern, we use a correlated random effects (CRE) panel data model, which controls for time-constant unobserved heterogeneity between donors. The second concern is that changes in donations by others over time are correlated with time-varying unobserved factors, for example external shocks like closing or opening of specific donation locations. To address this concern, we use a CRE instrumental variable (IV) approach that simultaneously addresses potential endogeneity with regard to time-constant and time-varying unobservables (Lin and Wooldridge, 2019). Both approaches are described in more detail in the section 'structural model'.

We implement these approaches in a structural equation modelling (SEM) framework. A SEM consists of two major components: a measurement model and a structural model. The measurement model describes how latent constructs, such self-identity as a blood donor, are related to the observed survey items. The structural model describes the relationships between the variables, as predicted by hypotheses 1–6. We first estimate the measurement model using full information maximum likelihood, and subsequently include the predicted factor scores of the latent variables in the structural model.[4]

We preregistered our hypotheses, the operationalisation of variables, and an analysis plan through the Open Science Framework: https://osf.io/wjyvg. We depart from the preregistered analysis plan in two ways. First, we additionally include permanent deferral from donating blood as covariate. This slightly increases precision but does not change the results substantially. Second, we do not rerun our analyses with

[4] This is to avoid numerical integration across many dimensions, which is required in maximum likelihood estimation of a nonlinear model including continuous latent variables and would make the estimation duration unfeasible and the results potentially inaccurate (Rockwood, 2021).

donations by others aggregated based on four-digit postcodes. These are much larger in size and, as our results will demonstrate, are therefore unlikely to accurately capture the donation behaviour of relevant others.

Statistical analyses are carried out in Stata 16 (StataCorp.). The models are estimated using quasi-maximum likelihood estimation (QMLE) to obtain standard errors that are robust to heteroskedasticity (e.g., violations of the Poisson models' assumption of equidispersion, which is further examined in Supplementary Material S1.4) (Cameron and Trivedi, 2013; Wooldridge, 2013; StataCorp, 2016).

2.3.1. Measurement model

In the measurement model, the survey items that make up latent constructs are included in a confirmatory factor analysis (CFA). We assume scalar longitudinal measurement invariance, meaning that the psychometric properties of constructs do not change with repeated measurements. Latent variables are therefore measured by the same items in both periods, and intercepts and path coefficients of the measurement model are constrained to be equal in both waves (Baldwin, 2019). Results of the CFA are displayed in Table 2. All indicators load significantly on the latent constructs. The composite reliability estimates (CR) suggest that convergent validity of most constructs is acceptable, with estimates being around or above 0.7. The measures of awareness of need, cognitive attitudes, and GST, however, have worse convergent validity, as indicated by composite reliability estimates of around 0.55, which is below the commonly suggested threshold of 0.6 (Bagozzi and Yi, 1988). To stick to commonly used scales and our preregistered analysis plan, we do not respecify the CFA based on composite reliability. Regarding discriminant validity, we observe that correlations between predicted factor scores are at most moderate in size (see Table S1), suggesting reasonable discriminant validity between constructs (Kline, 2016). Two exceptions are strong correlations of self-identity with moral norms ($r = 0.76$) and self-efficacy ($r = 0.70$), indicating that these constructs measure similar concepts. We discuss their potentially interrelated impact on donation behaviour below.

2.3.2. Structural model

Using longitudinal data provides the opportunity to account for unobserved time-invariant heterogeneity between individuals. We use a CRE Poisson regression for modelling the count of an individuals' blood donation attempts in the two periods from 2007 to 2009 and

Table 3
CRE Poisson regression of blood donation attempts on others' donations and mediators, and linear CRE regression of mediators on others' donations.

	(1)		(2)		(3)	
	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.
Individuals' donation attempts						
Donation attempts per inhab.	0.108*	(0.044)	0.102*	(0.043)	0.105*	(0.043)
Male	0.480***	(0.026)	0.474***	(0.026)	0.465***	(0.026)
Income	−0.040***	(0.008)	−0.022**	(0.008)	−0.026**	(0.008)
Age	−0.020***	(0.002)	−0.021***	(0.002)	−0.021***	(0.002)
Having children	−0.115***	(0.033)	−0.107***	(0.032)	−0.109***	(0.032)
ln(working hours+1)	−0.021**	(0.006)	−0.019**	(0.006)	−0.020**	(0.006)
Previous donations	−0.007***	(0.001)	−0.008***	(0.001)	−0.008***	(0.001)
ln(Individuals' invitations +1)	0.674***	(0.014)	0.674***	(0.014)	0.677***	(0.014)
Permanently deferred	−0.446***	(0.035)	−0.447***	(0.035)	−0.452***	(0.035)
Subjective norms			0.021	(0.011)	0.016	(0.011)
Self-identity			0.115***	(0.018)	0.024	(0.025)
Moral norms			−0.088***	(0.013)	−0.030*	(0.015)
Awareness of need			0.050***	(0.012)	0.055***	(0.015)
Cognitive attitudes			0.012	(0.009)	−0.001	(0.009)
Generalized social trust					0.016	(0.014)
Self-efficacy					0.038**	(0.013)
Altruism					−0.016	(0.012)
Affective attitudes					0.012	(0.010)
Constant	−1.087***	(0.069)	−0.998***	(0.069)	−0.963***	(0.069)
Subjective norms						
Donation attempts per inhab.					0.063*	(0.032)
Constant					0.001	(0.008)
Self-identity						
Donation attempts per inhab.					0.043	(0.029)
Constant					0.001	(0.008)
Moral norms						
Donation attempts per inhab.					0.030	(0.029)
Constant					0.003	(0.008)
Awareness of need						
Donation attempts per inhab.					−0.004	(0.034)
Constant					−0.007	(0.008)
Cognitive attitudes						
Donation attempts per inhab.					0.072*	(0.030)
Constant					0.000	(0.007)
N	24,552		24,552		24,552	
AIC	106,877.1		106,582.9		418,945.5	
BIC	106,998.8		106,753.2		419,351.4	

Abbreviations: Coef. = coefficient; S.E. = standard error.
For the Poisson regression (where the DV is individuals' donation attempts), the coefficient multiplied by 100 approximates the percentage change in the outcome for a one-unit change in the independent variable. Statistically significant contextual effects are included (but not shown) in the regressions with individuals' donation attempts as DV, and in the regressions with the mediating constructs as DV. Estimates for all contextual effects are shown in Table S5. Heteroskedasticity-robust standard errors in parentheses.
*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

2012–2014. The CRE model introduces an unobserved individual effect a_i to the panel data Poisson model

$$E[y_{it}|x_{it}, a_i] = a_i\, exp(\beta x_{it}), \tag{1}$$

where y_{it} denotes the outcome variable for person i at time t, x_{it} are the time-varying predictors with coefficients β, and a_i is the unobserved effect. The random effects (RE) assumption is that a_i is uncorrelated with the predictors x_{it}. If this assumption is not met, the time-varying predictors x_{it} are endogenous because of omitted variables that are captured by a_i and correlated with the time-varying predictors x_{it}, leading to a biased estimation of β (Hamaker and Muthén, 2020; Wooldridge, 2013). This assumption can be tested by including time-averaged values of time-varying predictors $\bar{x}_i$ to model the correlation between a_i and x_{it}. Assuming a linear relationship, a_i is modelled as

$$a_i = exp(\gamma \bar{x}_i + r_i), \tag{2}$$

where $\bar{x}_i$ is the time average of the time-varying variables with coefficients γ and r_i denotes unobserved heterogeneity that is assumed to be uncorrelated with x_{it} (Cameron and Trivedi, 2013). Substituting equation (2) into equation (1) gives

$$E[y_{it}|x_{it}, a_i] = exp(\beta x_{it} + \gamma \bar{x}_i + r_i), \tag{3}$$

which is the CRE Poisson model (Cameron and Trivedi, 2013). The estimate for γ, called the 'contextual effect', serves as tool for testing whether CRE or RE assumptions are necessary. An estimate of a contextual effect that is not statistically significantly different from zero means that the RE assumption is sufficient. In that case the RE approach delivers more efficient estimates of β (Wooldridge, 2013). We thus include the statistically significant contextual effects into our models (Schunck and Perales, 2017).

We first estimate a model with socio-demographic variables as controls (Model 1 in Table 3). In the second model, we include the mediators in the regression of individuals donation attempts on donation attempts per inhabitant (Model 2 in Table 3). In the third model, we include attitudinal covariates which might be confounders regarding the mediators and individual's donation attempts (Model 3 in Table 3). Model 3 also includes the estimates for how the mediators are affected by the donation attempts per inhabitant. For analysis of the indirect effects we use the product method and obtain standard errors via the delta method (Coxe and MacKinnon, 2010).

2.3.3. Instrumental variable approach

We use an instrumental variable approach to address the concerns of endogeneity with regard to time-varying unobservables. In the Netherlands, the vast majority of blood donations are made following a personal invitation from the blood bank. We use the number of invitations to donate blood per other inhabitant as an instrument for the donation attempts per other inhabitant. This instrument should meet the relevance and exogeneity requirements of an appropriate instrumental variable: it is strongly related to the donation behaviour of others, but, conditional on covariates (e.g., the individuals' invitations to donate), not directly related to the individuals' blood donation behaviour. It should therefore affect the individual's donations only through its effect on the donations by others. One caveat to the exogeneity of the instrument might be that donors could receive invitations addressed to someone else living in the same household. However, invitations are personal and we therefore consider it unlikely that an individual donates based on the invitation to someone else. Invitations per inhabitant is calculated in a way analogous to the number of donation attempts per inhabitant, based on data from the Donor Registry. To implement the instrumental variable approach in the CRE Poisson model, we follow the two-step control function approach described in Lin and Wooldridge (2019). In the first step, the donations by others are regressed on the number of invitations to others and covariates in a fixed-effects regression. In the second step, we re-estimate Model 3 described above while including the residuals from the first step (the control function), and obtain standard errors via bootstrapping based on 5000 replications (Cameron and Trivedi, 2013, p. 56; Lin and Wooldridge, 2019).

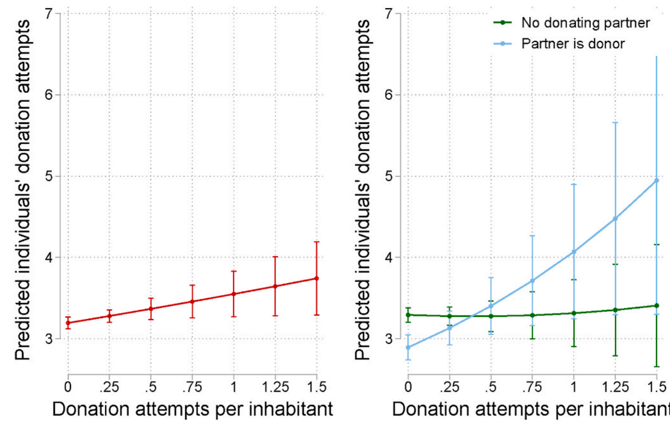

Fig. 3. Predicted number of individuals' blood donation attempts with 95% CIs derived from model 3 in Table 3. **Left**: Predicted number of individuals' blood donation attempts by number of donations per inhabitant. **Right**: Predicted number of individuals' blood donation attempts by number of donations per inhabitant and by having a partner that is a blood donor or not. Predictions are marginal with respect to the individual-specific random effect.

3. Results

We first present results on social contagion of blood donation behaviour, and exploratory analyses on the question through which social relations social contagion within neighbourhoods occurs. We then present results on the potential mediating mechanisms underlying social contagion.

3.1. Social contagion influences repeated blood donations

Hypothesis 1 stated that individuals increase or decrease their donations in line with the donations made by others. From Model 1 in Table 3 we see that a one-unit increase in the number of donations per inhabitant is estimated to increase the number of an individual's donations by about 11% ($b = 0.108$, $p = 0.013$). This estimate does not substantially change after including the potential mediators (Model 2) and further covariates (Model 3). The left-hand panel of Fig. 3 visualises this effect. It indicates that an increase in the donation attempts per inhabitant from 0 to 1 would increase the individual's donations from about 3.2 donations to about 3.5 donations.

The results from the IV approach support this finding (see Supplementary Material S2). The coefficient for donations by others is positive and significant ($b = 0.227$, $p = 0.011$).[5] Because the IV approach estimates a local average treatment effect, the coefficient indicates that for those donors whose neighbours are actually affected by invitations to donate, a one-unit increase in the number of donations per inhabitant is estimated to increase the number donations by about 22%. Next, we adjust for multiple hypothesis testing of our six hypothesis (including the mediated relationships) to control for the false discovery rate (FDR) following Benjamini and Hochberg (1995). Controlling for the FDR, the significance threshold for H1 is reduced to $p < 0.008$, which the result for H1 does not meet. Finally, after excluding potential outliers (see Supplementary Material S1.3 for details) the estimate for the effect of the donations of others remains similar but no longer significant ($b =$

[5] Among donors living alone, the coefficient is negative and no longer statistically significant ($b = -0.12$, $p = 0.61$). The reason for the sign switch is likely that the most influential other donors (e.g., partners) are excluded.

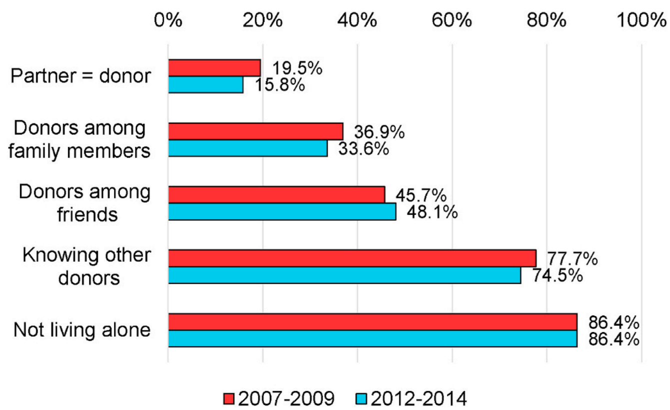

Fig. 4. Donors within the focal donor's social network.
Note: Participants were asked 'Are there people among your direct acquaintances who are blood donors?' and could select several of the first three response options given above. Knowing other donors is a dummy that captures whether 'yes' was answered to any of these options. 'Not living alone' is a dummy that indicates whether donors live alone (or with children), or together with others, including potential donors.

Table 4
Interaction effects of donations by others with donors in network.

	Coef.	S.E.
Interaction of donations by others with:		
Partner = donor	0.335**	(0.115)
Donors among family members	−0.086	(0.105)
Donors among friends	−0.184	(0.110)
Knows any other donors	0.070	(0.199)
Not living alone	0.313	(0.180)

Abbreviations: Coef. = coefficient; S.E. = standard error.
Results based on including interaction terms of donations per inhabitant with dummy variables for each of the variables for having donors within the social network and living alone. Heteroskedasticity-robust standard errors in parentheses.
$^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.

0.093, $p = 0.091$). Together with the results from a robustness check using the number of donors instead of the number of donations (see Supplementary Material Table S8), this might suggest that it is (clusters of) very active donors that influence others' donation behaviour. To summarise, the result for H1 seems to be robust regarding potential time-constant and time-varying unobservables, but the estimated effect is small and therefore sensitive to the control of the FDR and exclusion of potential outliers.

3.1.1. Social contagion between whom?

As outlined above, Dutch postcodes are a good proxy for what individuals perceive as their neighbourhood, but they do not necessarily capture individuals' social networks. Based on participants' information about their 'donor network', we can explore between whom social contagion within postcodes might operate. From Fig. 4 we can see that most donors (about 75%) know some other donors, about half of them have donors among friends, about a third have donors among family members, and about 20% of donors have a partner who also donates blood.

Our exploratory analysis shows a significant interaction effect between donations made by others in the same postcode and having a partner who is also a blood donor (Table 4). As shown in the right-hand panel of Fig. 3, the effect of social contagion is much stronger for those who have a partner who is also a donor. Re-estimating Model 3 among the subsample of donors with a donating partner suggests that a one-unit increase in the number of donations per inhabitant increases the number of the individuals' donations by about 35% ($b = 0.350$, $p < 0.001$). For those that do not have a donating partner, the association is close to zero (see the right-hand panel of Fig. 3). While the absence of evidence does not necessarily mean that there is no effect, the 95% confidence interval of the estimate for those without a donating partner shows that large effects by neighbours other than the partners are generally unlikely (Lakens et al., 2020). Thus, social contagion within neighbourhoods seems to be mostly driven by social contagion within donor couples.

3.2. No evidence that normative and informational social influence mediate social contagion

Model 3 in Table 3 shows the results for the mediated relationships (H2–H6). The lower half of the table shows how individuals' attitudes towards blood donations change with the donation behaviour of others. Each of the potential mediators is displayed in its own row, which shows the results from a linear CRE regression of the mediator on donations by others. In line with our hypotheses, individuals' subjective norms and cognitive attitudes are positively and significantly related to the donation behaviour of others. For each one-unit increase in the number of donations per inhabitant, individuals' subjective norms are estimated to increase by about 0.06 units (the subjective norms measure has a range of 3.81). For each one-unit increase in the number of donations per inhabitant, individuals' cognitive attitudes are estimated to increase by about 0.07 units (the cognitive attitudes measure has a range of 8.53). However, theses associations are small, suggesting that changes in subjective norms and cognitive attitudes are not strongly influenced by the donation behaviour of others within the neighbourhood. The remaining mediators are not significantly related to the donation behaviour of others.

The upper half of Table 3 shows to what extent the potential mediators affect individuals' whole blood donation attempts. Model 3 shows that a one-unit increase in individuals' moral norms about blood donations (which has a range of 4.41) is estimated to decrease the number of individuals' donations by about 3%. A one-unit increase in individuals' awareness of need for blood donations (which has a range of 5.99) is related to a 5.5% increase in the number of individuals' donations. Changes in individuals' subjective norms, self-identity, and cognitive attitudes are not associated with changes in individuals donation behaviour. Because of the strong bivariate association between self-efficacy and both self-identity and moral norms, we included the covariates stepwise in Model 3 (see Table S7). This shows that the coefficients of self-identity and moral norms are particularly sensitive to the inclusion of self-efficacy as a covariate, highlighting that the within-person effects of individuals' self-efficacy, self-identity, and moral norms on blood donation behaviour are highly related.

Finally, we test for evidence of mediation. From the test for the significance of the indirect effects (Fig. 5) we see that none of them are significantly different from 0. Hypotheses 2–6 about normative and informational social influence underlying social contagion of blood

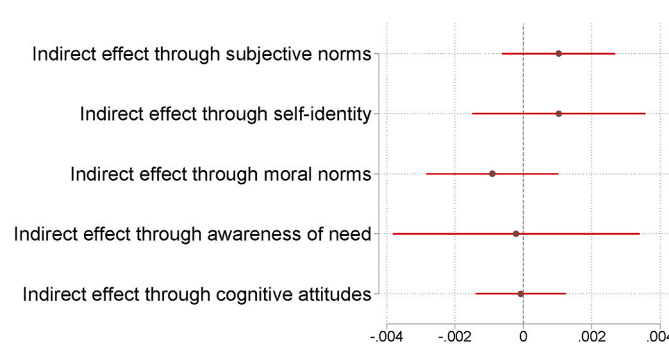

Fig. 5. Results of the mediation analysis.
Note: Estimates are based on coefficients of Model 3 (see Table 3). Standard errors obtained via the delta method.

donation are therefore not supported by our data.

4. Discussion

This study has analysed how social contagion affects blood donation behaviour, a prosocial behaviour enabling life-saving transfusions and other routine medical treatments. While extensive theoretical and experimental work demonstrated that social contagion can contribute to sustaining prosocial behaviour over time, this insight had not yet been integrated into individual-centred work on repeated real-world prosocial behaviour. We linked these two strands of literature by providing a theoretical framework of social contagion through social influence. The goal of the empirical part of this study was twofold: firstly, to assess to what extent social contagion contributes to sustaining repeated blood donations; and secondly, to assess whether social contagion is mediated by normative and informational social influence.

Our results show that social contagion does play a role for blood donation behaviour: a one-unit increase in the number of donations per inhabitant of the focal donor's neighbourhood (e.g., all others donating twice instead of once) is associated with a 11% increase in the number of whole blood donations by the focal donor. This result is robust with regard to time-constant and time-varying unobservables, but the estimated effect is small and therefore sensitive to the control of the FDR and the exclusion of potential outliers. Our exploratory analysis shows that the effect is likely driven by social contagion among donor-couples. For those donors with a donating partner, the effect is much stronger and a one-unit increase in the number of donations per inhabitant is associated with a 35% increase in the number of whole blood donations by the individual. In line with previous research, these results show that the behaviour of those that are socially close is most relevant for social contagion. This result is important for future studies: even with the use of very small-scale geographical data, a large sample, and behavioural data based on register data rather than self-reports, our study reveals only small social contagion effects, which our exploratory analysis further attributes to donor couples. Similarities in behaviour within geographical areas should therefore not simply be attributed to processes of social influence.

It is currently unclear to what extent these findings on blood donation might generalise to other forms of prosocial behaviour. In our view, they might be most readily applicable to other forms of prosocial behaviour that require planning and deliberate repeated engagement, such as donations of other bodily fluids (e.g., blood plasma, platelets) and volunteering. In contrast, generalisability to rare behaviours, such as living organ donation, is likely limited. Another limiting condition is the observability of behaviour. While blood donation and volunteering can be easily observable to others (especially to those that engage in the same behaviour), other forms of prosocial behaviour such as charitable giving are generally less observable and might therefore depend on explicit strategies of making other's behaviour visible, such as social information (van Teunenbroek et al., 2020).

We did not find evidence that social contagion is mediated by normative or informational social influence, that is blood donors' subjective norms, self-identity, moral norms, awareness of need, or cognitive attitudes about blood donation. In our data, this is for two reasons. First, most of these beliefs and attitudes do not seem to be (strongly) influenced by the donation behaviour of close neighbours, at least not in the relatively short term of about 4 years and among those that are already blood donors. The formation and change of attitudes through social learning might be more likely to occur through childhood and adolescence, for example through familial influences (Bandura, 1977; Hughes et al., 2018; Quéniart, 2013). In adulthood, a four-year period might not be enough for beliefs and attitudes about blood donation behaviour to change in response to others' behaviour, especially given that most donors already have favourable attitudes towards this behaviour. Second, many of these constructs that have been found to be central for capturing between-person influences on intentions to donate blood show small and/or insignificant within-person effects on donation behaviour.

In sum, the behaviour of others seems to exert an independent influence on repeated prosocial behaviour, and it therefore remains a challenge to identify the mechanisms through which social contagion in prosocial behaviour works. One alternative explanation for social contagion could be that it is based on stable social preferences, such as inequity aversion or generalised reciprocity (Fischbacher et al., 2001; Gächter et al., 2013). These preferences do not need to change over time in order for social contagion to work.

4.1. Limitations and directions for future research

A limitation of our study is the restricted information about focal donors' social networks. While neighbourhoods cover individuals' cohabitants and direct neighbours, they do not capture relations to family members, friends, and colleagues who might be socially but not geographically close to our focal donors. An important next step for future work would be to reassess social contagion in blood donation based on longitudinal social network data.

Another promising avenue for future research would be to uncover heterogeneity in how individuals are affected by the donation behaviour of others. While our study has assumed that all individuals are positively affected by the donation behaviour of others, there might be donors who donate particularly because others do not (Ferguson and Lawrence, 2016; Oliver, 1984).

4.2. Implications

Two major implications follow from our results. The first concerns recruitment and retention efforts of blood banks. Many of them face declining numbers of first time and repeat blood donors, and thus need novel recruitment and retention strategies (Ferguson et al., 2020; Slonim et al., 2014). Bruhin et al. (2020) have previously shown that donation invitations are more effective when directed at donor couples rather than individuals. Similarly, our results show that blood bank retention efforts are likely to be more successful when targeted at groups, particularly donor couples. Such interventions could make the behaviour of other donors more salient, e.g., by mentioning how often others usually donate or through group-donation programmes. Our results further imply that such interventions might be more successful when focused on social networks, especially couples rather than spatially defined communities.

The second implication relates to theories of repeated prosocial behaviour. Our results show that the presumed importance of social contagion for maintaining prosocial behaviour in the literature on collective action does, to some extent, translate to a better understanding of repeated real-world prosocial behaviour: social contagion can contribute to sustaining individuals' repeated prosocial behaviour. Our results are not consistent with the 'pure altruism' model of prosocial behaviour, where individuals' contributions are crowded out by the prosocial behaviour of others. We show that, on average, blood donations by individuals and others complement rather than substitute one another. Also, we do not find that the effect of social contagion is mediated by attitudinal constructs included in current theoretical models of repeated prosocial behaviour; it should therefore be included as independent predictor of individuals' repeated prosocial behaviour. Theoretical models aimed at explaining repeated prosocial behaviour would benefit from incorporating this insight.

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Declaration of competing interest

The authors declare no conflict of interest.

Data availability

The authors do not have permission to share the data. Requests for access can be made via donorinsight@sanquin.nl for researchers who meet the criteria. Analysis code is available at the OSF page.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.healthplace.2023.103072.

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