Updating Clinical Risk Stratification Models Using Rank-Based Compatibility

Evaluating & Optimizing Clinician-Model Team Performance

MLHC 2023
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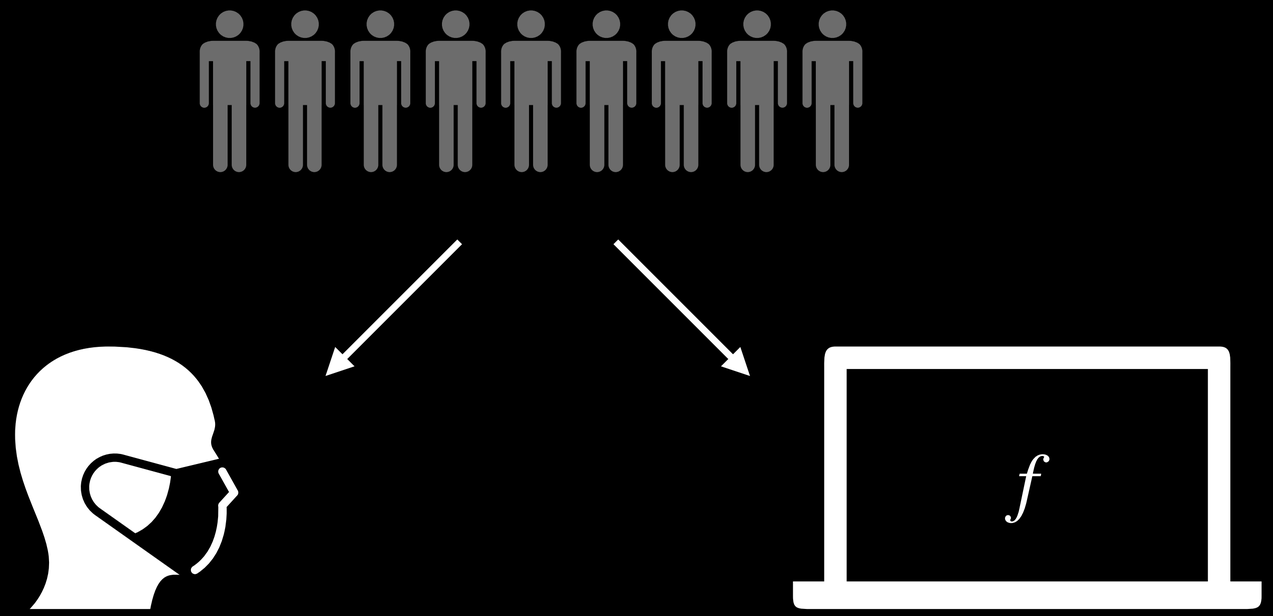
Physicians and models function as a team in healthcare settings.



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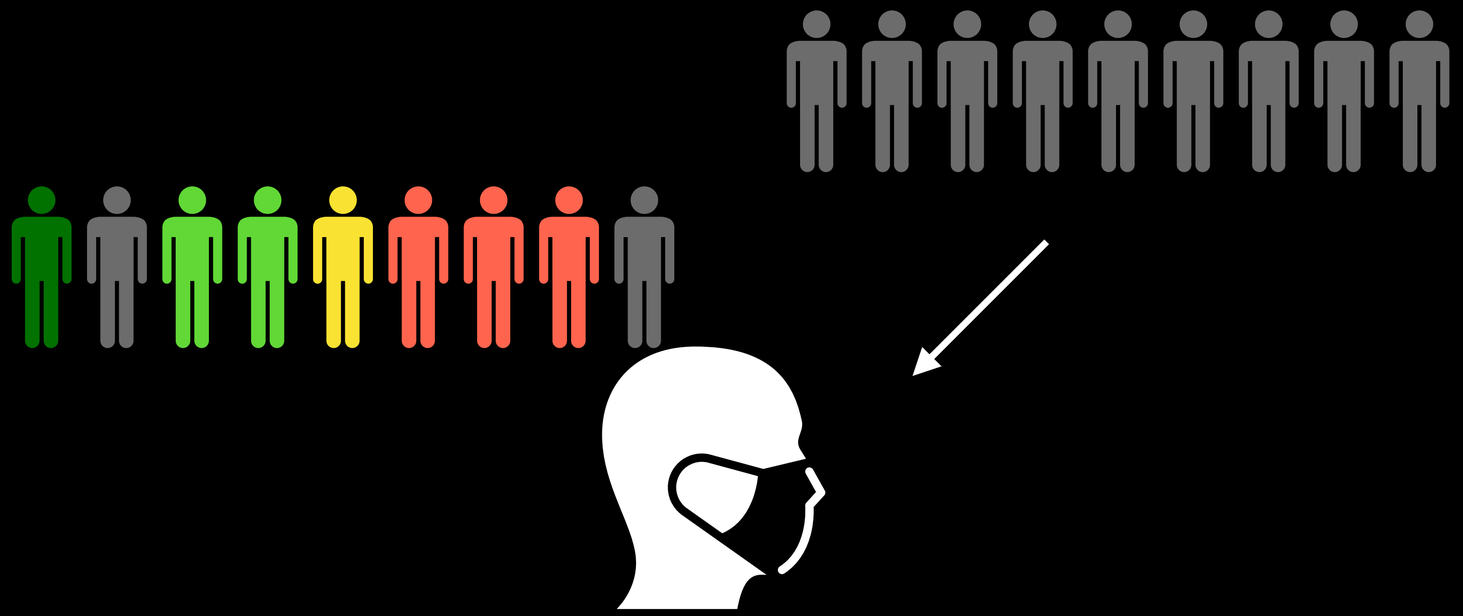

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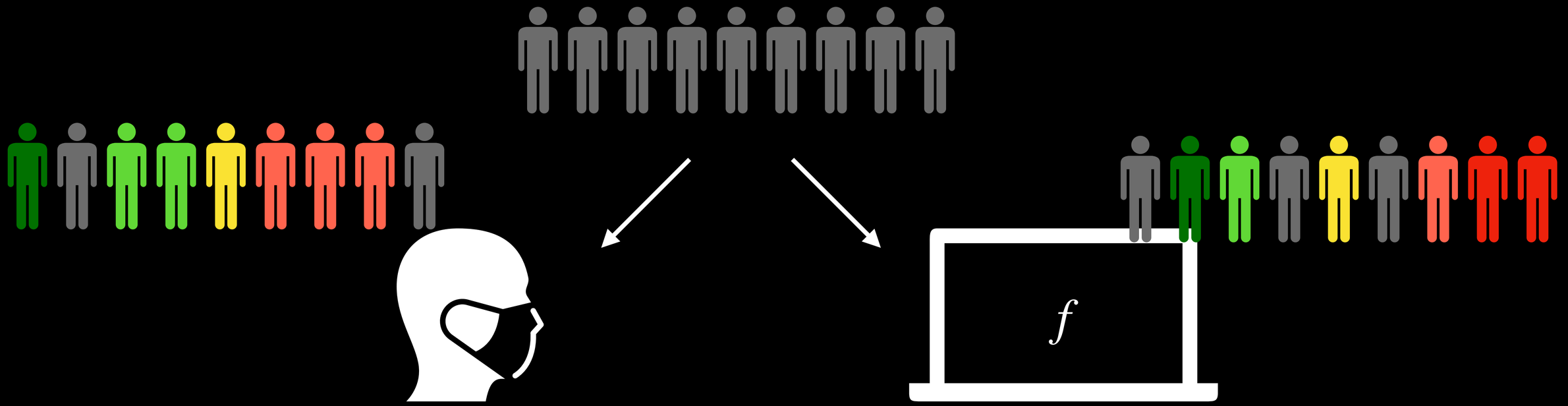

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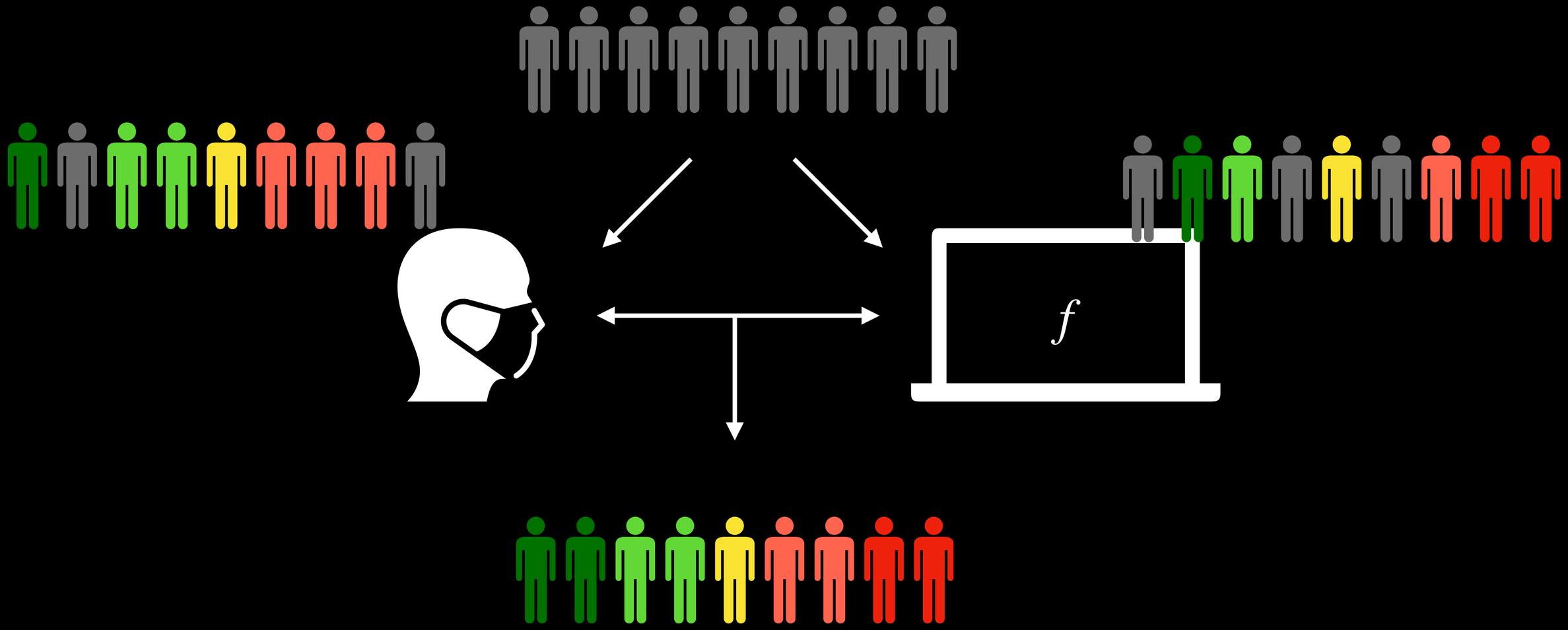
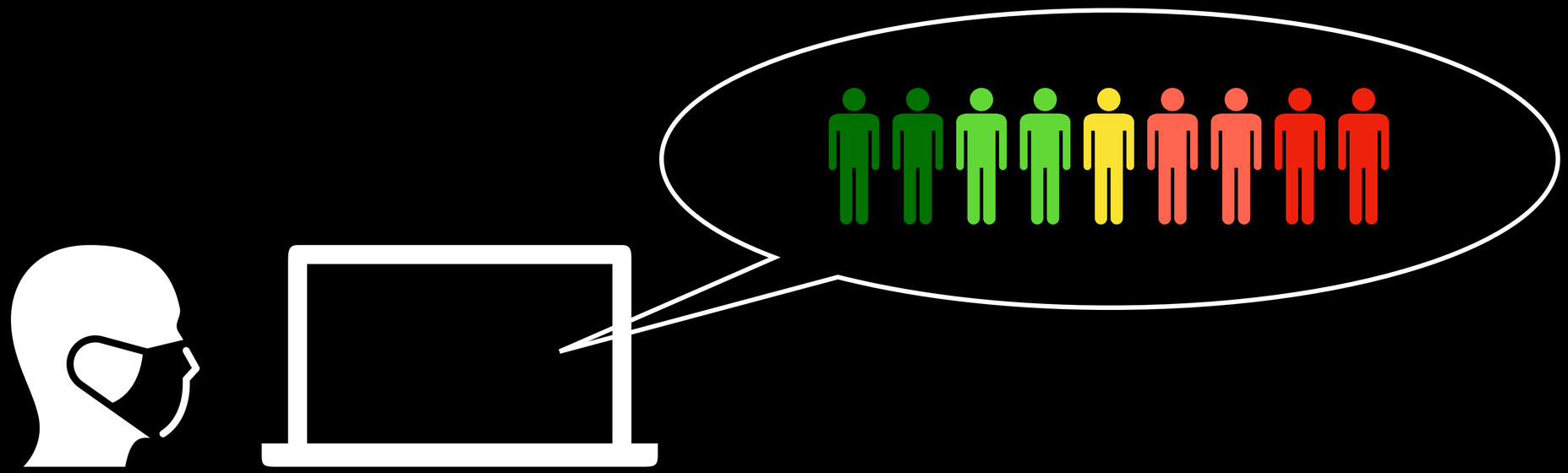


Updates can mess with user expectations.



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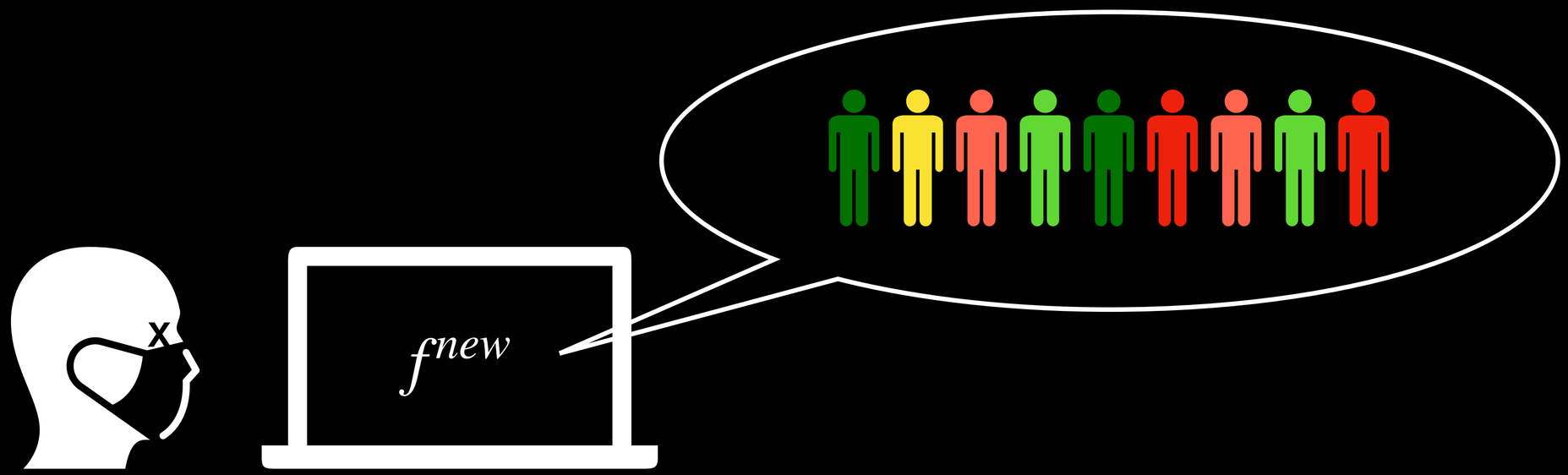
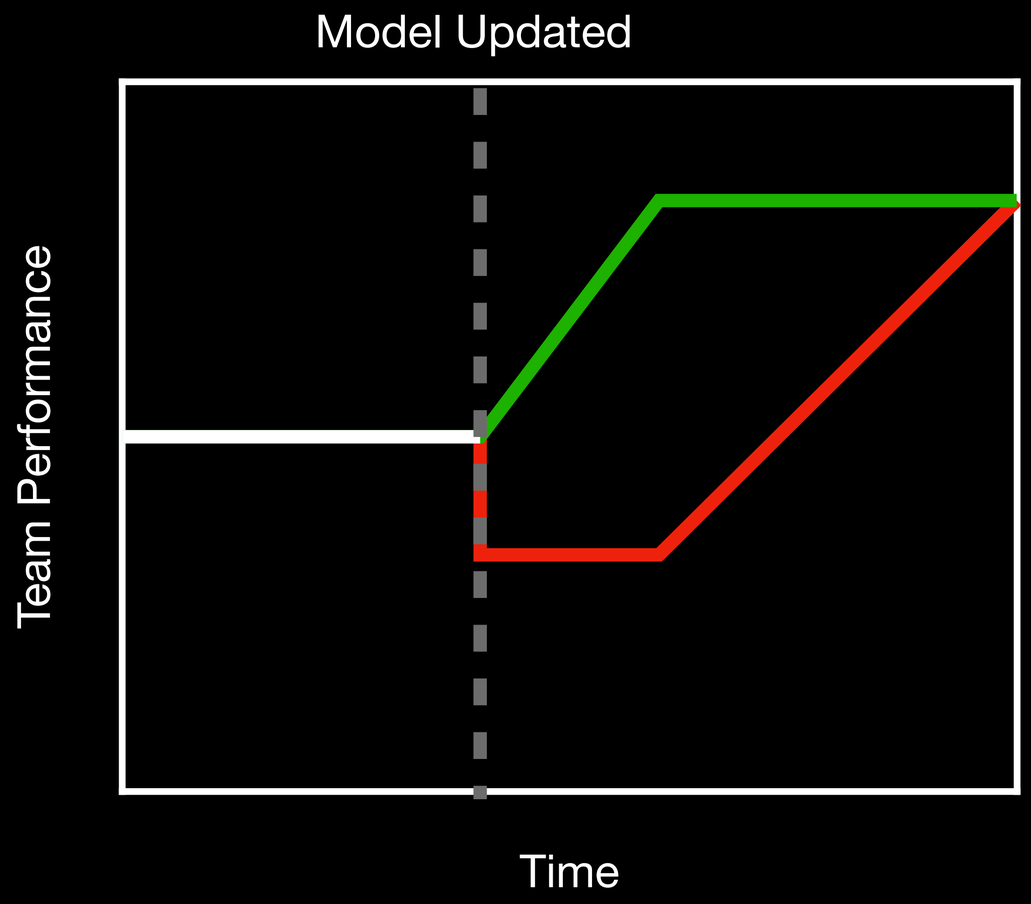


Team performance may suffer if models don’t meet user expectations.



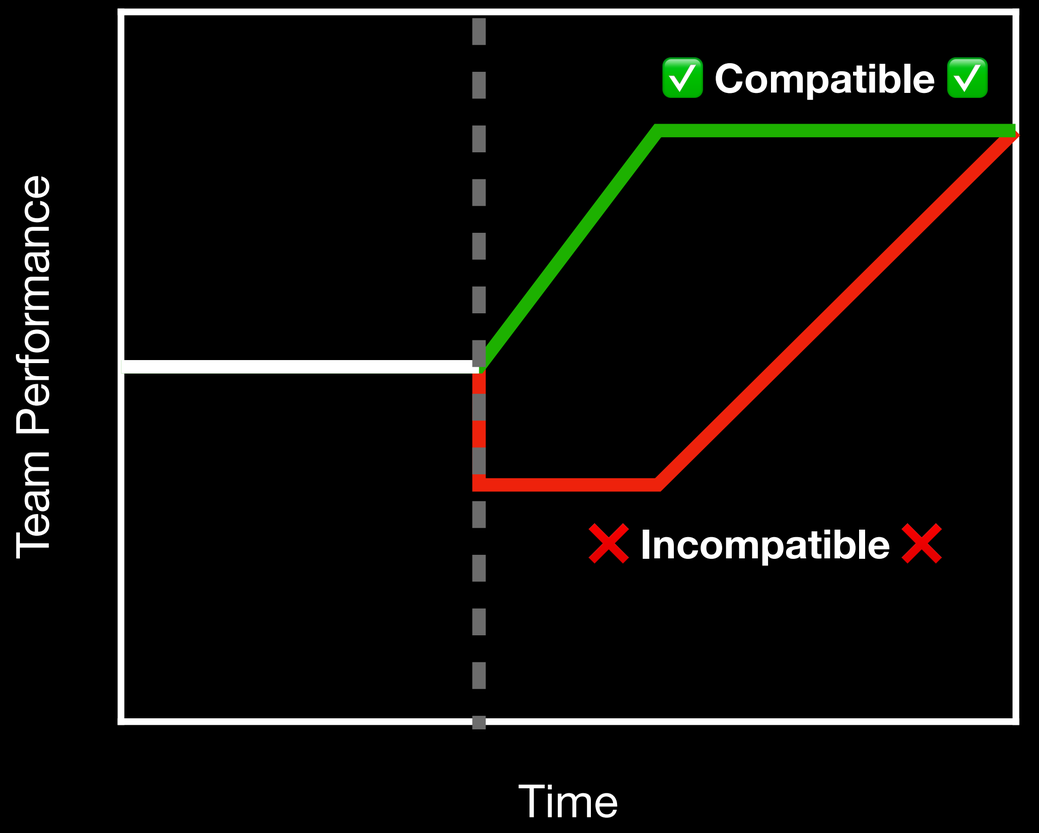
Adapted from Bansal 2019

Ideally updated models meet the expectations of users

Compatibility: the amount an updated model continues the correct behavior of an original model

Way to measure user expectations

Goal: updated models should have high compatibility



Bansal 2019

Problems with existing compatibility measures.

Existing measure depends on equality comparison

Problematic for use in risk stratification model & healthcare settings

Depends on setting a single decision threshold

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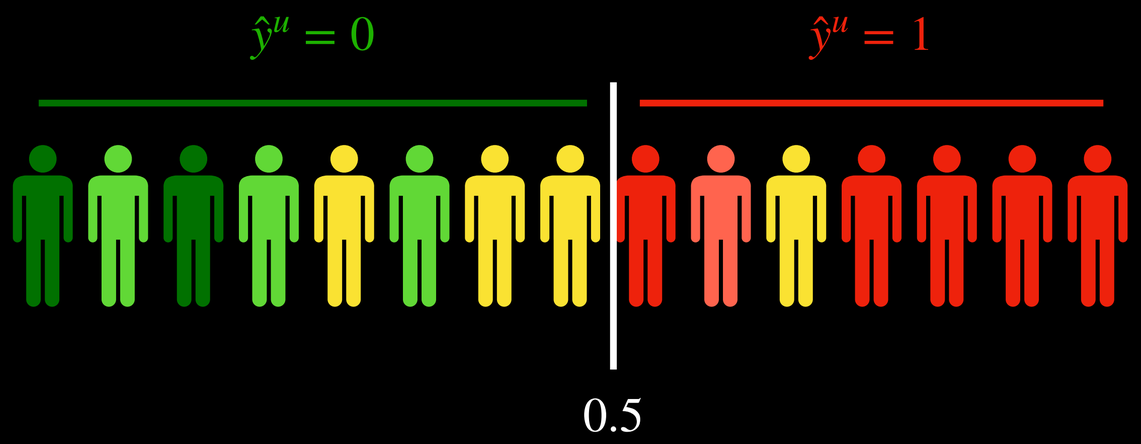

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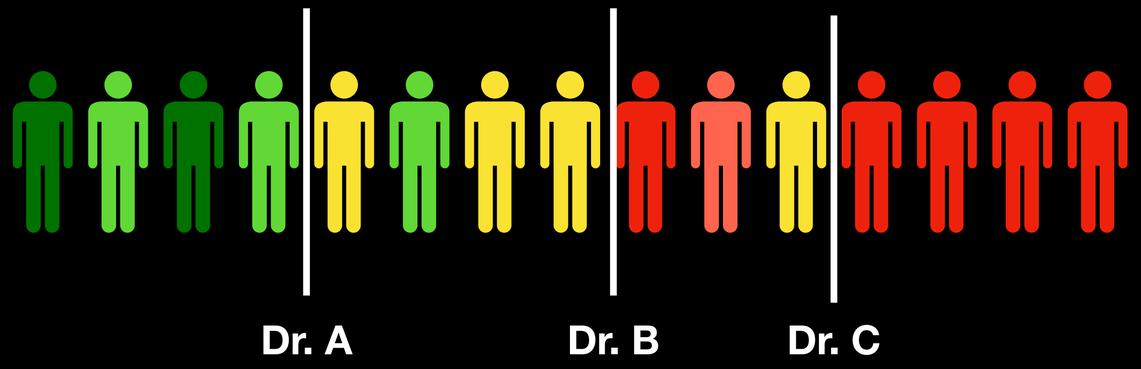

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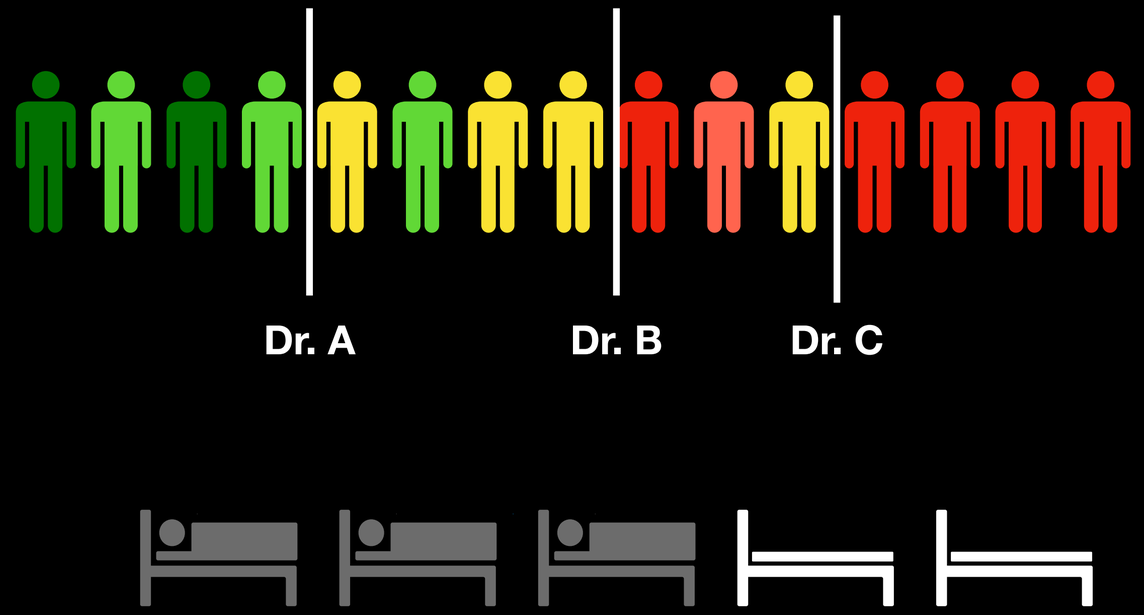


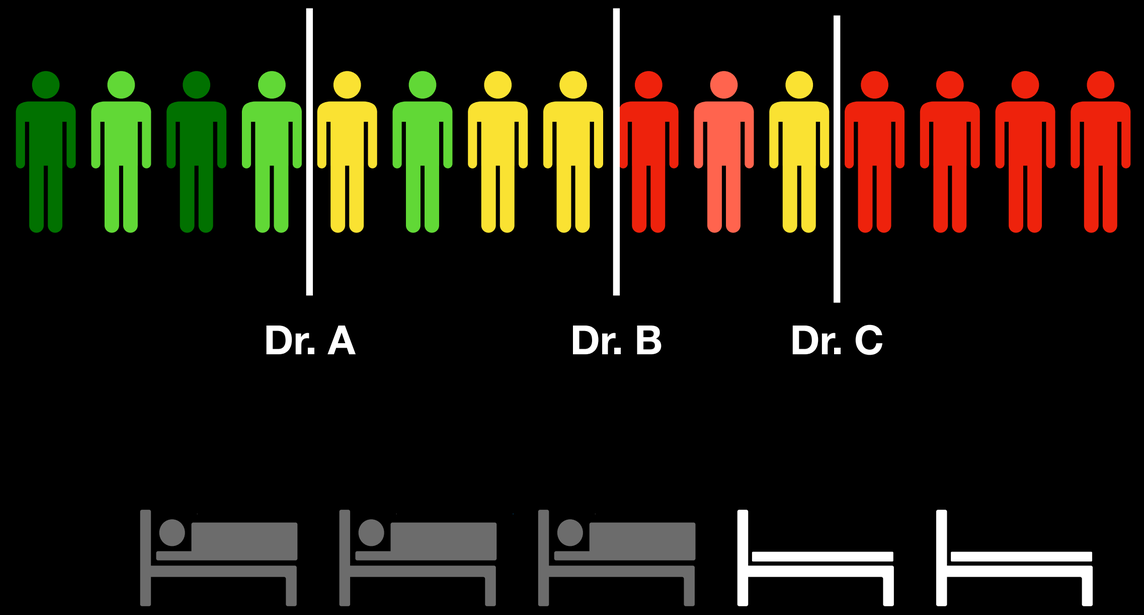
Problems with existing compatibility measures.

Existing measure depends on equality comparison

Problematic for use in risk stratification model & healthcare settings

- Depends on setting a single decision threshold

- No direct relationship with AUROC



Our contributions

Define a new rank-based compatibility measure (C^R)

Characterize C^R and its relationship with AUROC

Custom loss function to engineer model updates with improved C^R

Rank-based compatibility C^R

Agreement of risk estimate rankings produced by original & updated models given original ranked correctly:

$$C^R(f^o, f^u) = \frac{\sum_{i \in I^0} \sum_{j \in I^1} \mathbf{1}(\hat{p}_i^o < \hat{p}_j^o) \cdot \mathbf{1}(\hat{p}_i^u < \hat{p}_j^u)}{\sum_{i \in I^0} \sum_{j \in I^1} \mathbf{1}(\hat{p}_i^o < \hat{p}_j^o)}$$

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original model

updated model

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updated model ranks correctly

original model ranks correctly

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both models rank correctly

original model ranks correctly

Rank-based compatibility C^R

Agreement of risk estimate rankings produced by original & updated models given original ranked correctly:

$$C^R(f^o, f^u) = \frac{\sum_{i \in I^0} \sum_{j \in I^1} \mathbf{1}(\hat{p}_i^o < \hat{p}_j^o) \cdot \mathbf{1}(\hat{p}_i^u < \hat{p}_j^u)}{\sum_{i \in I^0} \sum_{j \in I^1} \mathbf{1}(\hat{p}_i^o < \hat{p}_j^o)}$$

1 → perfect compatibility, 0 → perfect incompatibility

We introduce rank-based incompatibility loss.

Rank-based incompatibility loss:

$$\mathscr{L}^R(f^o, f^u) = 1 - C^R(f^o, f^u)$$

Minimization of $\mathscr{L}^R$ will lead to higher levels of C^R.

Differentiable approximation $\widetilde{\mathscr{L}^R}$ for SGD.

C^R is a new compatibility measure inspired by AUROC

Not threshold dependent: ↑ clinical utility

Has a direct relationship with AUROC which we can balance against compatibility

In the paper you'll find…

Empirical results characterize C^R

Using $\widetilde{\mathscr{L}^R} \rightarrow \uparrow C^R$ & ↑AUROC

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