Matching Algorithms for Blood Donation

DUNCAN C MCELFRESH, University of Maryland, College Park
CHRISTIAN KROER, Facebook Core Data Science and Columbia University
SERGEY PUPYREV, Facebook Core Data Science
ERIC SODOMKA, Facebook Core Data Science
KARTHIK ABINAV SANKARARAMAN, Facebook
ZACK CHAUVIN, Facebook
NEIL DEXTER, Facebook
JOHN P DICKERSON, University of Maryland, College Park

Managing perishable inventory, such as blood stock awaiting use by patients in need, has been a topic of research for decades. This has been investigated across several disciplines: medical and social scientists have investigated *who* donates blood, *how frequently*, and *why*; management science researchers have long studied the blood supply chain from a logistical perspective. Yet global demand for blood still far exceeds supply, and unmet need is greatest in low- and middle-income countries. Both academics and policy experts suggest that large-scale coordination is necessary to alleviate demand for donor blood. Using the recently-deployed Facebook Blood Donation tool, we conduct the first large-scale algorithmic matching of blood donors with donation opportunities. In both simulations and real experiments we match potential donors with opportunities, guided by a machine learning model trained on prior observations of donor behavior. While measuring actual donation rates remains a challenge, we measure *donor action* (i.e., calling a blood bank or making an appointment) as a proxy for actual donation. Simulations suggest that even a simple matching strategy can increase donor action rate by 10-15%; a pilot experiment with real donors finds a slightly smaller increase of roughly 5%. While overall action rates remain low, even this modest increase among donors in a global network corresponds to *many thousands* of more potential donors taking action toward donation. Further, observing donor action on a social network can shed light onto donor behavior and response to incentives. Our initial findings align with several observations made in the medical and social science literature regarding donor behavior.

CCS Concepts: • **Applied computing** → **Life and medical sciences**; • **Theory of computation** → **Theory and algorithms for application domains**.

Additional Key Words and Phrases: blood donation; matching; online algorithms

ACM Reference Format:
Duncan C McElfresh, Christian Kroer, Sergey Pupyrev, Eric Sodomka, Karthik Abinav Sankararaman, Zack Chauvin, Neil Dexter, and John P Dickerson. 2020. Matching Algorithms for Blood Donation. In *Proceedings of the 21st ACM Conference on Economics and Computation (EC '20), July 13–17, 2020, Virtual Event, Hungary*. ACM, New York, NY, USA, 2 pages. https://doi.org/10.1145/3391403.3399458

1 OVERVIEW

Blood is a scarce resource; its donation saves the lives of those in need. Countries approach blood donation in different ways, running the gamut from privately-run to state-run programs, with or without monetary compensation, and with varying degrees of public campaigns for action. As

EC '20, July 13–17, 2020, Virtual Event, Hungary

ACM ISBN 978-1-4503-7975-5/20/07.
https://doi.org/10.1145/3391403.3399458

such, blood donation rates differ across different countries; for example, approximately 3.2%, 1.5%, 0.8%, and 0.5% of the population donates in high-, upper-middle-, lower-middle-, and low-income countries, with varying rates of voluntary versus paid donors [5]. Yet global demand for blood still far exceeds supply, and unmet need is greatest in low- and middle-income countries [4]. Thus, experts suggest that the blood supply chain be managed at a national level [5].

Optimization-based approaches to management of the blood supply chain have a rich history in the operations research and healthcare management literature. Yet, most optimization-based research in the initial *collection* stage of the blood supply chain has focused on *prediction* of blood supply (e.g., during a crisis). In this work, we instead focus on the *creation* and *coordination* of blood supply via automated social prompts, subject to the preferences and constraints of potential donors and the overall donation system. That is, we focus on *donor recruitment*.

We propose a personalized donor recruitment strategy using the recently developed Facebook Blood Donation tool[1], which connects millions of potential blood donors with opportunities to donate, in several countries around the world. Using this tool, donors can opt-in to receive notifications about nearby donation opportunities. Our strategy aims to notify donors about opportunities they are *more likely* to take action on. We frame this as an online matching problem [2]–a well-studied paradigm which has been applied to many settings including online advertising [3] and rideshare services [1]. We demonstrate, both in computational simulations and a real A/B test, that even a simple matching policy can substantially increase the likelihood of donor action.

The potential impact of this work is considerable, as even a small increase in donor action rate among Facebook Blood Donation tool users corresponds to many thousand of additional donors taking action toward donation. Before implementing these policies at a large scale, it is important to understand their potential impacts on both blood donors and recipients. In this study impact on donors is minimal; the only difference between notification policies we test is in *which donation opportunity* a donor is notified about. However our simulation results indicate that certain blood *recipients* may be impacted by even a small change in notification policy. To mitigate these impacts, we propose a utilitarian-based notion of equity, and a corresponding randomized notification policy. However more work is needed to ensure equitable treatment of recipients before deploying this automated matching system at a large scale.

ACKNOWLEDGMENTS

McElfresh and Dickerson performed this work while consultants with Facebook.

REFERENCES

[1] John P Dickerson, Karthik A Sankararaman, Aravind Srinivasan, and Pan Xu. 2018. Allocation problems in ride-sharing platforms: Online matching with offline reusable resources. In *AAAI Conference on Artificial Intelligence (AAAI)*.

[2] R. M. Karp, U. V. Vazirani, and V. V. Vazirani. 1990. An Optimal Algorithm for On-line Bipartite Matching. In *Proceedings of the Annual Symposium on Theory of Computing (STOC)*. 352–358.

[3] Aranyak Mehta, Amin Saberi, Umesh Vazirani, and Vijay Vazirani. 2007. AdWords and Generalized Online Matching. *J. ACM* 54, 5 (2007).

[4] Nicholas Roberts, Spencer James, Meghan Delaney, and Christina Fitzmaurice. 2019. The global need and availability of blood products: a modelling study. *The Lancet Haematology* 6, 12 (2019), e606–e615.

[5] World Health Organization WHO. 2017. Blood safety and availability. https://www.who.int/news-room/fact-sheets/detail/blood-safety-and-availability

[1] https://socialgood.fb.com/health/blood-donations/