Assortment Optimization for Patient-Provider Matching

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Carnegie Mellon University

Harvard | October 10th

Doctors are Important

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Regular Checkups

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Injury Treatment

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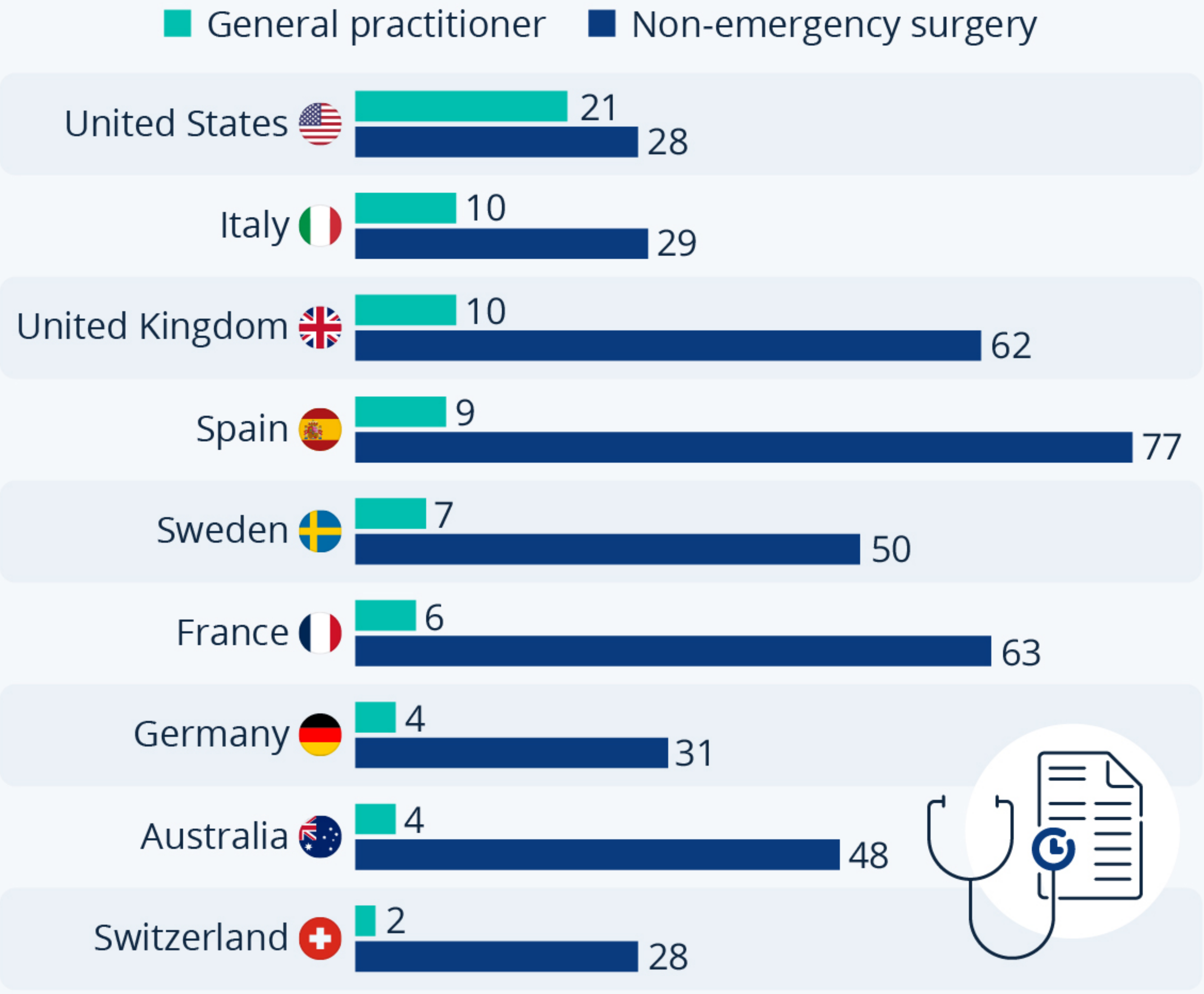
Regular Checkups

Injury Treatment

Disease Prevention

Healthcare: How Long Do Patients Have To Wait?

Average waiting time for a doctor's appointment and for non-emergency surgery in 2023 (in days)



Facts & Figures 2024

Numbers alone can't express the work of our colleagues, and our impact on our communities.
But data explains the breadth and depth of our commitment in service of our mission: "To improve the health and healing of all."

$6.5
BILLION
Operating Revenue

500
Locations

185
Towns in Service Area

44,000
Colleagues

6,389
Physicians on Staff

6,803
Nurses (all types)

948,473
Primary Care Visits

480,686
ED Visits

109,479
Transitions from Inpatient Care

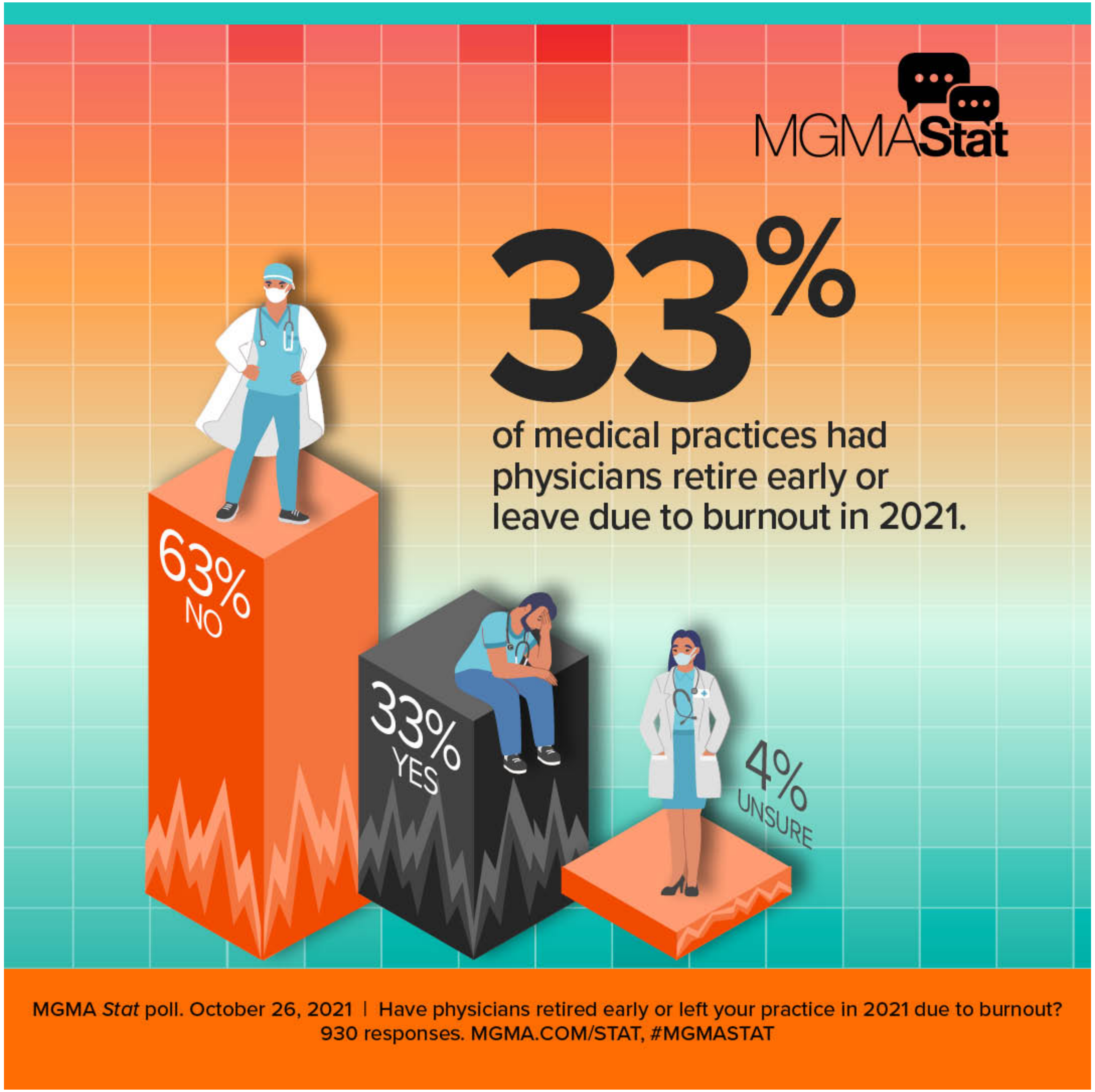
2,488
Licensed Beds (including bassinets)

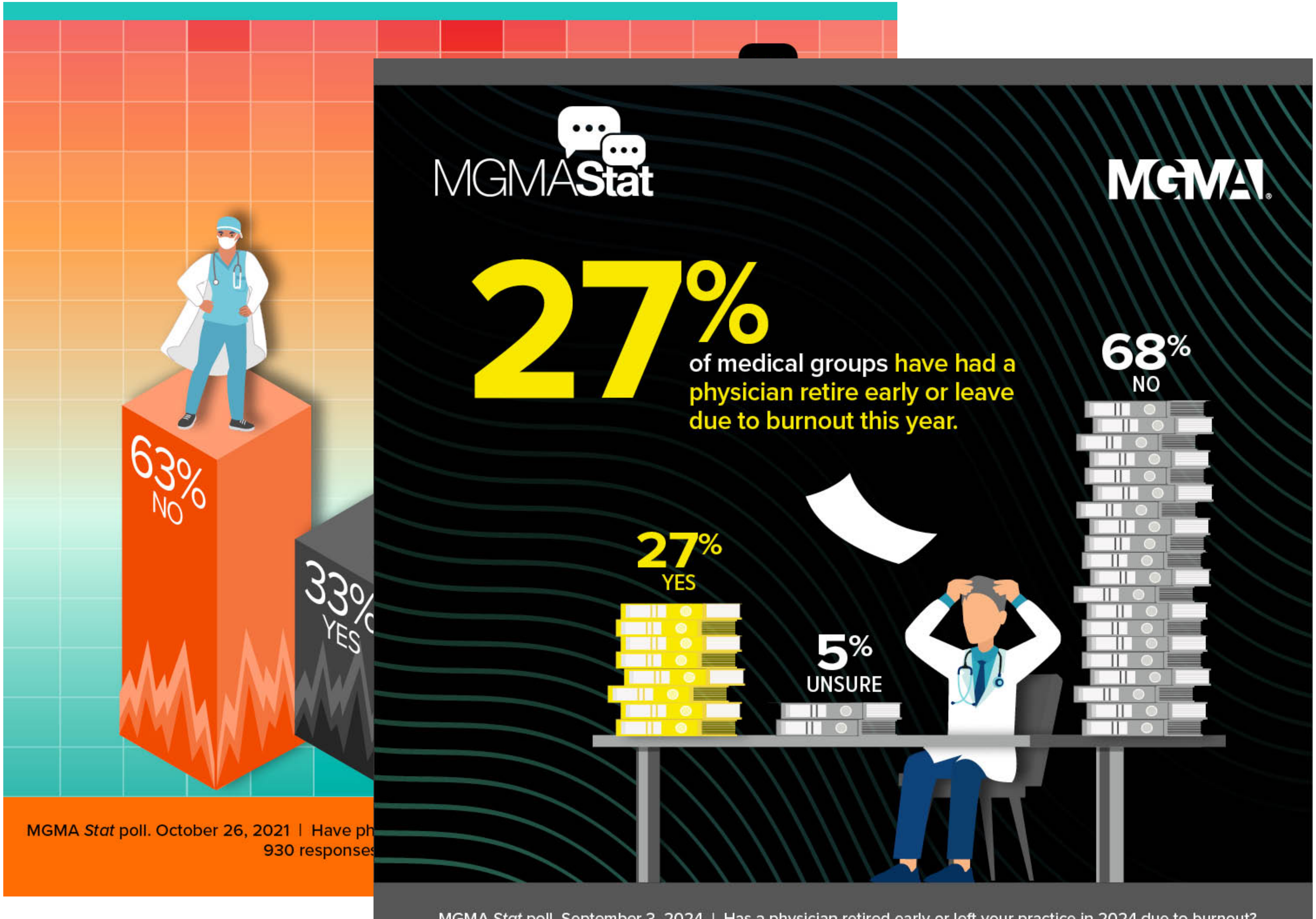
8,822
Newborn Admissions

25,227
Inpatient Surgeries

104,229
Ambulatory Surgeries

Includes Hospital OP surgeries and ASC surgeries, excludes GI cases


MGMAStat
33%
of medical practices had physicians retire early or leave due to burnout in 2021.
63% NO
33% YES
4% UNSURE
MGMA Stat poll. October 26, 2021 | Have physicians retired early or left your practice in 2021 due to burnout?
930 responses. MGMA.COM/STAT, #MGMASTAT


63% NO
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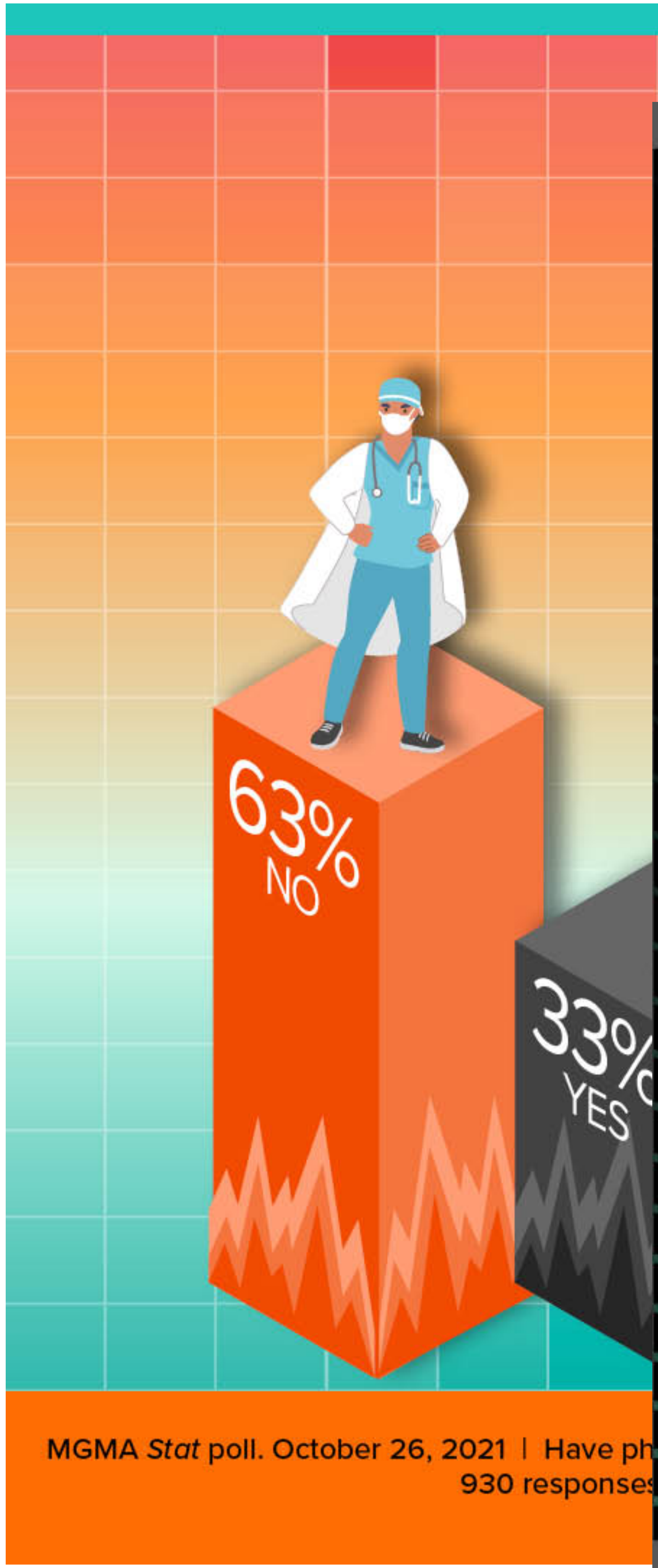
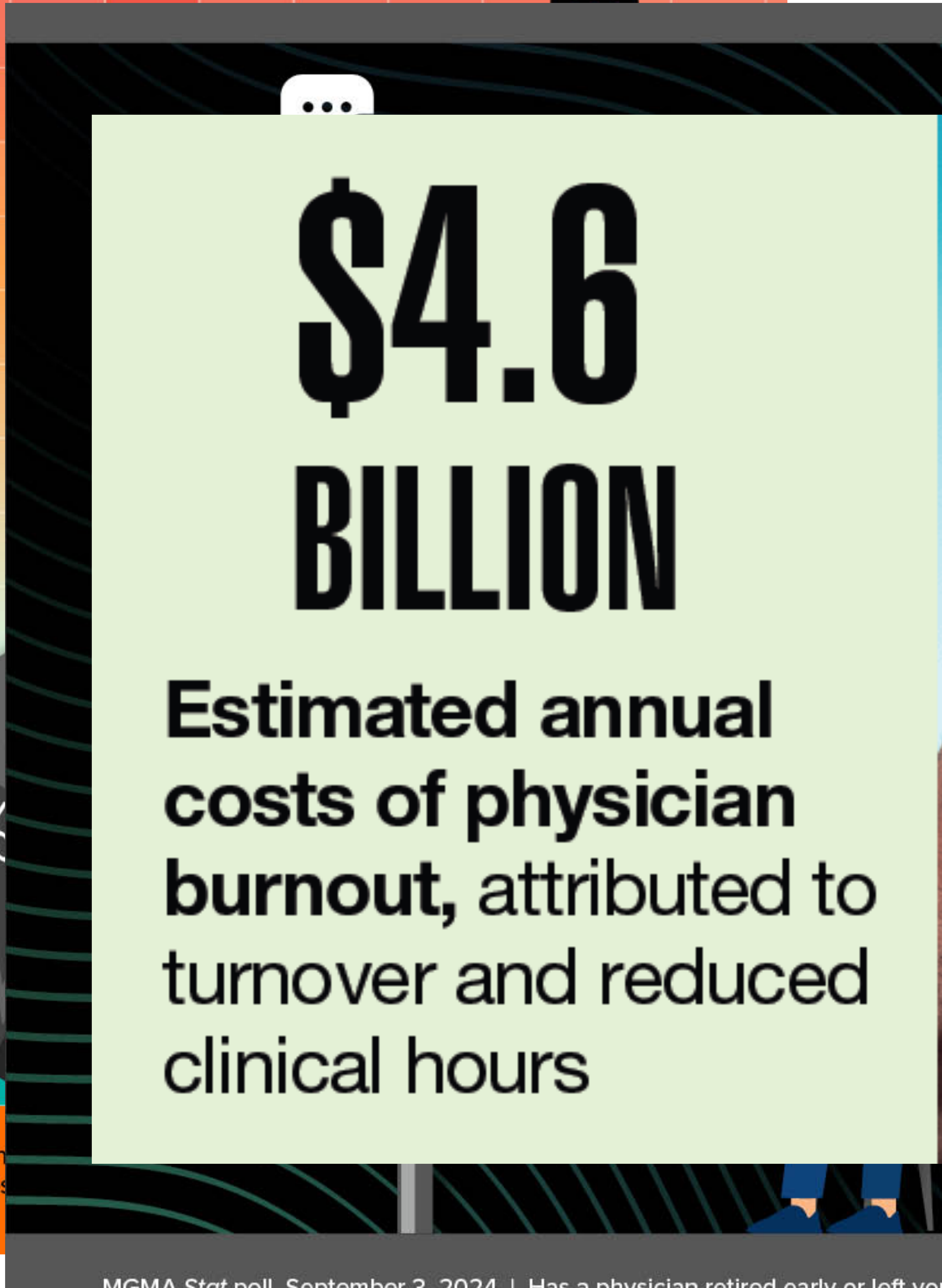
MGMA
27% of medical groups have had a physician retire early or leave due to burnout this year.
68% NO
27% YES
5% UNSURE
MGMA Stat poll. September 3, 2024 | Has a physician retired early or left your practice in 2024 due to burnout?





$4.6 BILLION

Estimated annual costs of physician burnout, attributed to turnover and reduced clinical hours

Push Towards Centralization

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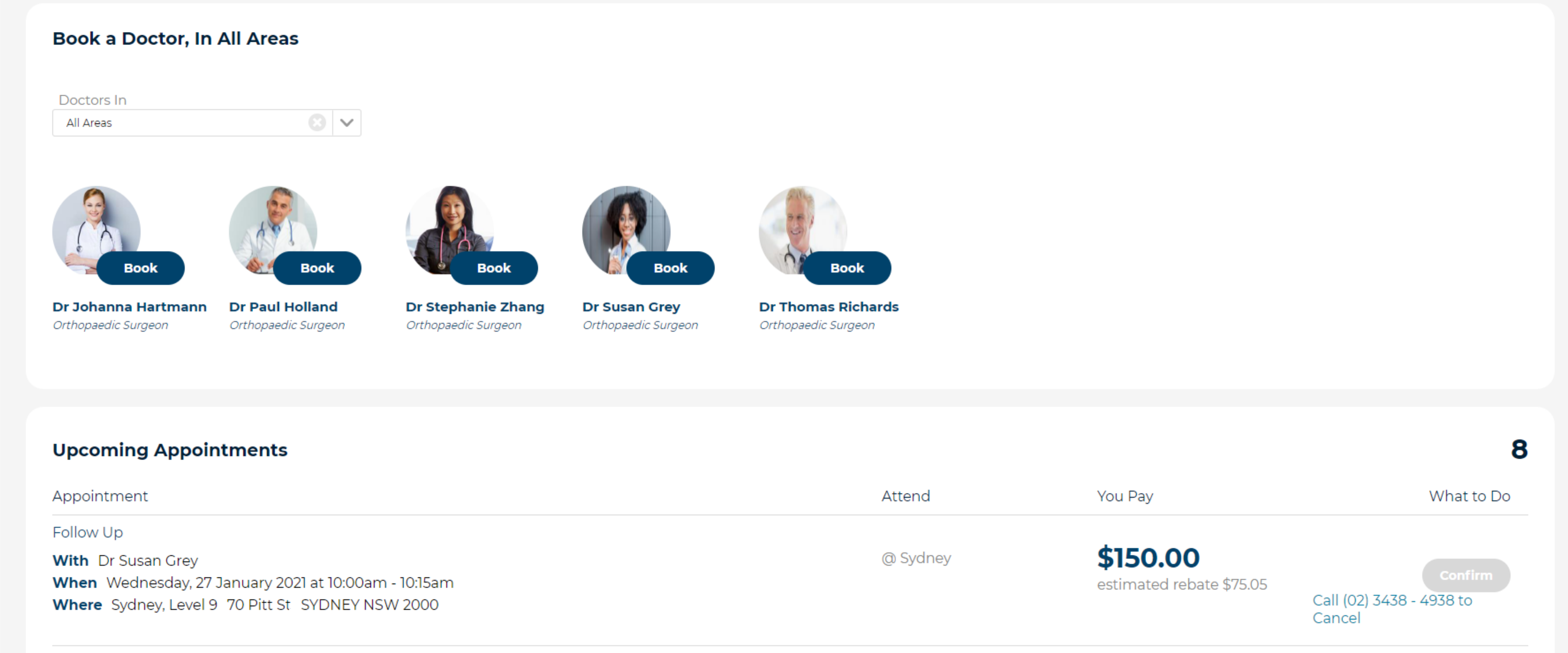
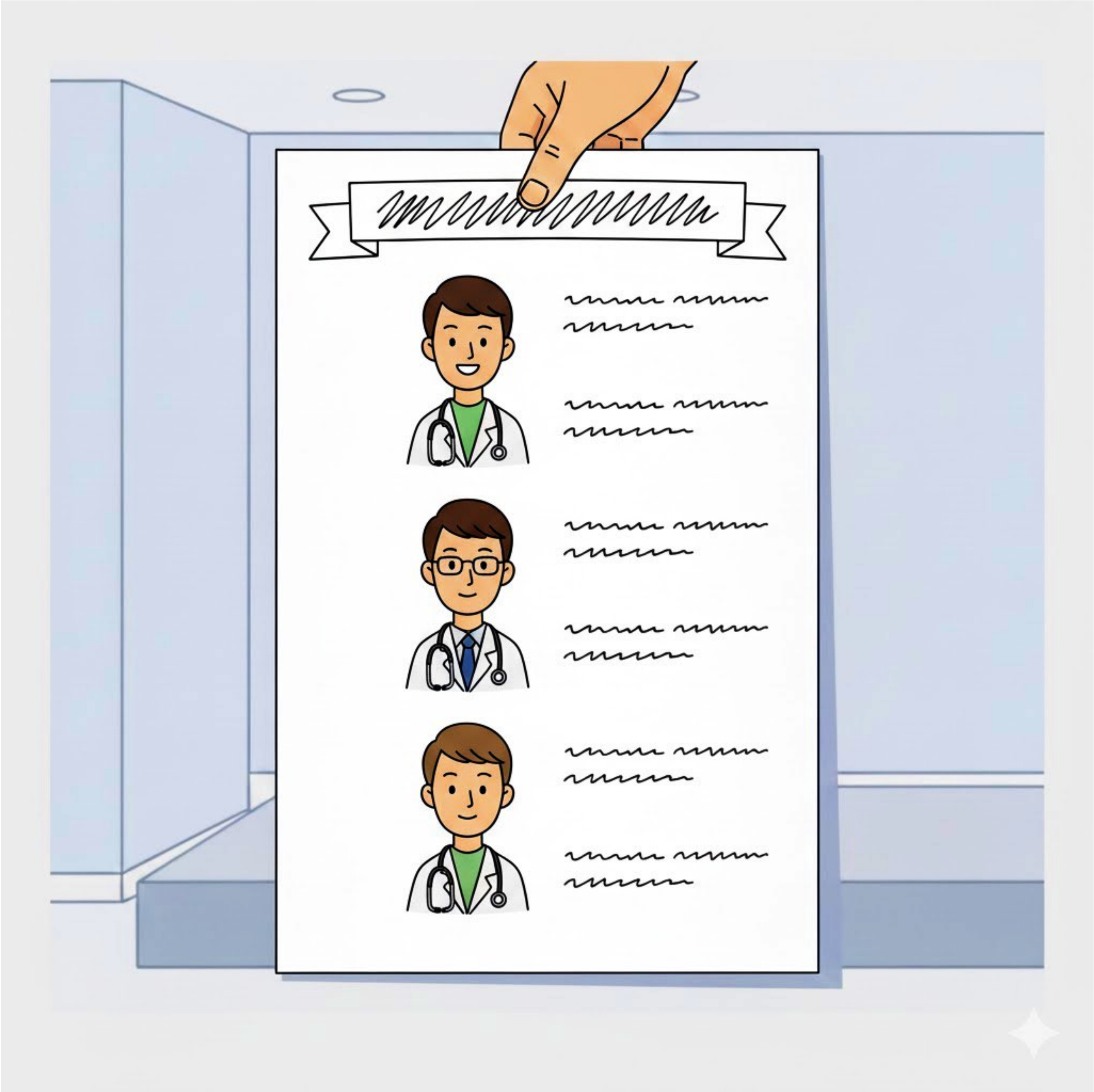


How does patient choice impact overall utility and fairness?

Three Components



Patient Utility

Patient Choice

Response Order

Three Components

Patient Utility

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Response Order

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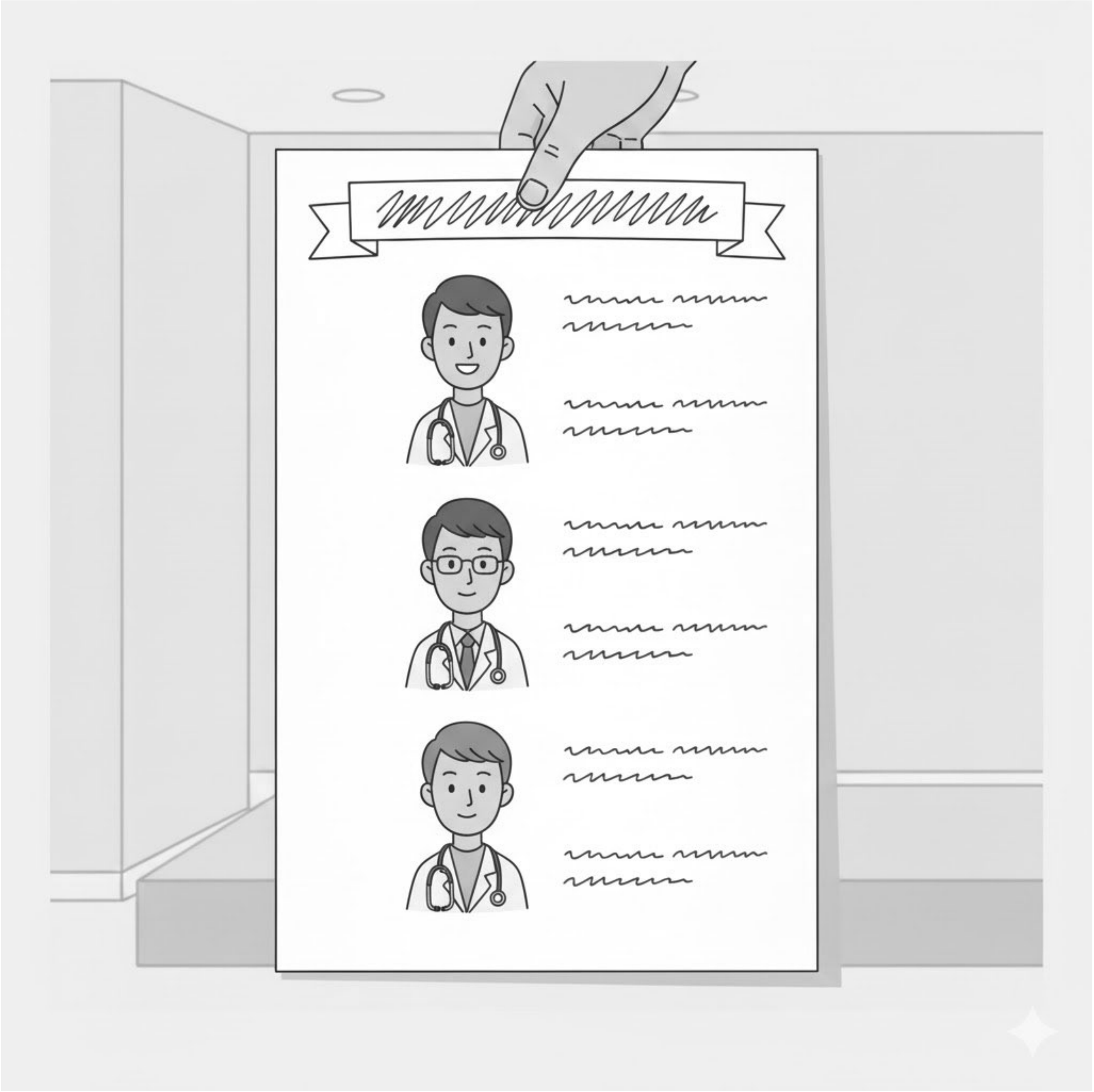

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Which providers should we offer to each patient?

Offline Offering and Online Matching

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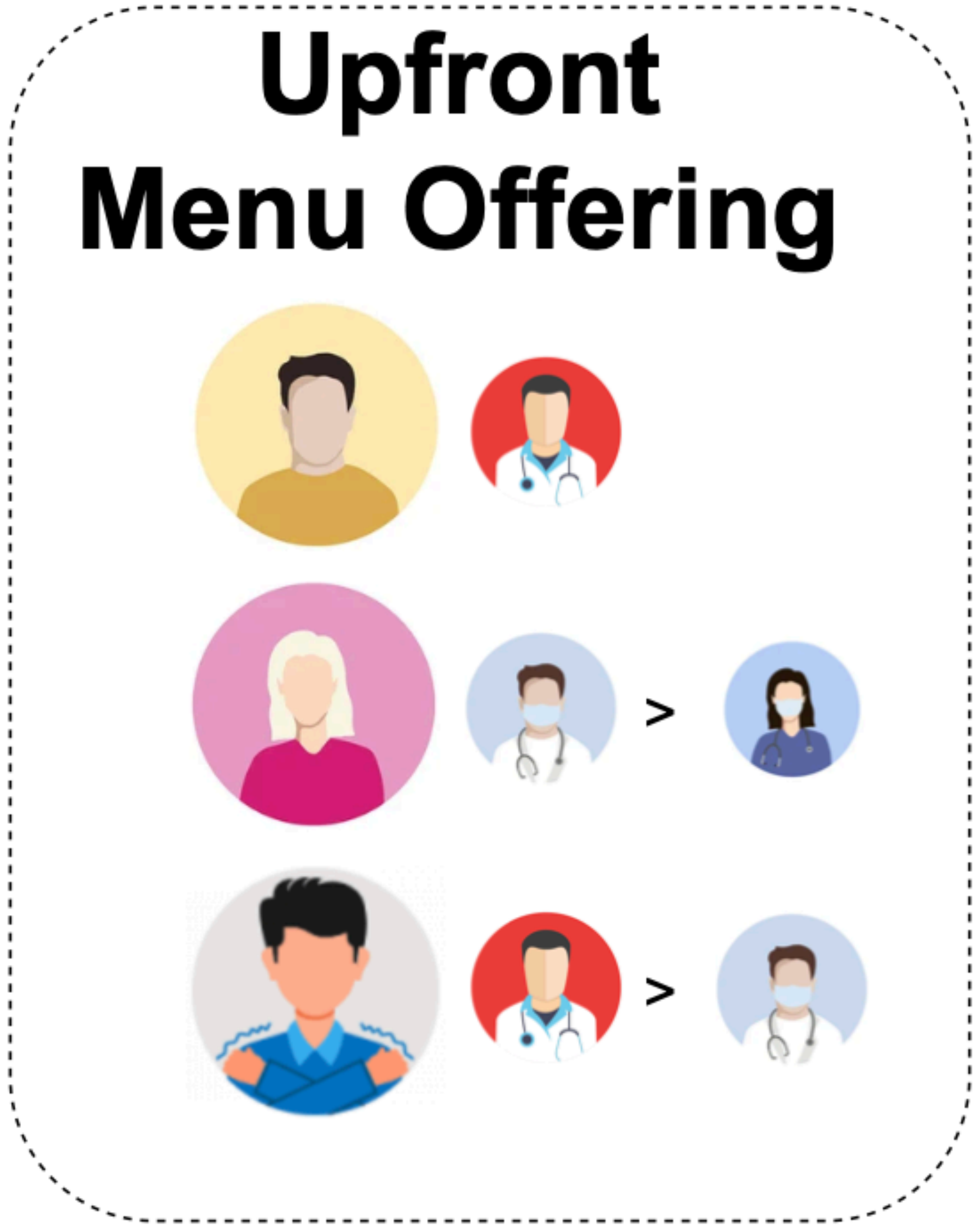

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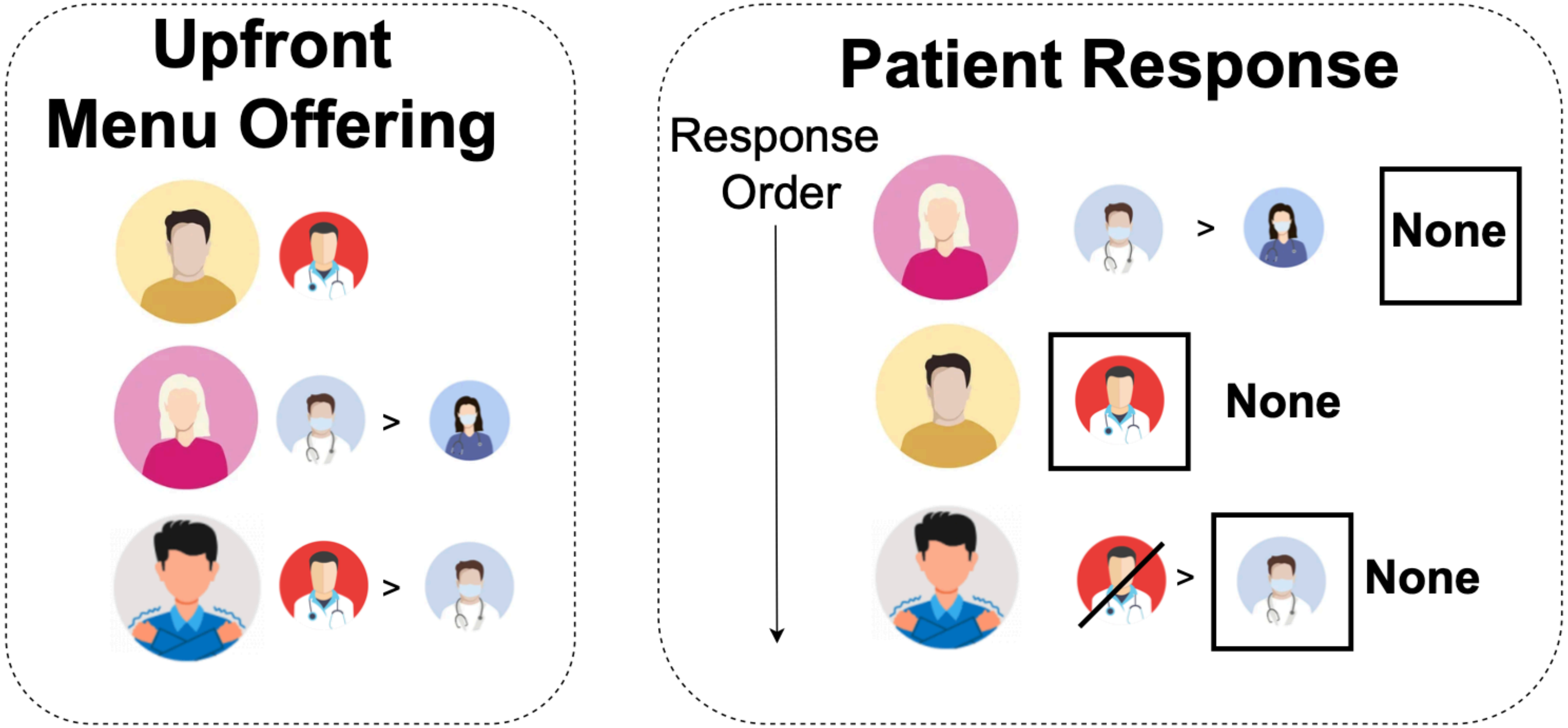

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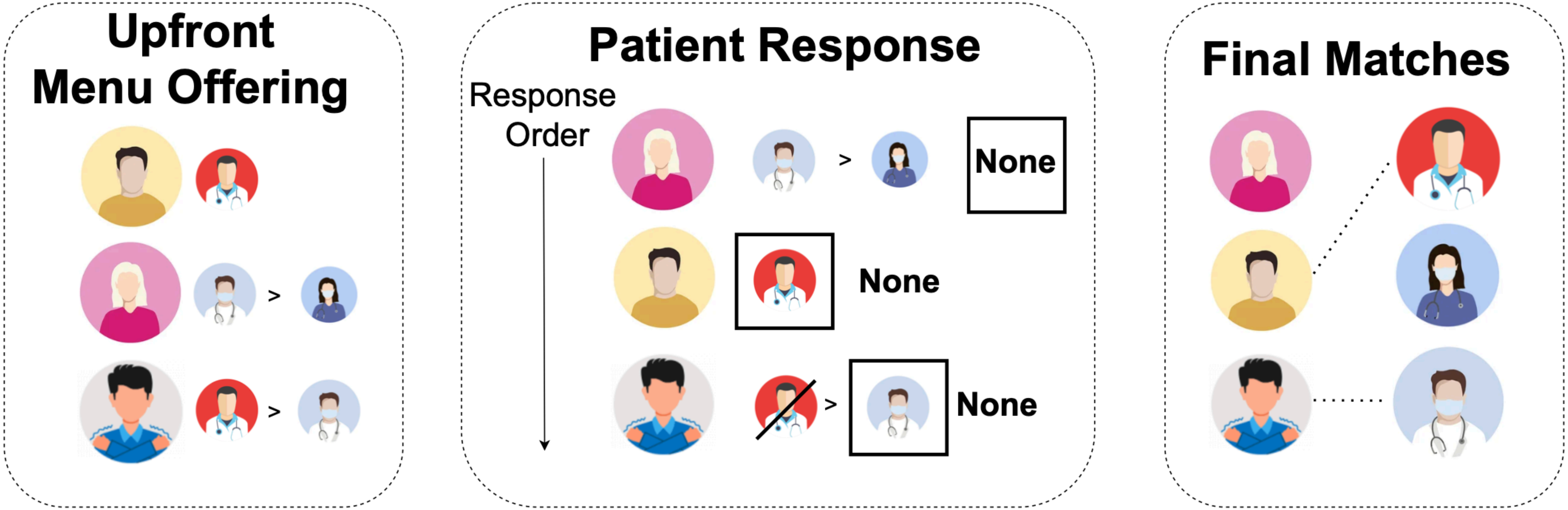

Why Offline-Online Hybrid?

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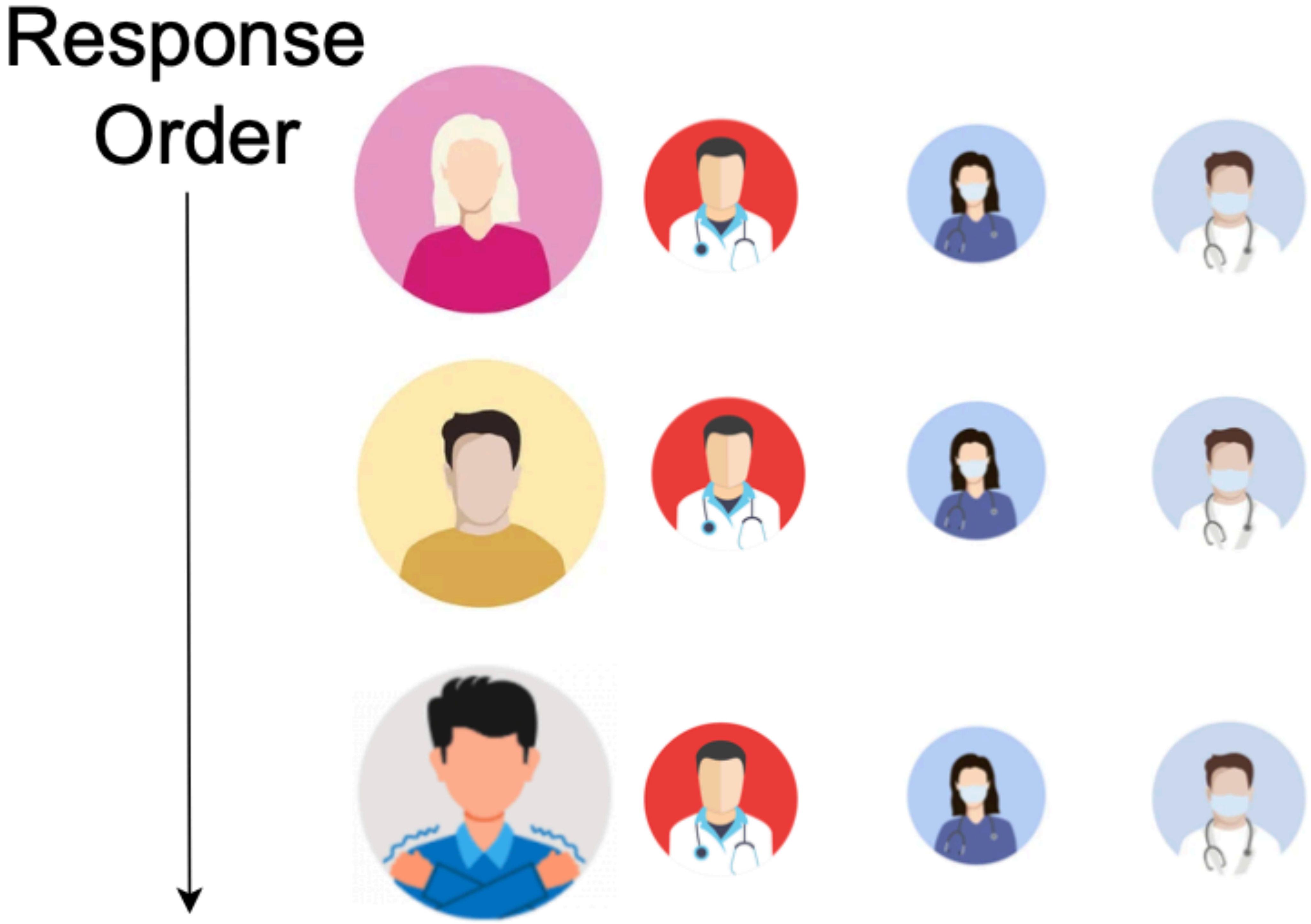
Offline Matching

Disadvantage: No Autonomy

Why Offline-Online Hybrid?

Offline Matching

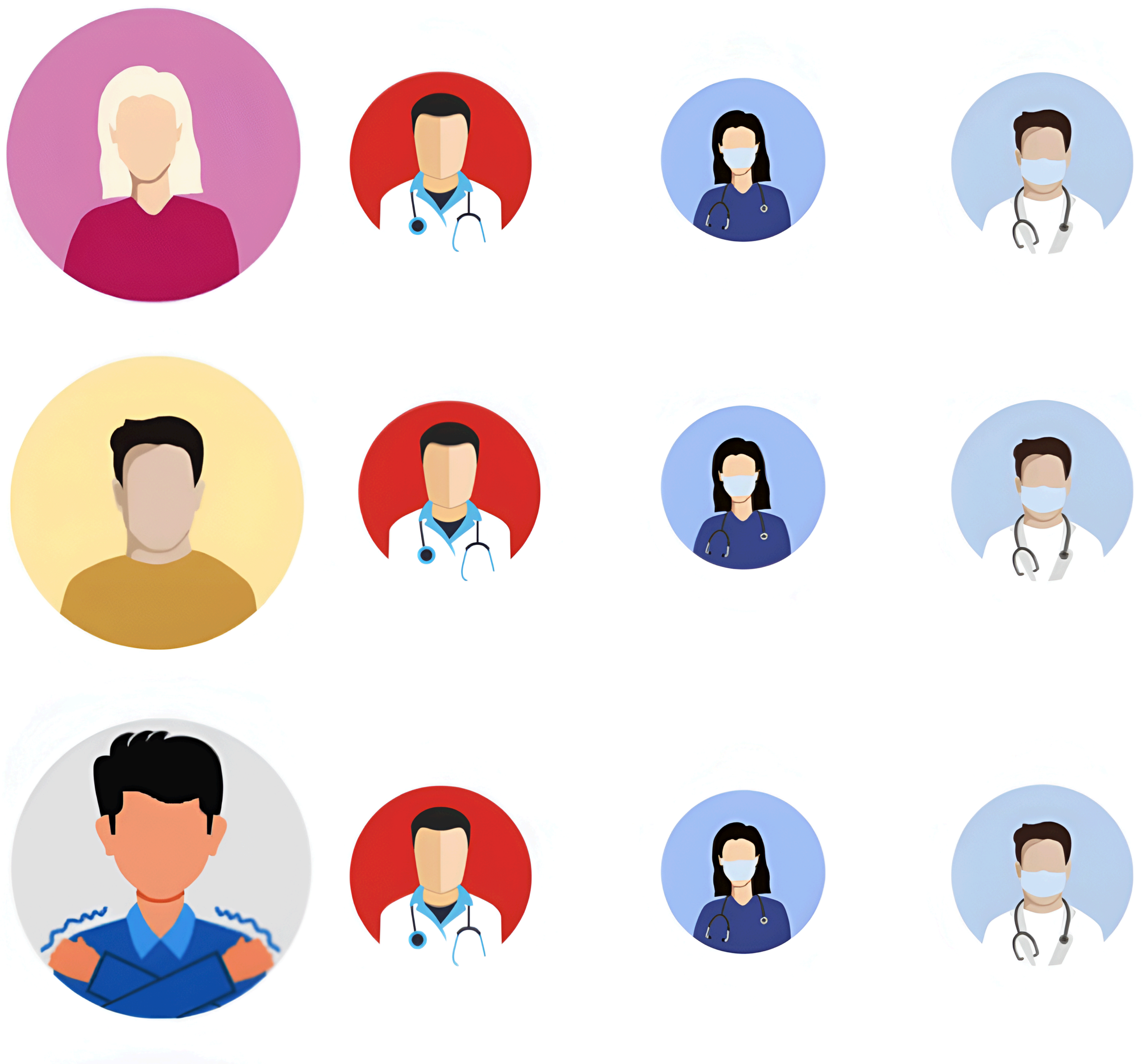
Online Matching



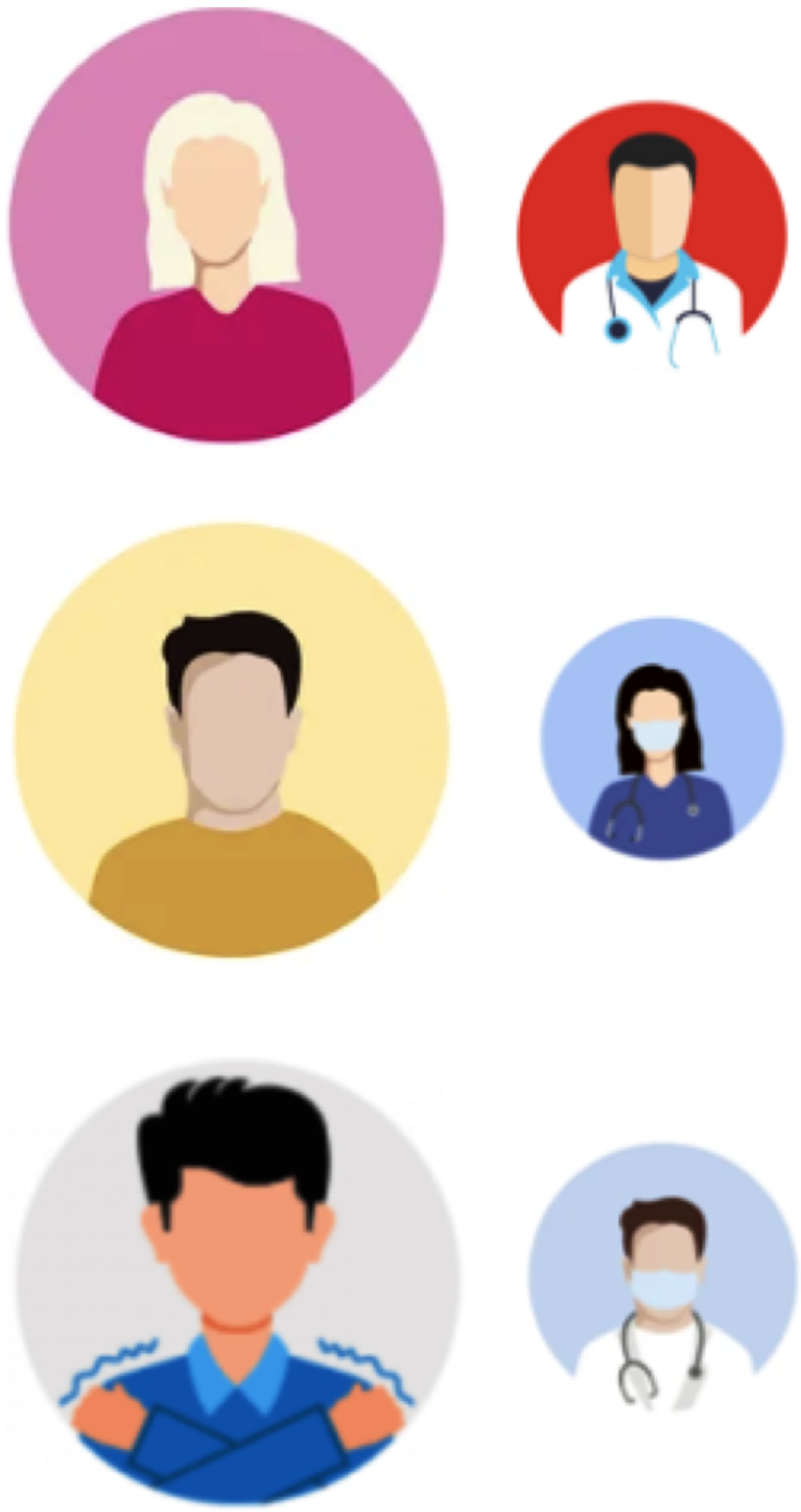
Disadvantage: No Autonomy

Disadvantage: Patients might wait to match; incentive compatibility

Two Extreme Policies

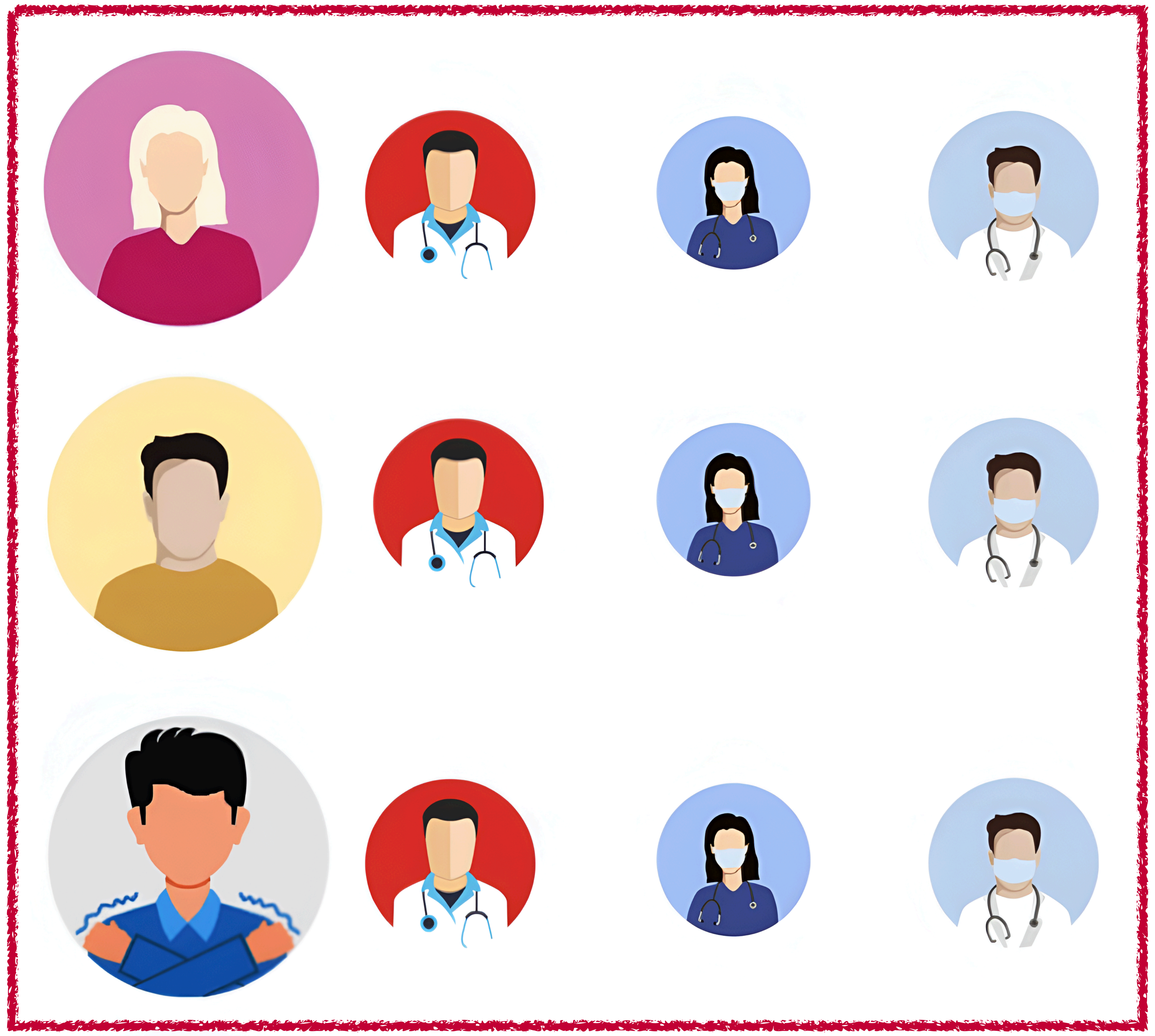


Greedy



Pairwise

Two Extreme Policies



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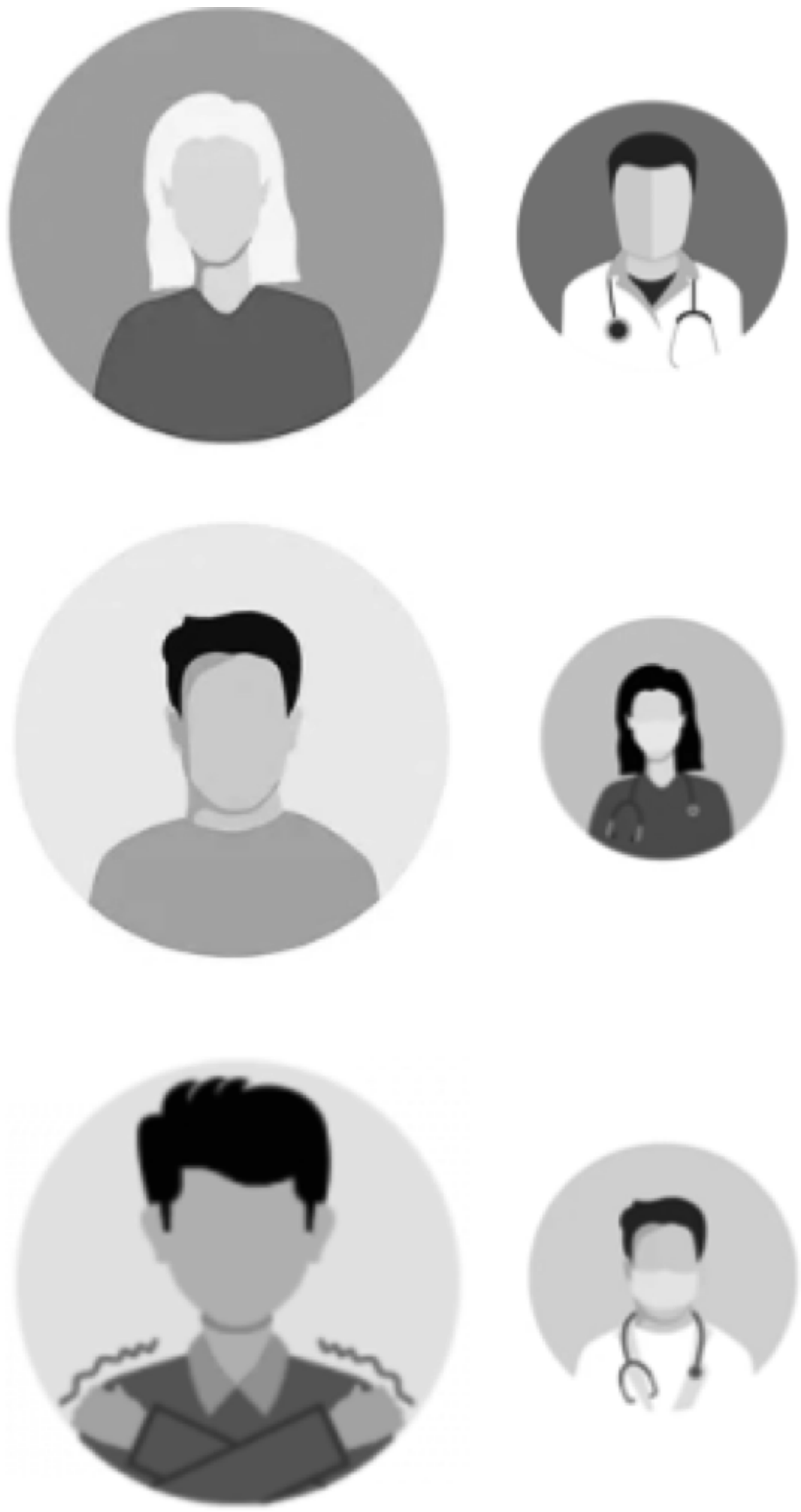

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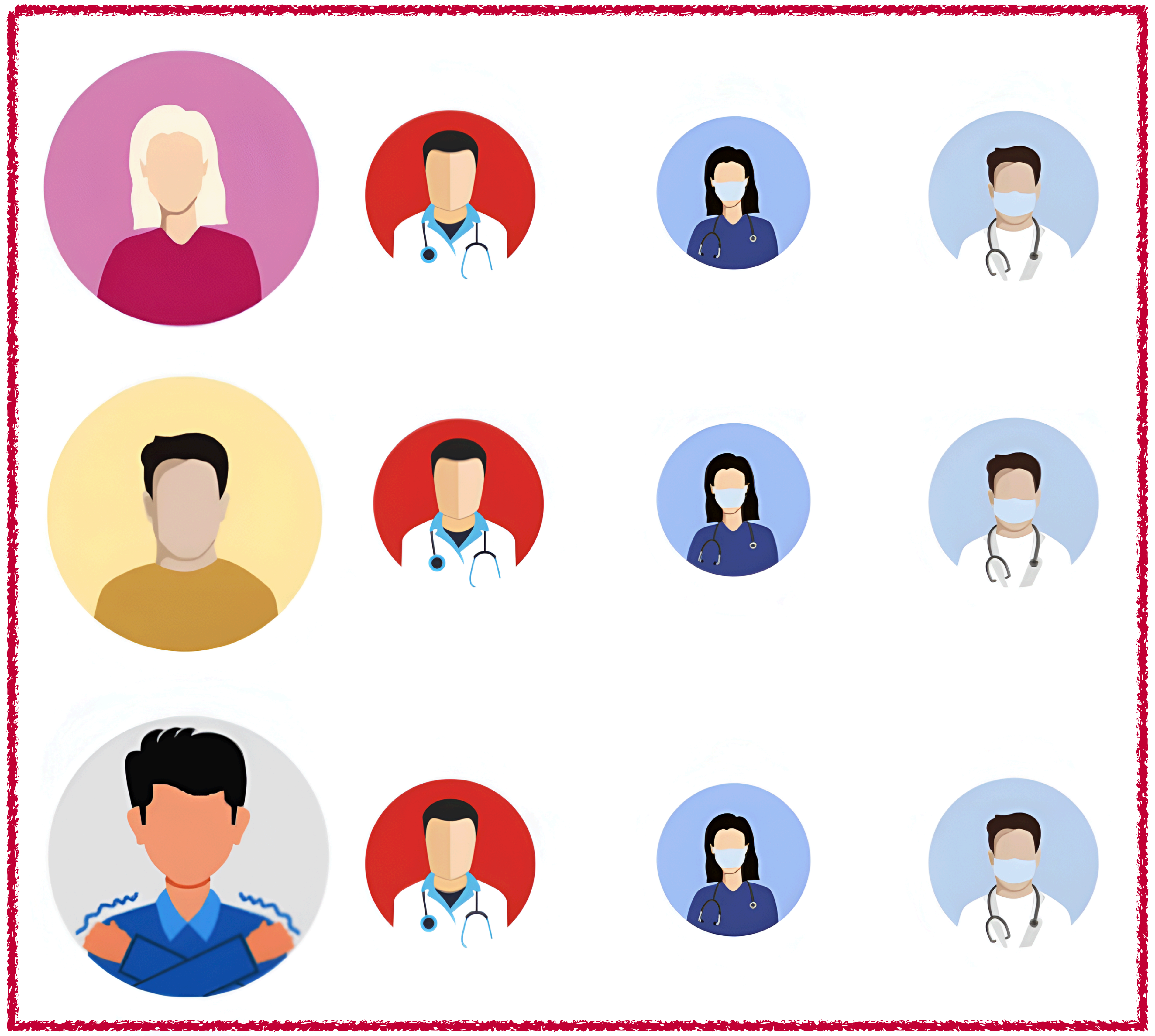

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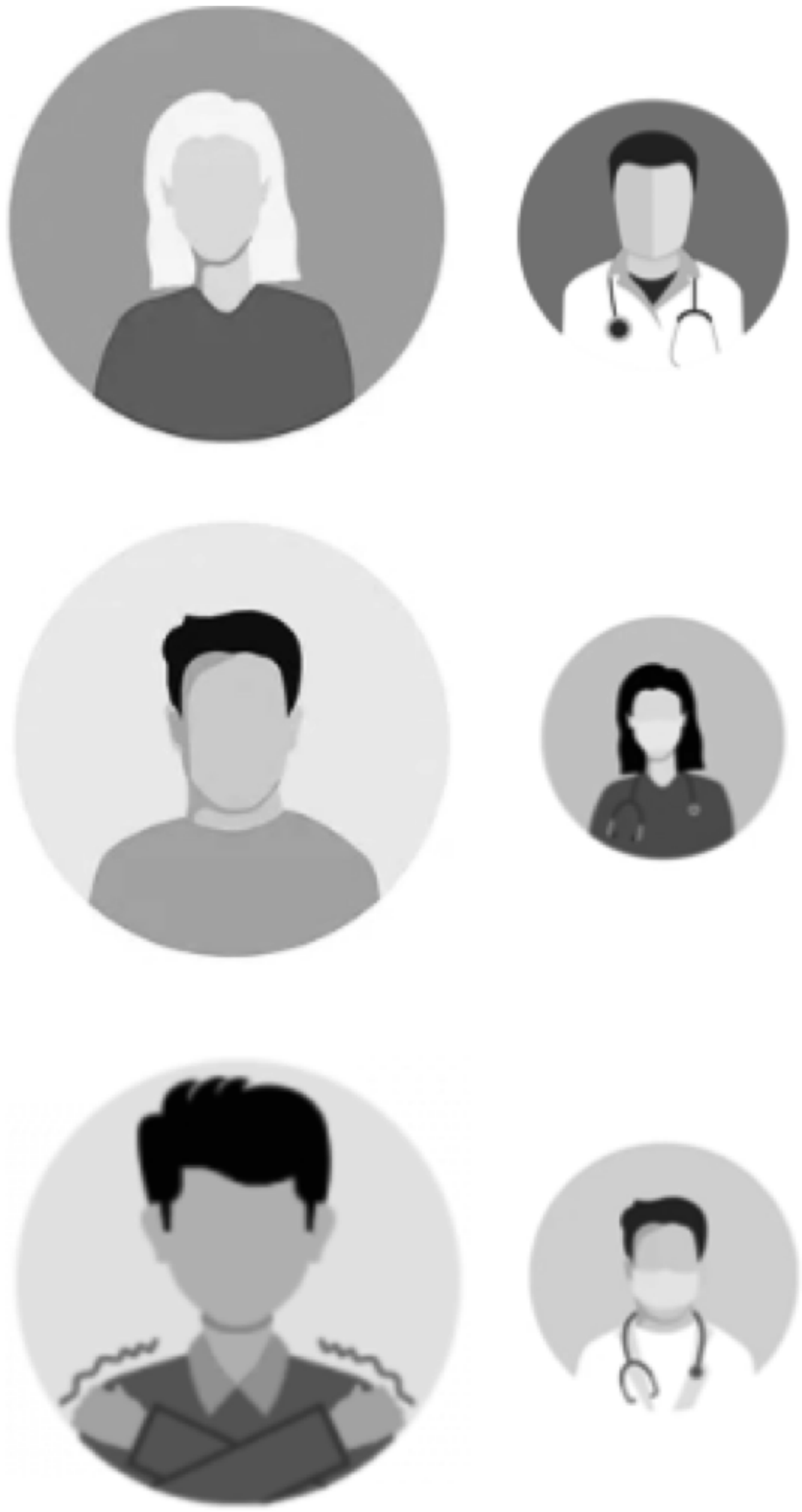
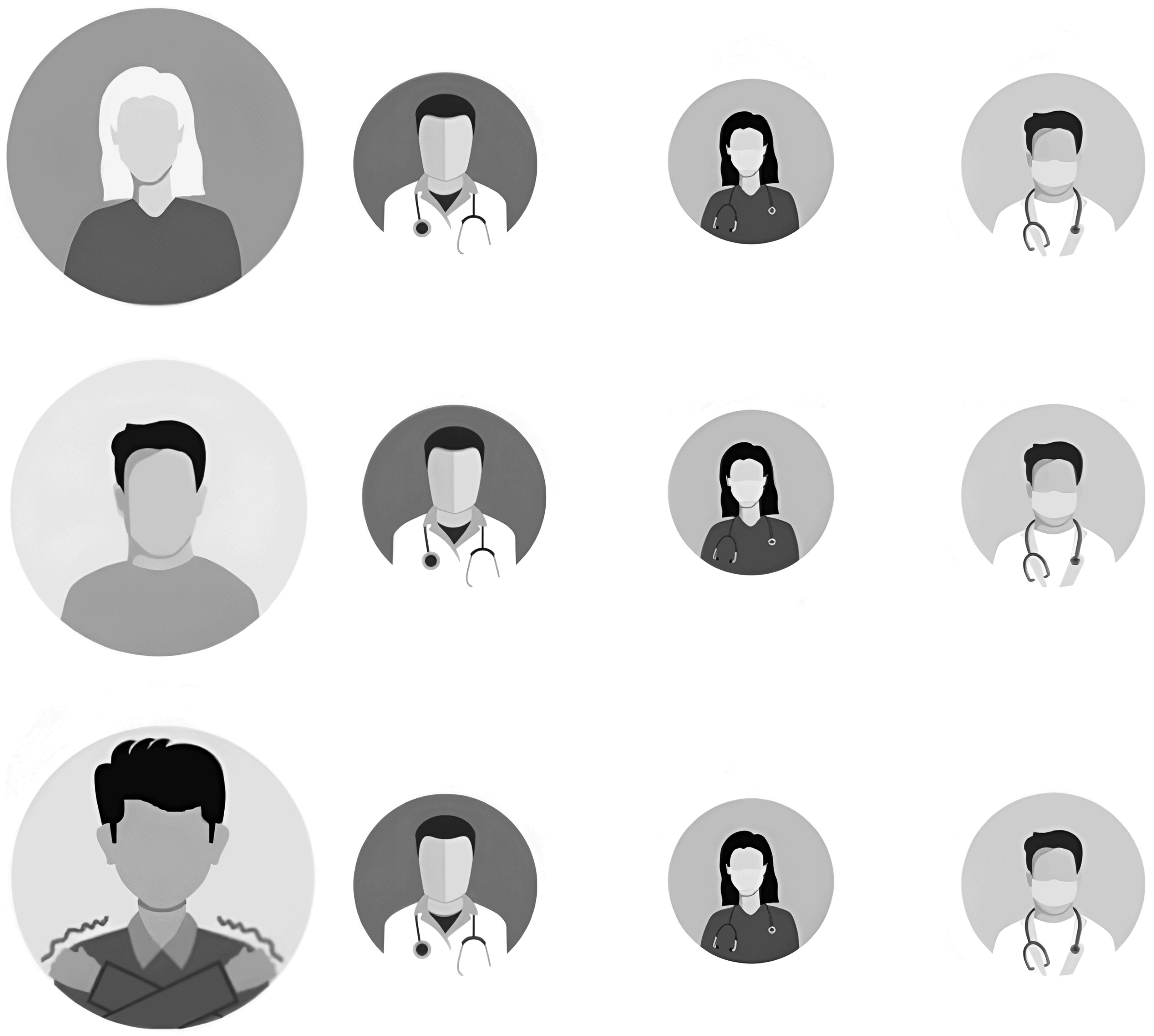


Pairwise

Beneficial when there's uncertainty in patient selections

Two Extreme Policies



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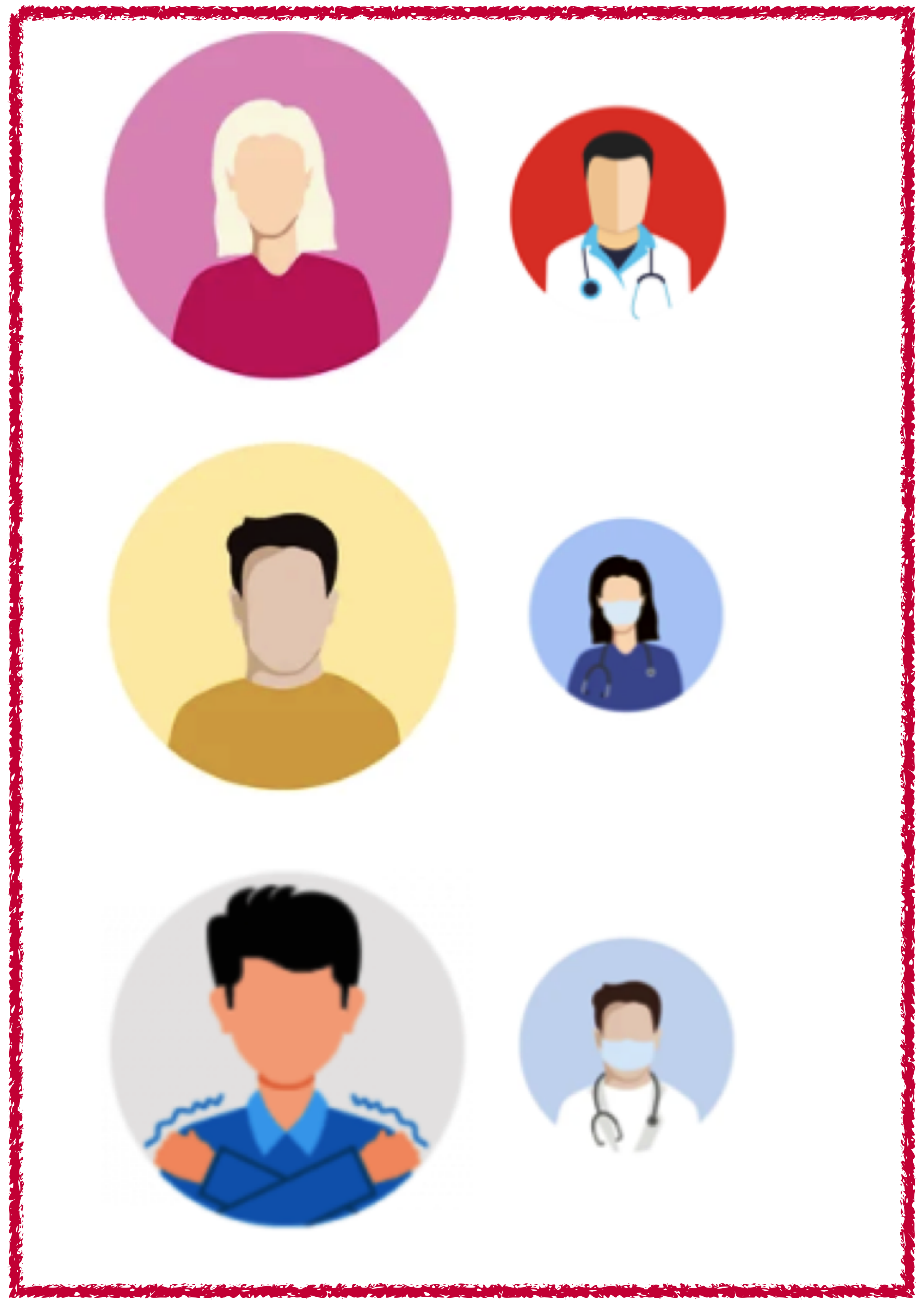

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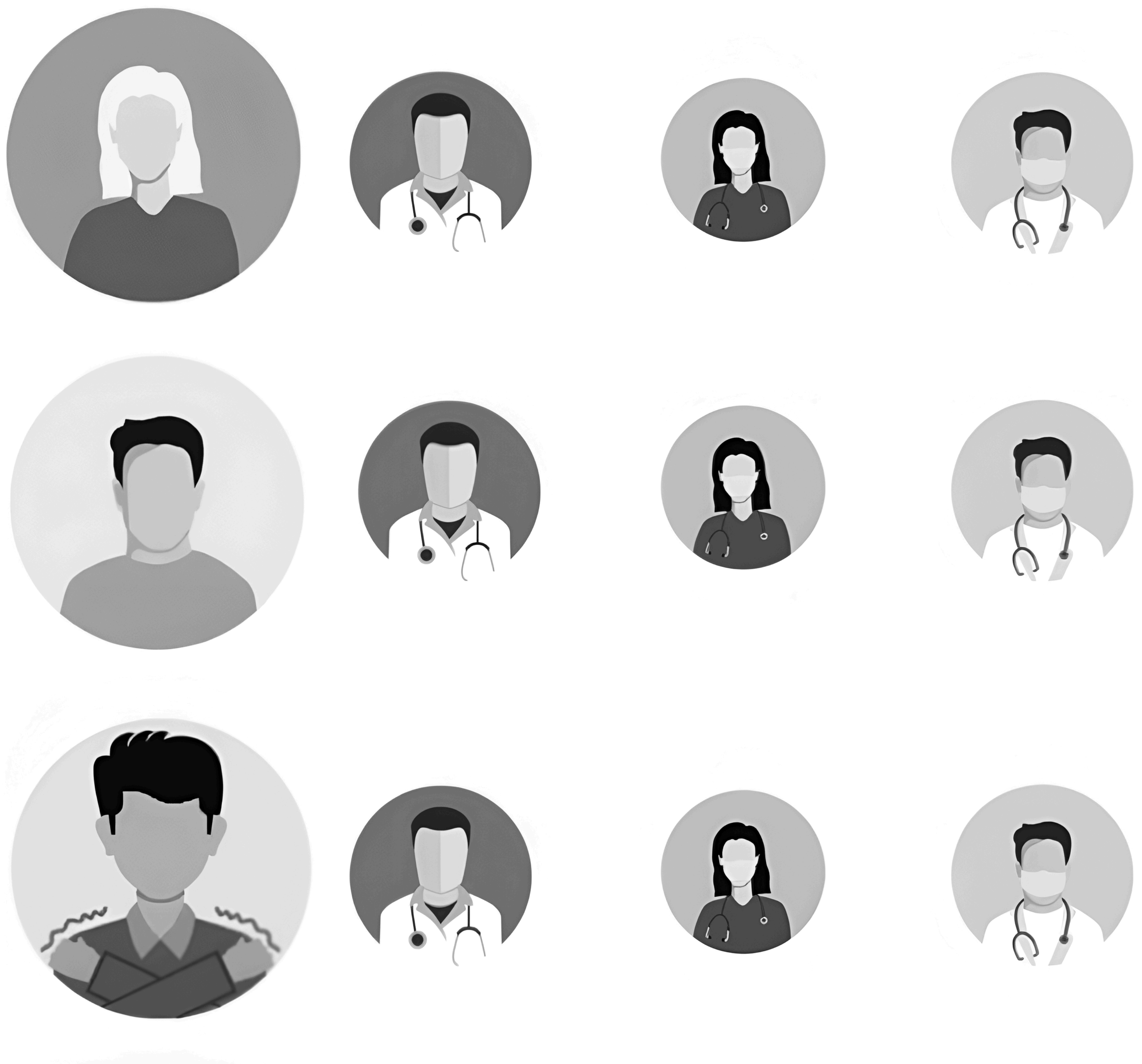

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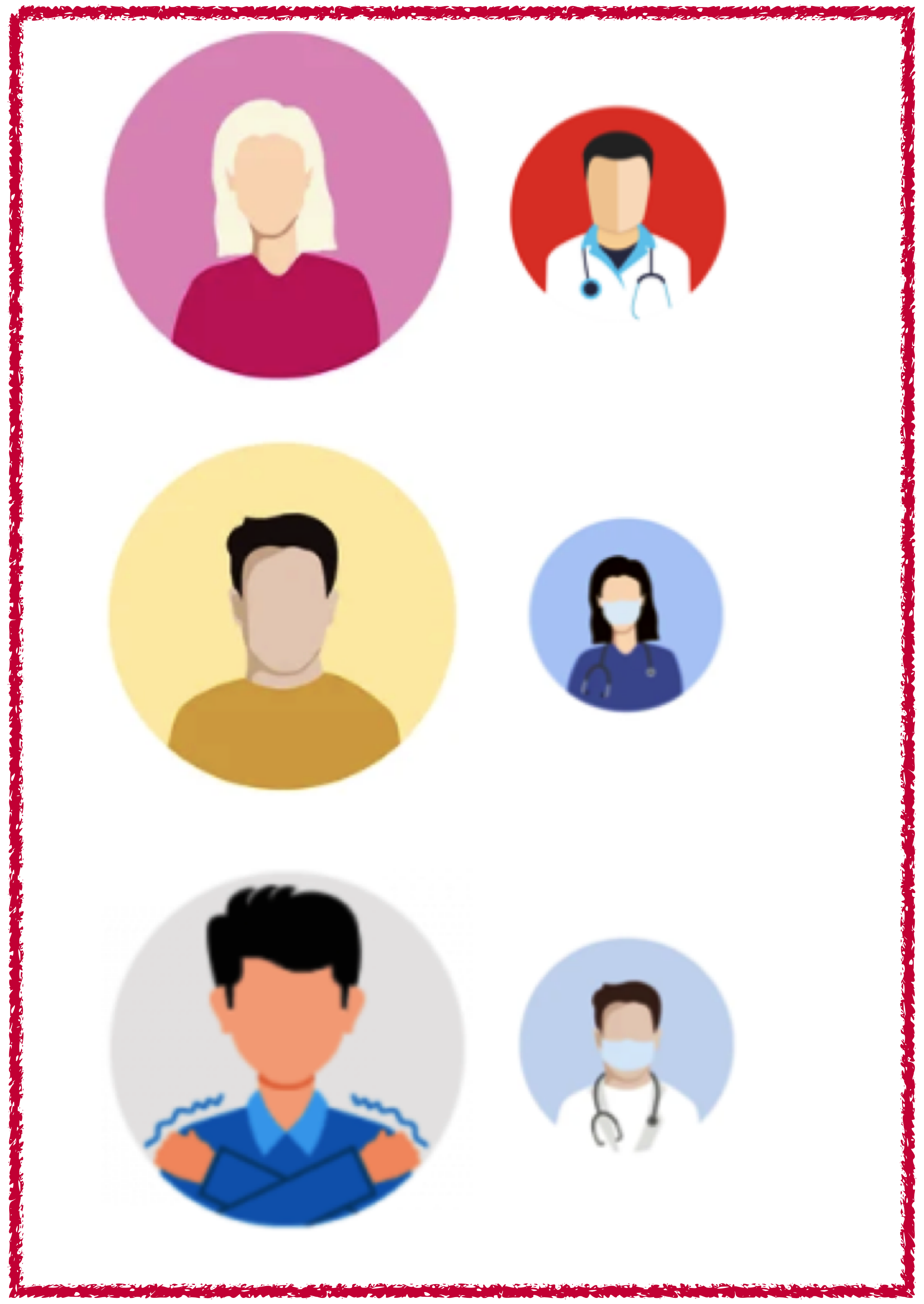
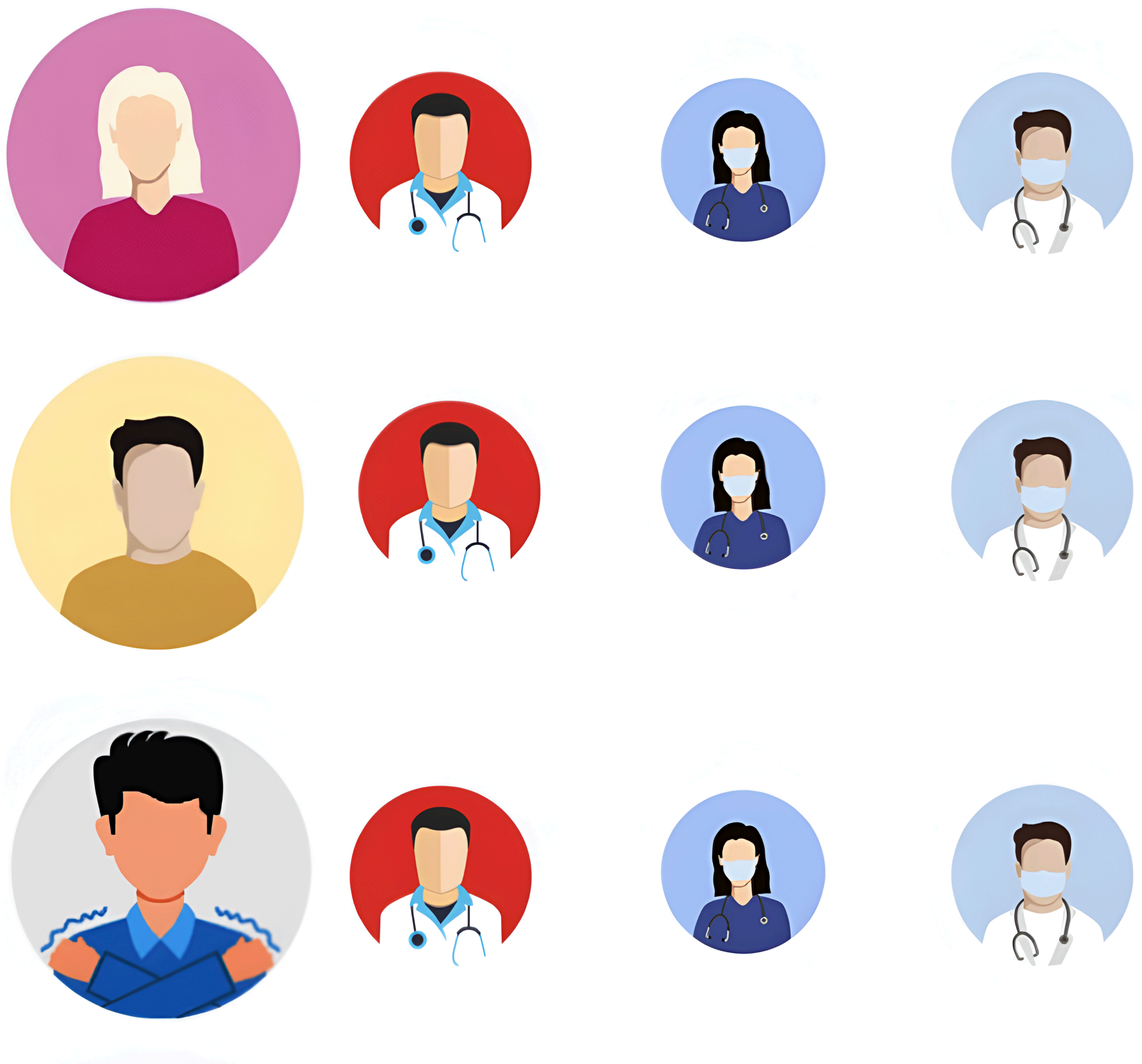


Pairwise

Beneficial when patient choices are known & determinstic

Two Extreme Policies



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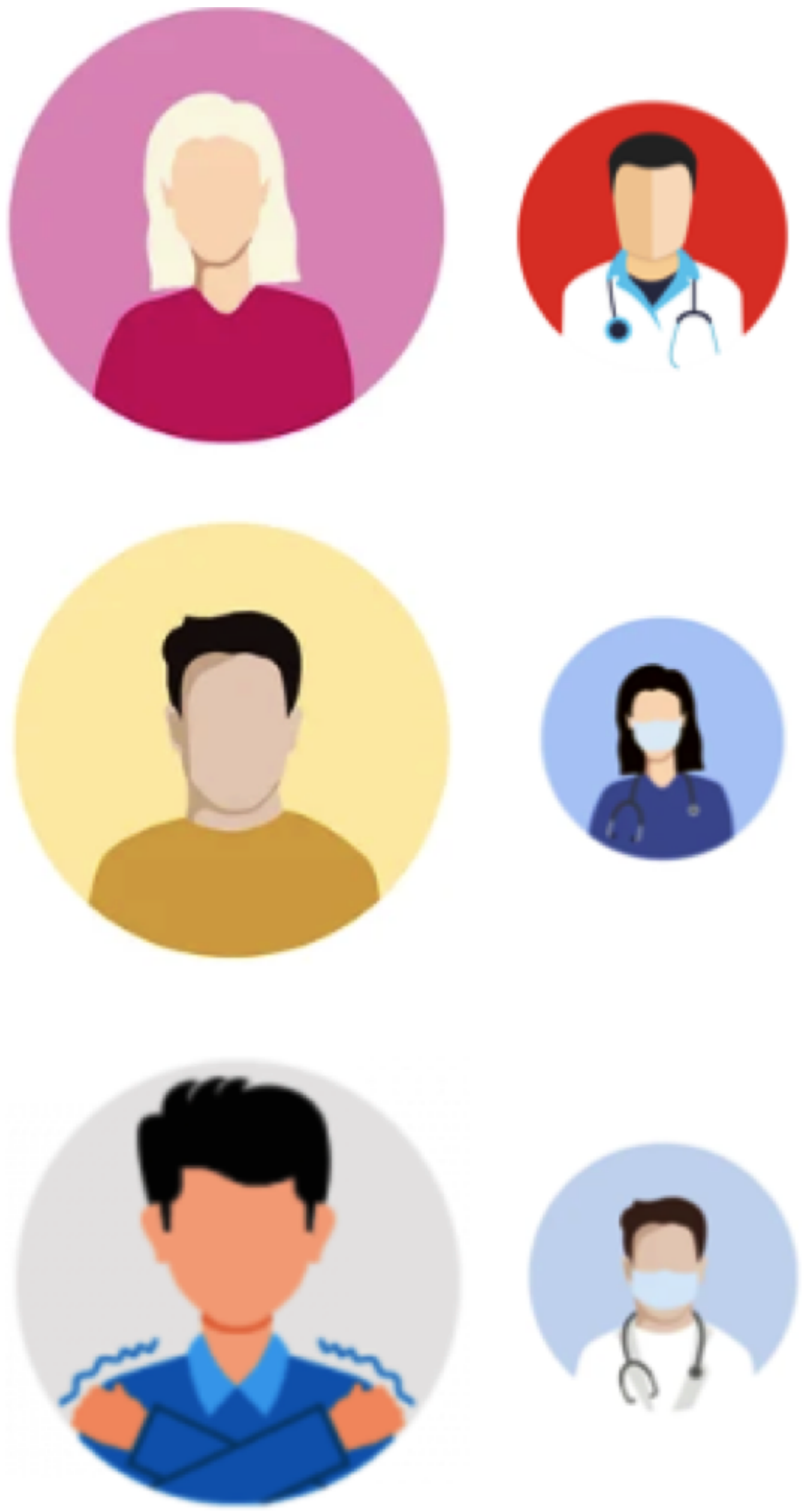

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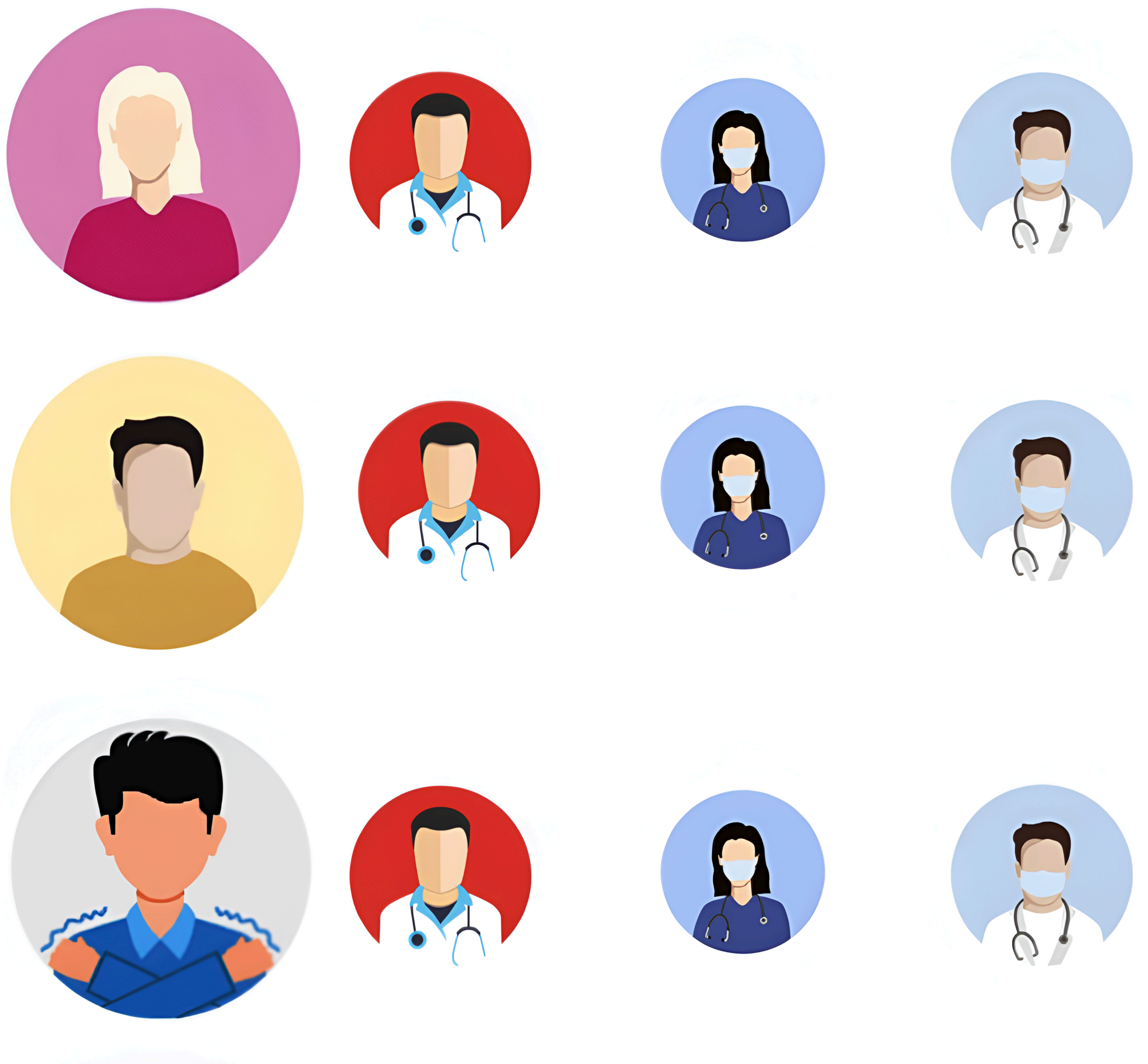

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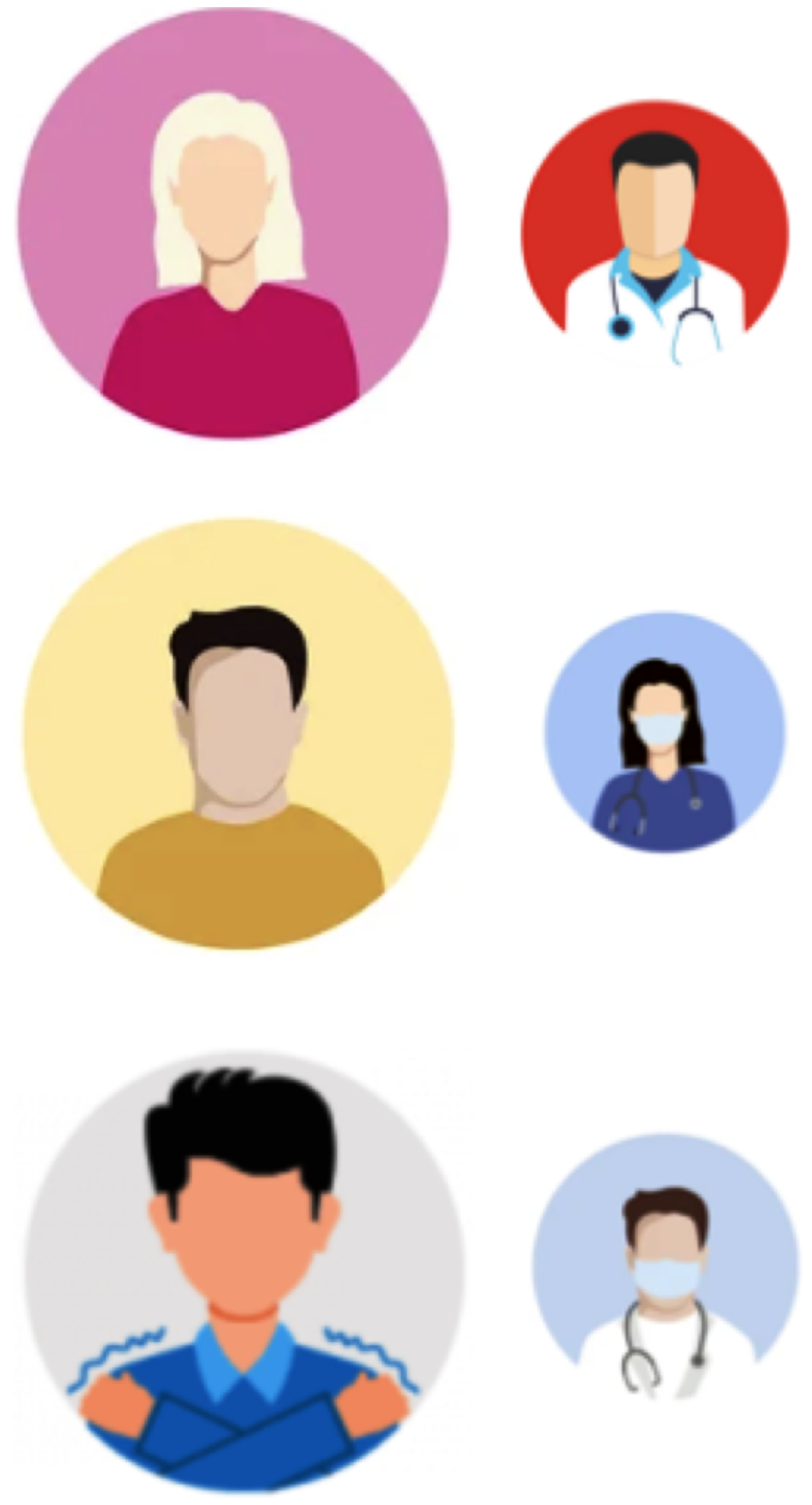
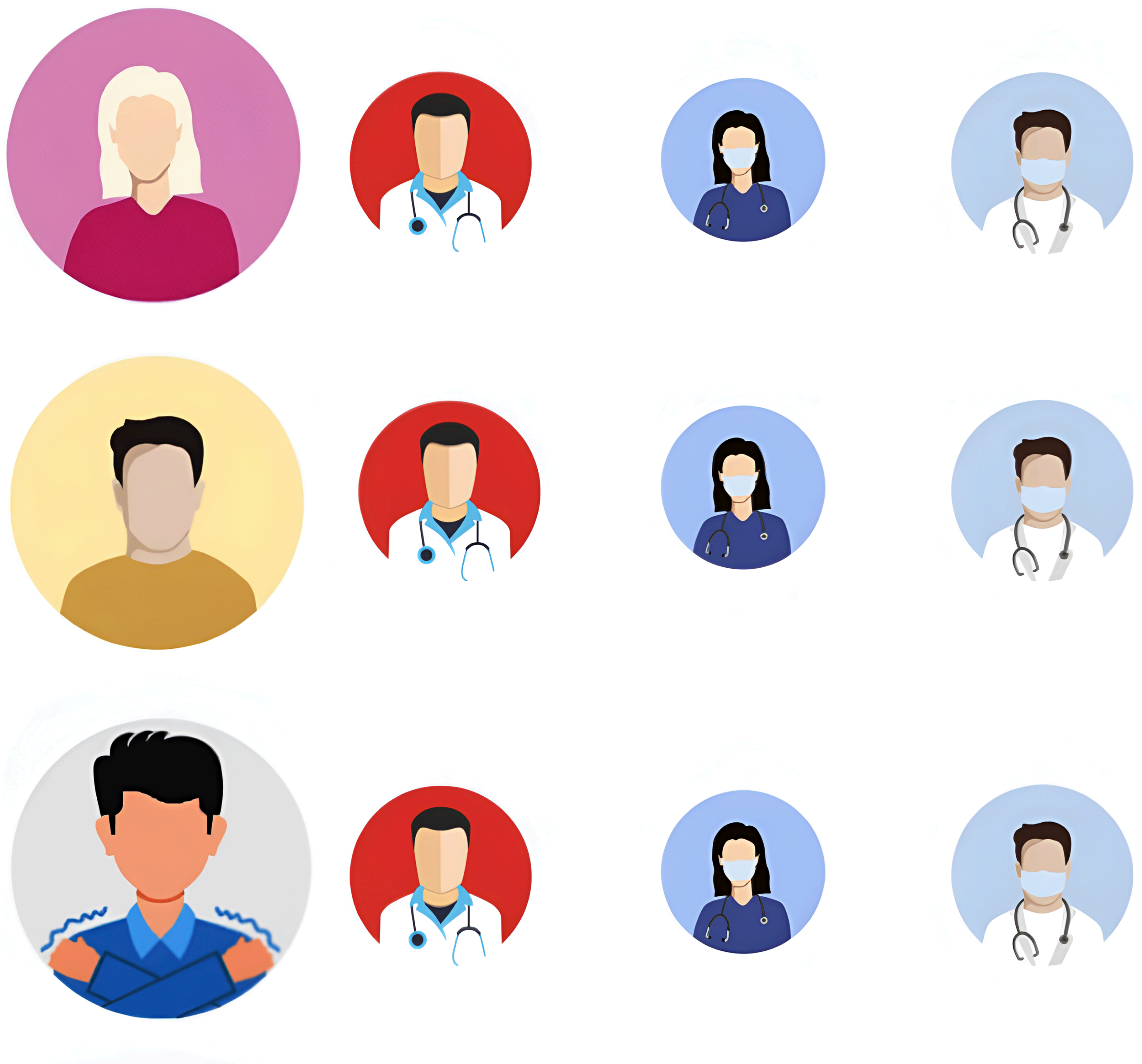


Pairwise

Choice allows us to overcome patient uncertainty during matching

Going beyond the Extremes



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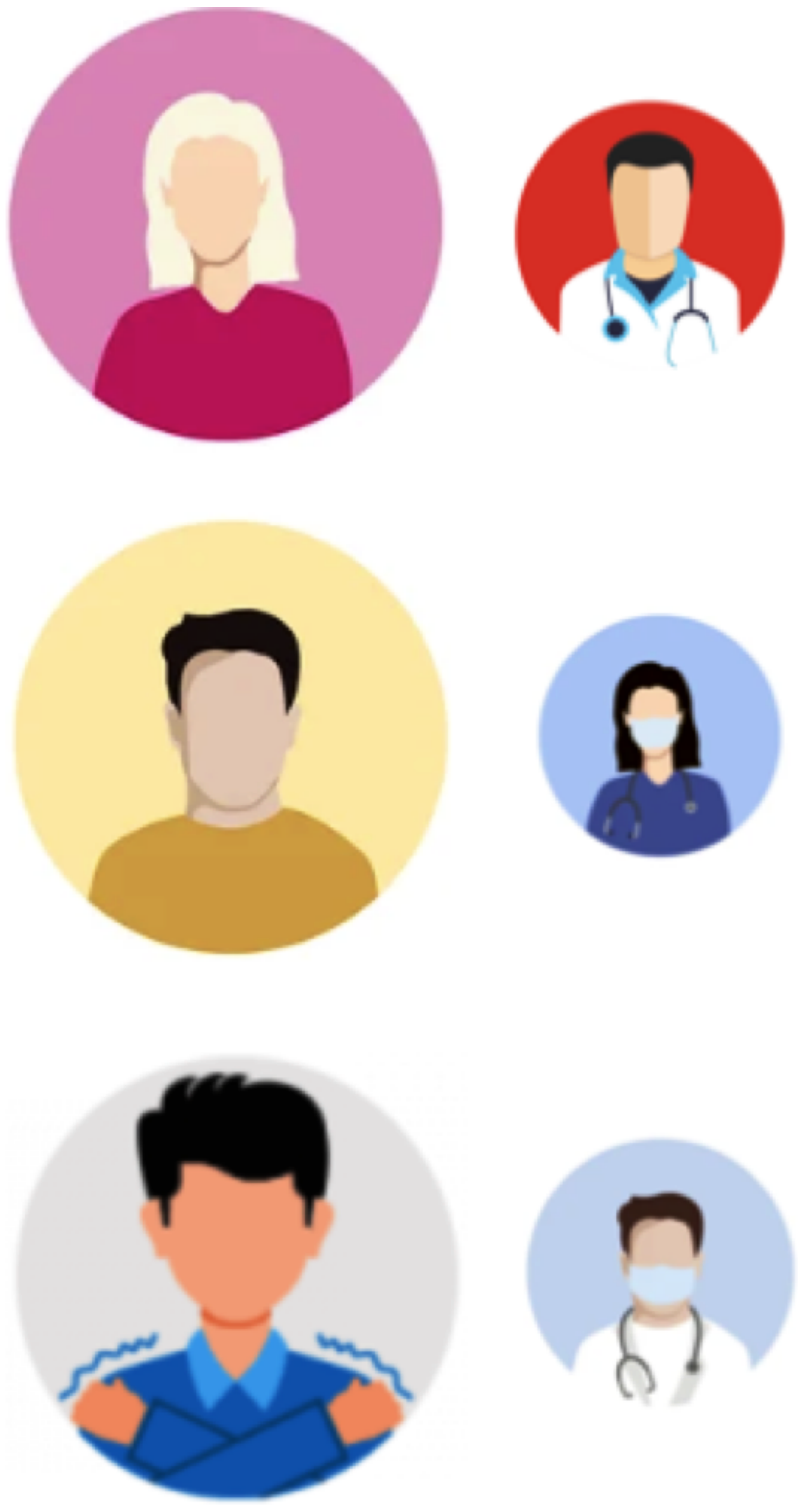

Pairwise

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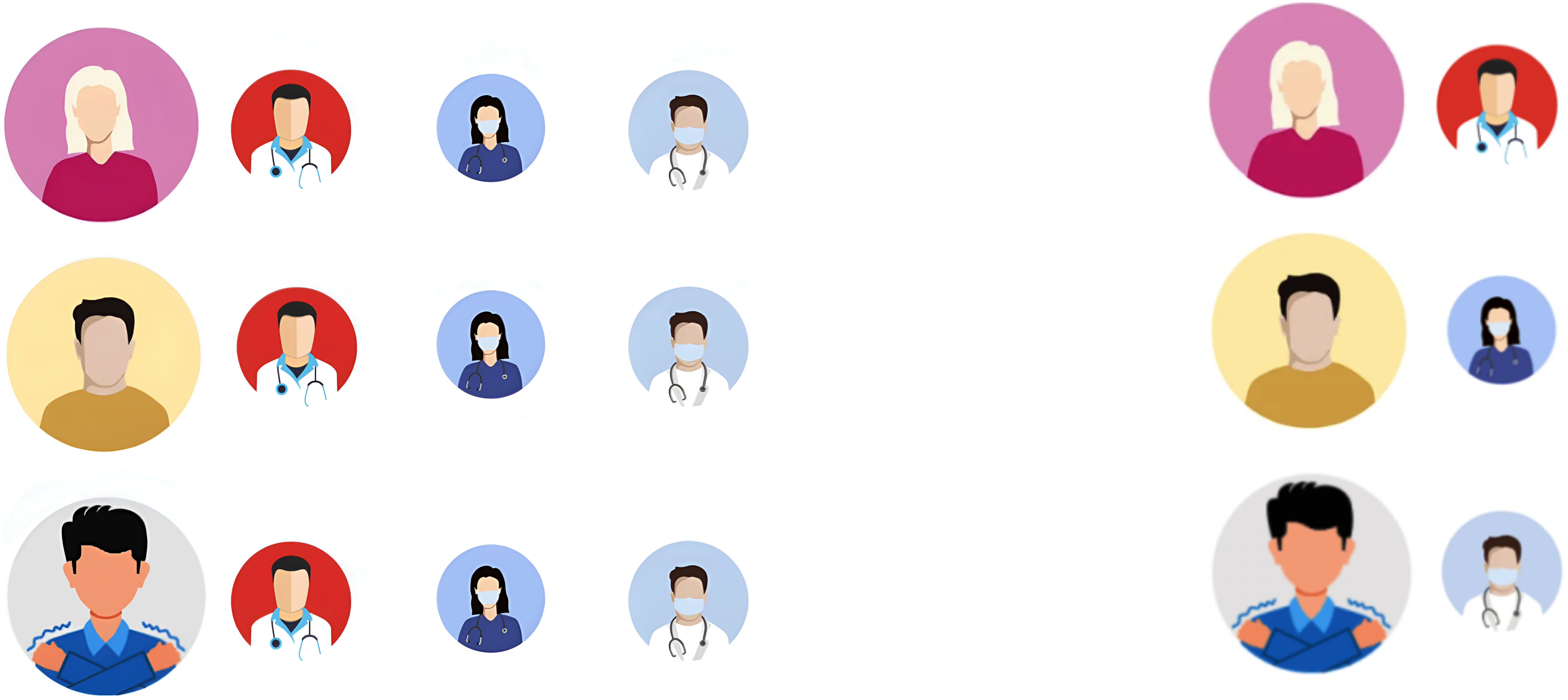

Greedy

Pairwise

Greedy and pairwise lie on a spectrum of patient choice

Optimization Problem

Heuristic lower bounds utility

We optimize a heuristic approximation for match quality with two components

$$h(\mathbf{X}) = \sum_{\text{Patient } i} \sum_{\text{Provider } j} \text{Utility}(i,j)\,\Pr[\text{j available}]\ \Pr[\text{i selects j} \mid \text{j available}]$$

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Find the assortment **X** that maximizes the heuristic

Impact of Patient/Provider Ratio

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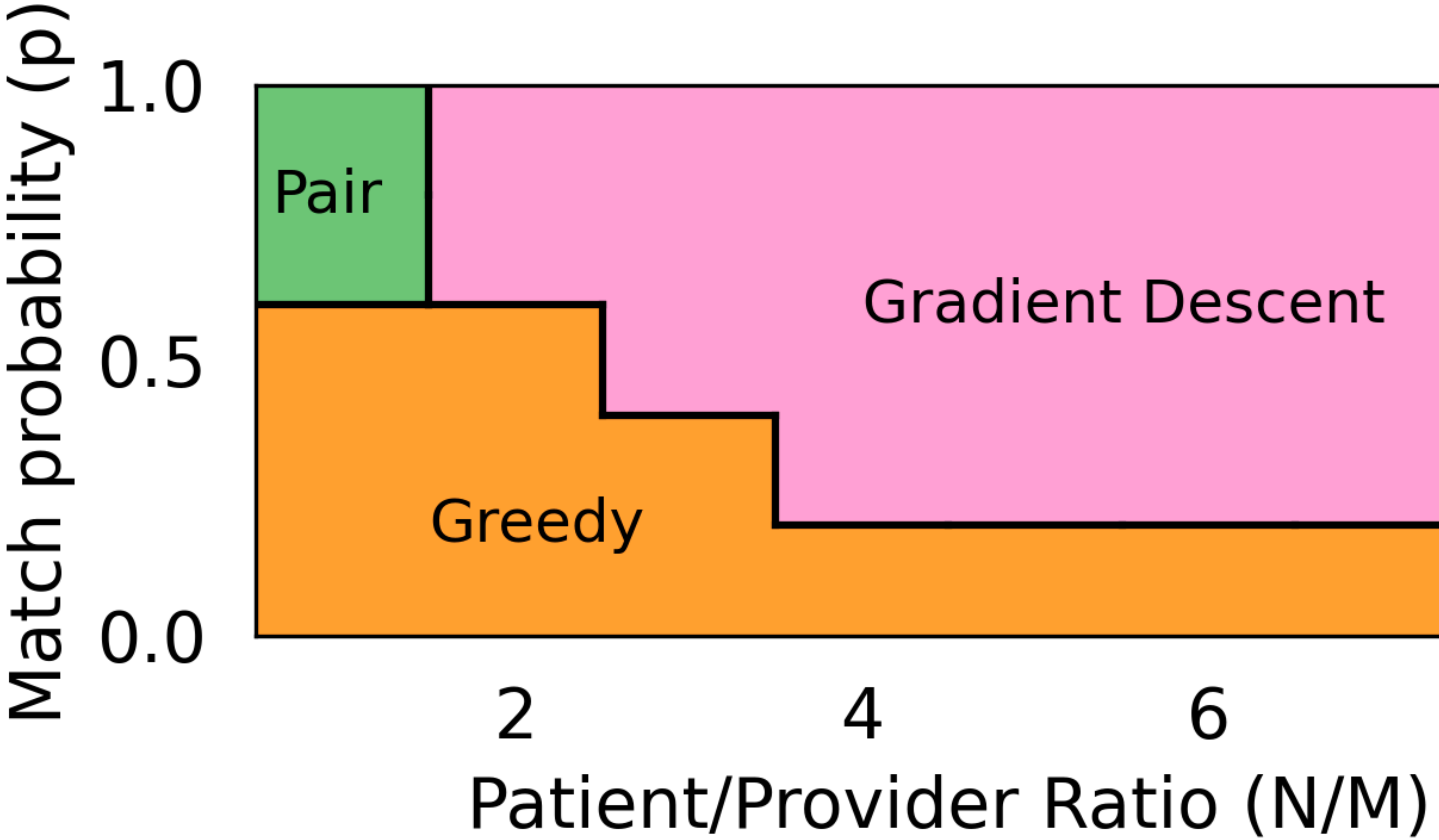
Impact of Match Probability

Impact of Match Probability



Constructing a Semi-Synthetic Dataset

We build a dataset mimicking the Hartford Healthcare system

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Choice Model

Patients have a fixed probability of matching after utility reaches a threshold

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Match Quality

Incorporates provider proximity and comorbidities present

Match Quality Comparison

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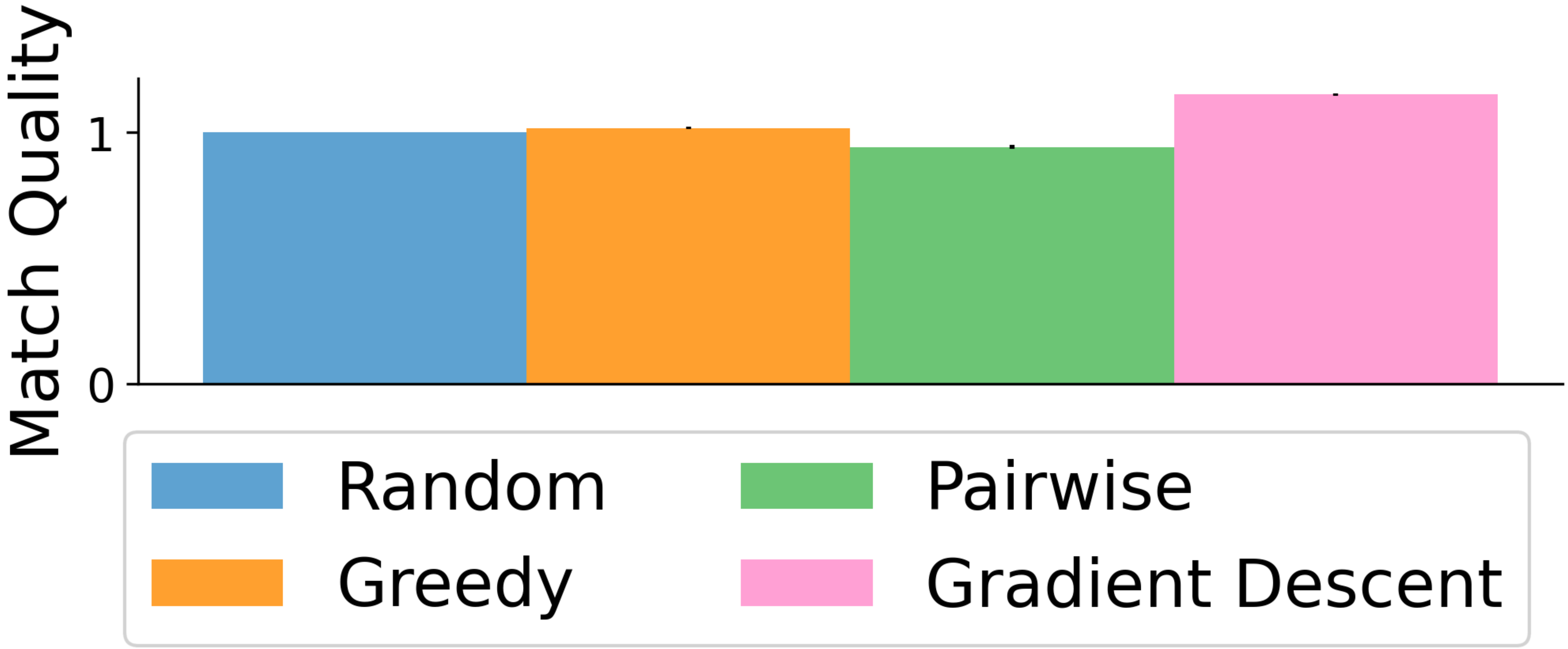

Who actually gets Matched?

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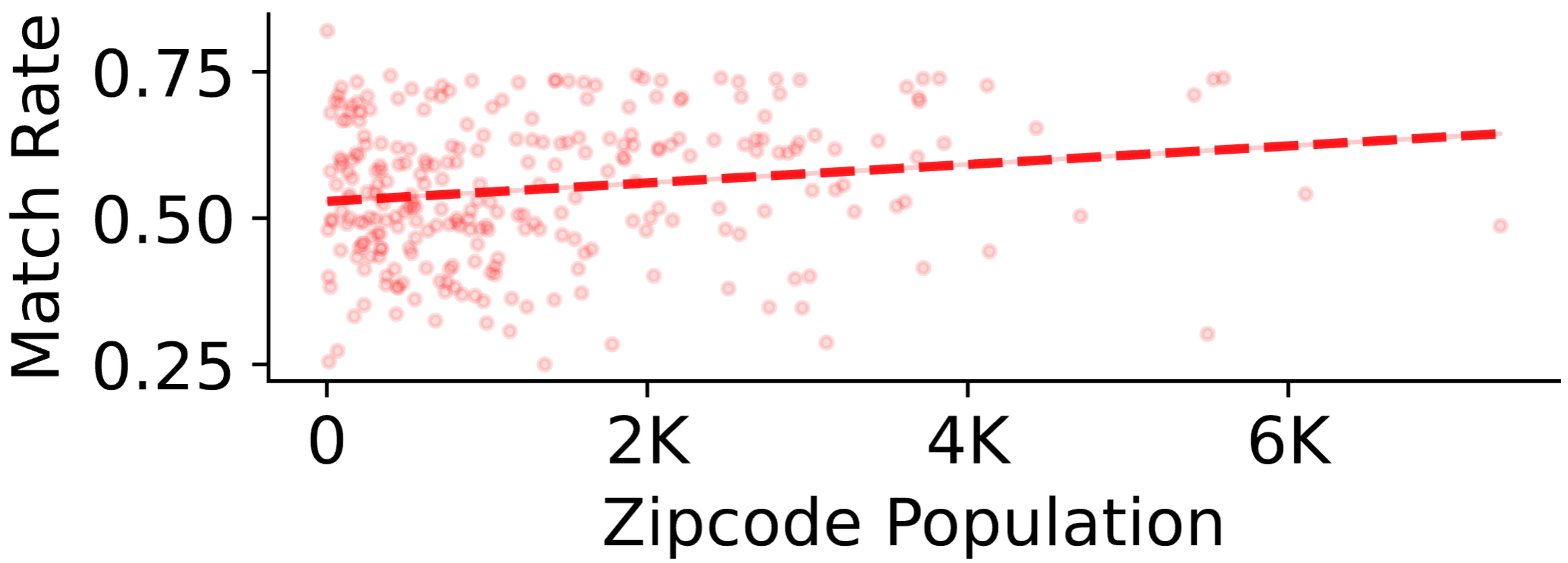

People from populated areas

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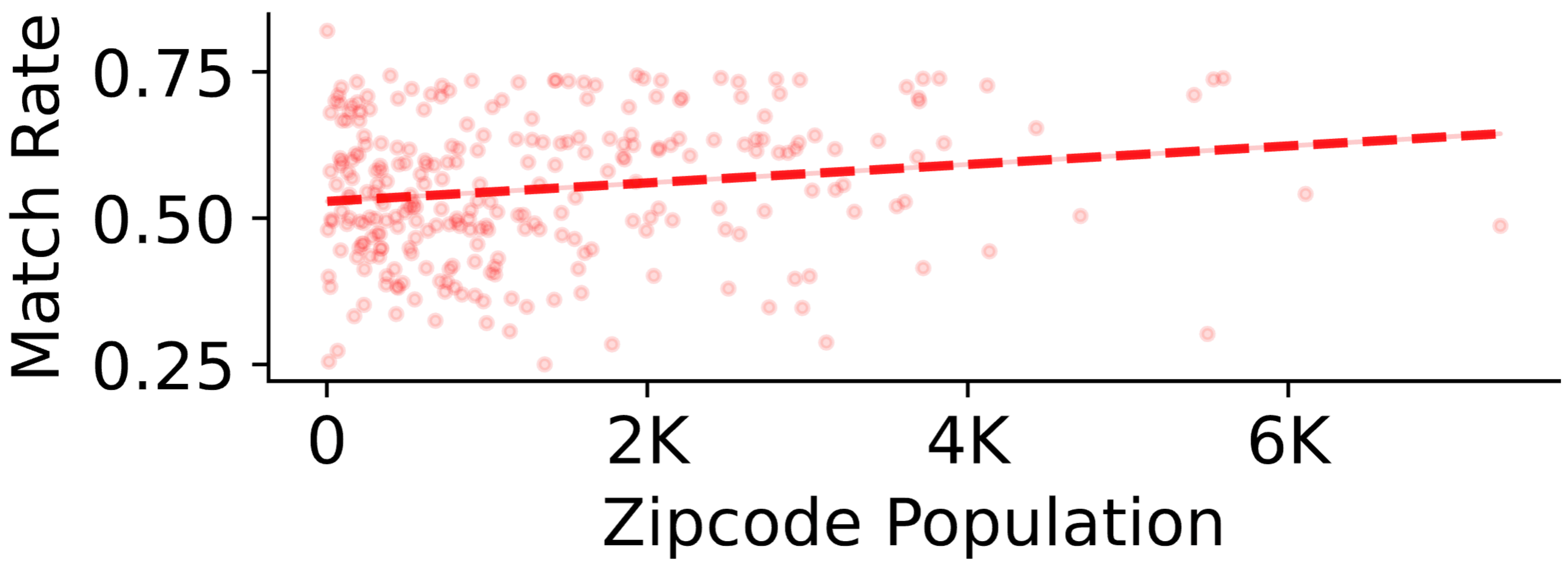
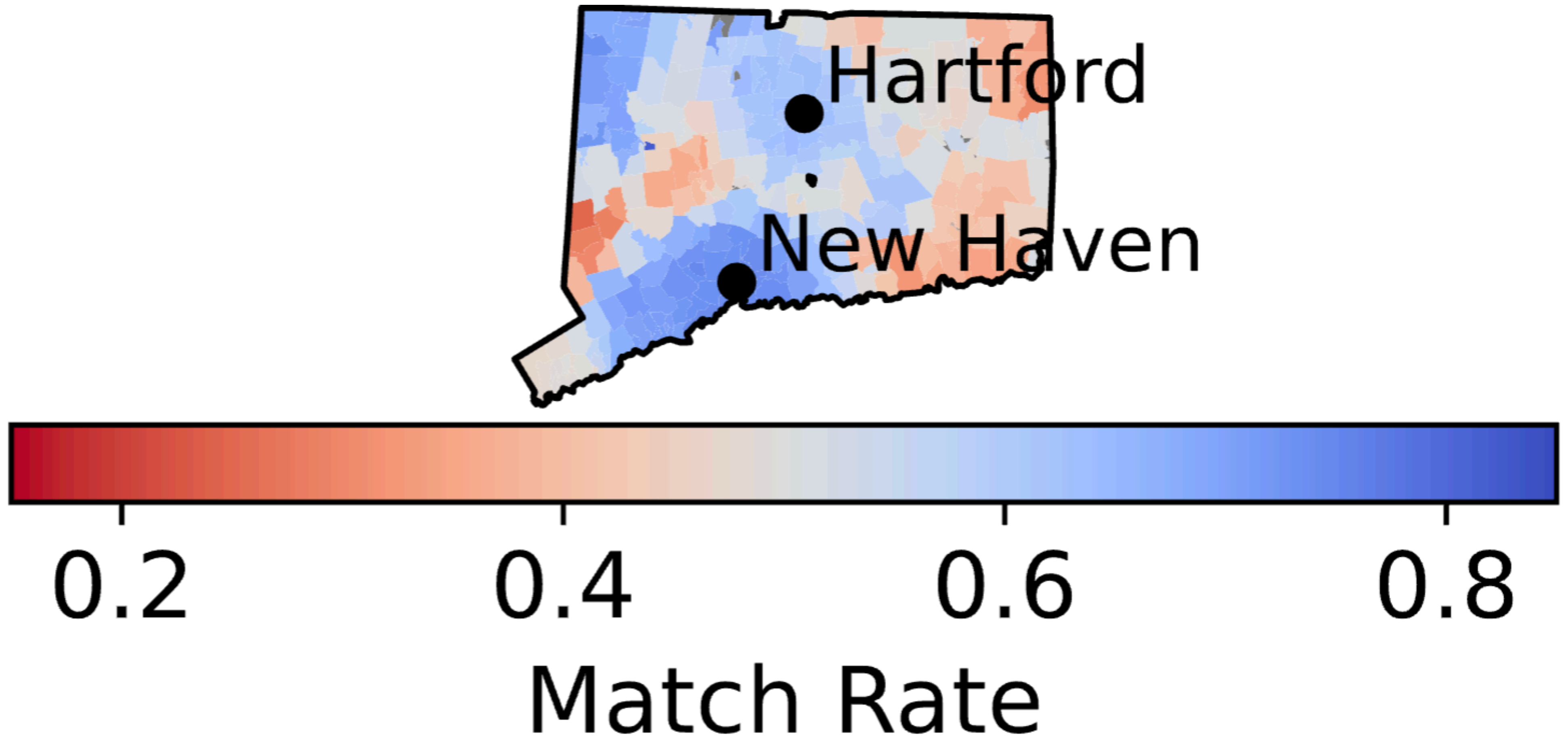


People near big cities

People from populated areas



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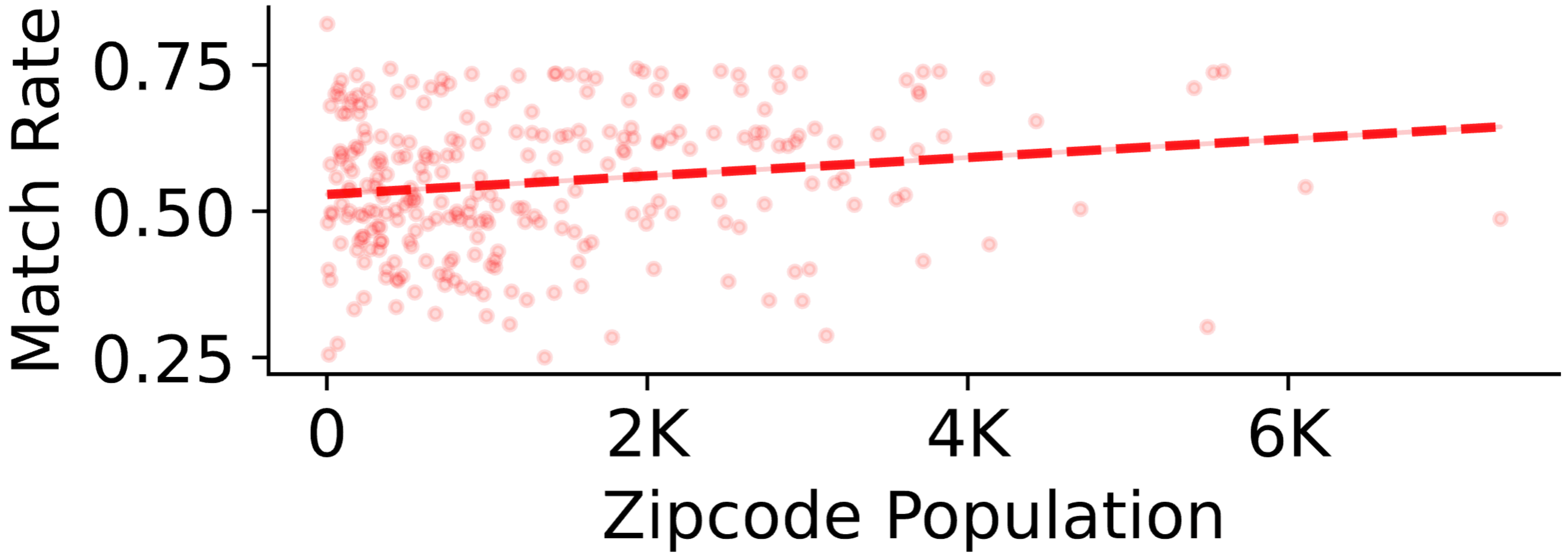

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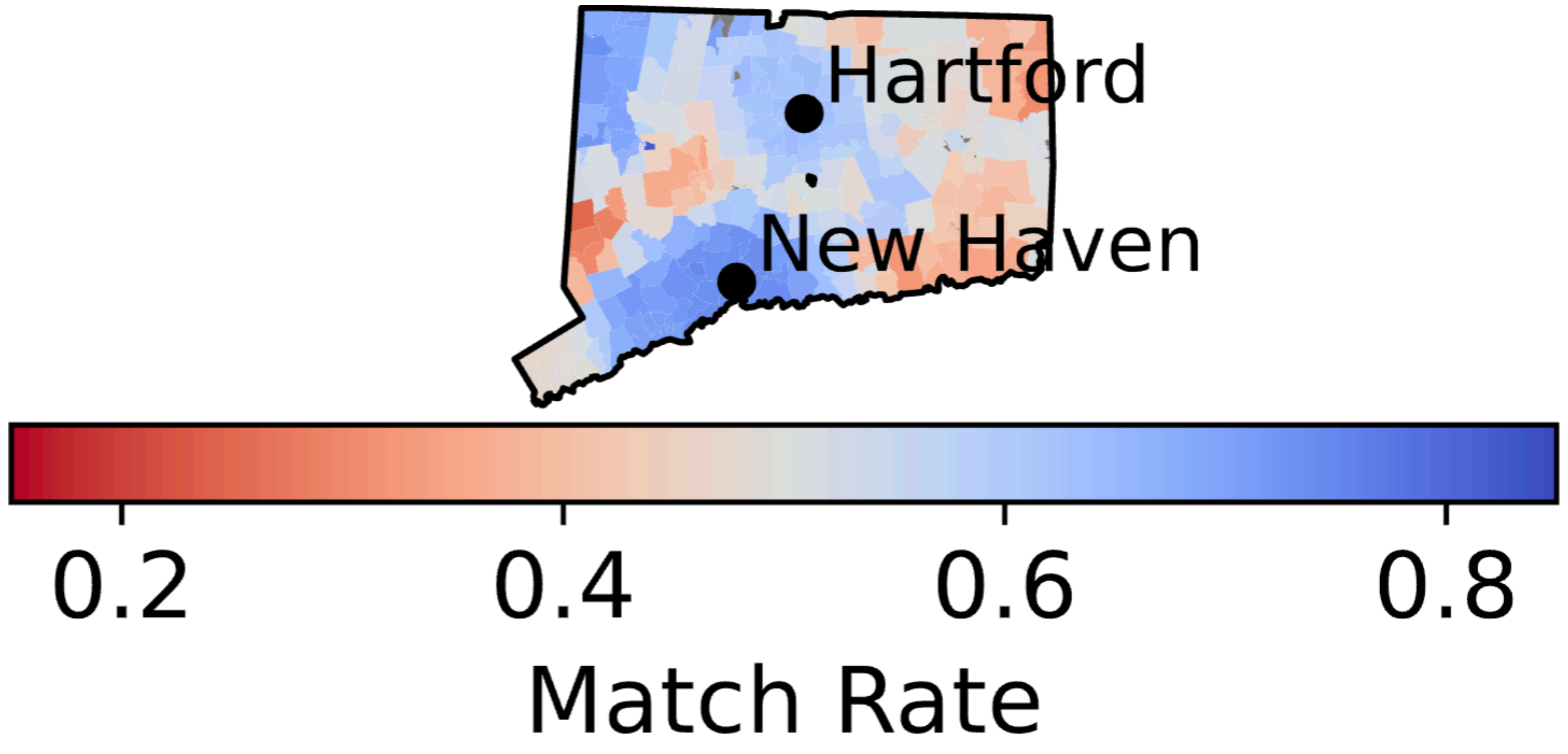

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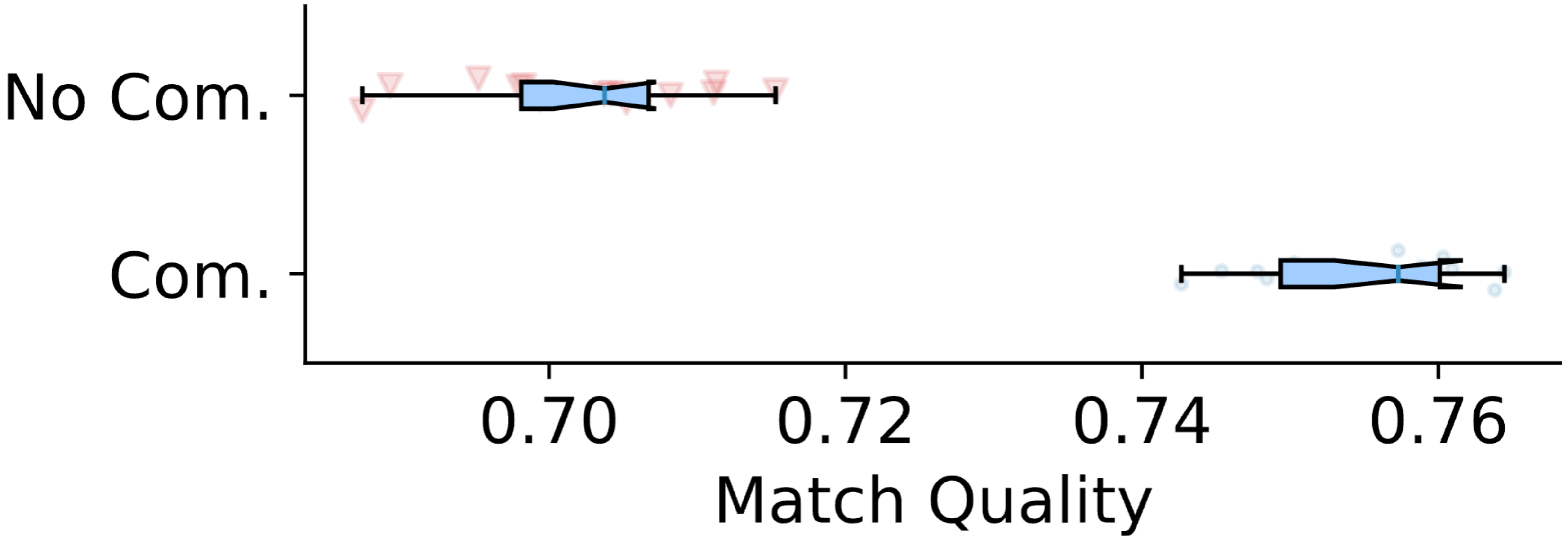

People with Comorbidities

Tension between Fairness and Match Rate/Quality

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Takeaways

Tailoring policies improves match quality. However, high match quality can lead to poor performance on other outcomes of interest, such as fairness.

Insights for Practitioners

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Patient choice becomes more useful under uncertainty

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Metrics such as fairness and match quality can be in tension

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Underlying factors might impact *who* gets matched

Patient-Provider Matching