Outpatient clinic blueprint scheduling with limited waiting area capacity

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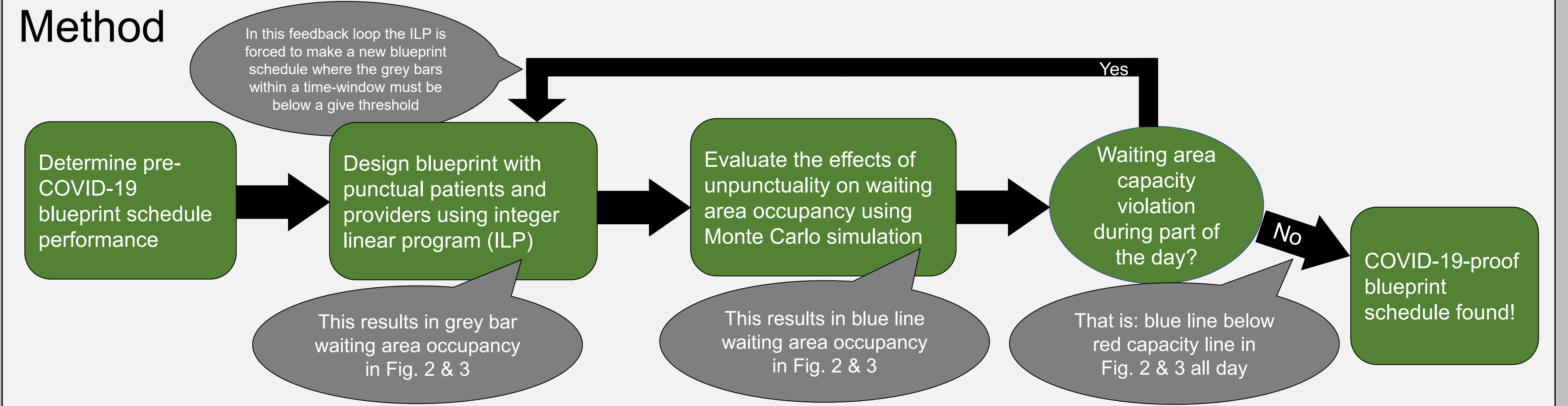
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COVID-19-proof waiting room!

Objective

- COVID-19 distancing measures require patients to stay 1.5m apart in hospital waiting areas
- Under pre-COVID-19 blueprint schedules waiting areas would be overcrowded

- Intervention using mathematical optimisation and simulation to design **COVID-19-proof blueprint schedules** that schedules **as many in-person appointments** as possible given a **maximum waiting area capacity**
- In-person appointments may be replaced by digital alternatives

Method

In this feedback loop the ILP is forced to make a new blueprint schedule where the grey bars within a time-window must be below a give threshold

Determine pre-COVID-19 blueprint schedule performance → Design blueprint with punctual patients and providers using integer linear program (ILP) → Evaluate the effects of unpunctuality on waiting area occupancy using Monte Carlo simulation → Waiting area capacity violation during part of the day? — Yes (loops back) / No → COVID-19-proof blueprint schedule found!

This results in grey bar waiting area occupancy in Fig. 2 & 3

This results in blue line waiting area occupancy in Fig. 2 & 3

That is: blue line below red capacity line in Fig. 2 & 3 all day

Introduction

- Patients visit hospital for series of appointments, e.g., for case study at Rheumatology clinic of Sint Maartenskliniek (SMK):
  diagnostic test ➡ consultation with nurse ➡ consultation with physician
- Diagnostic tests, consultations with nurse and consultations with physician come in different types and duration, so jointly define *Patient trajectories*
- *Bridging time* 🛈: Minimum required time between steps in patient trajectory to gather test results/information. Patient spends this time in waiting area
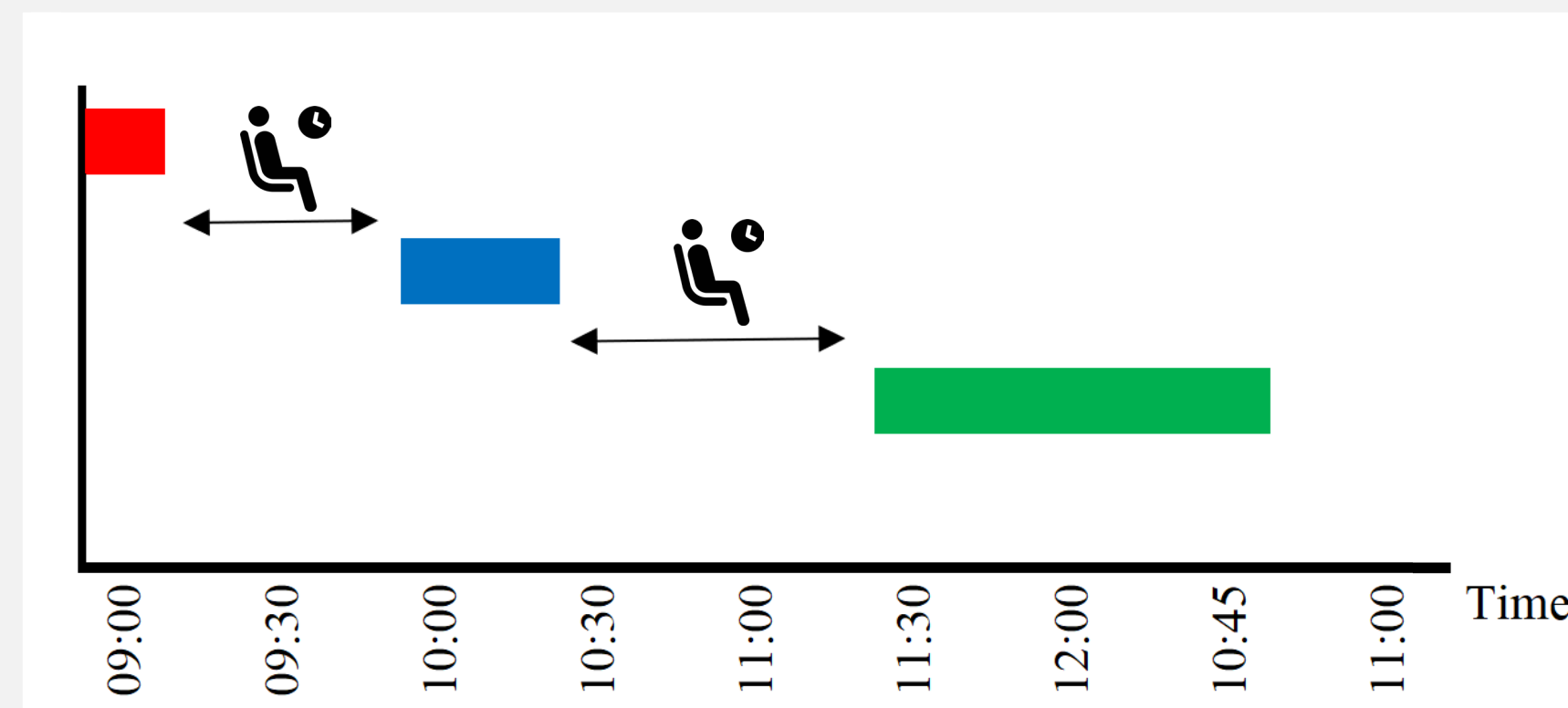

Fig 1. Schematic depiction of a patient trajectory.

- **Scheduling patient trajectories determines waiting area occupancy,** e.g., scheduling 4 patients with nurses at 9AM for a 15 min. consultation and with bridging time of 60 min. implies waiting area occupancy of at least 4 patients between 9:15 – 10:15
- Difficulty: actual time spend in waiting area is subject to patient and/or provider (un)punctuality

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References

Dijkstra S, Otten M, Leeftink G, *et al*. (2022). Limited waiting areas in outpatient clinics: an intervention to incorporate the effect of bridging times in blueprint schedules. *BMJ Open Quality* 2022;**11**:e001703. DOI: 10.1136/bmjoq-2021-001703

Otten M, Dijkstra S, Leeftink G, *et al*. (2021). Outpatient clinic scheduling with limited waiting area capacity. Journal of the Operational Research Society. DOI: 10.1080/01605682.2021.1978347

Results

Case study setting: Rheumatology clinic SMK. Clinic opens at 8:15, closes at 17:00; 3 nurses (blueprint schedules on top), 10 physicians (blueprint schedules at the bottom). Every colour corresponds to a patient trajectory, so if colour occurs in both nurses' and physicians' blueprints, there is bridging time 🛈. Hatched (x) blocks correspond to digital consultations of the colour matching the patient trajectory. Waiting area capacity: 18 seat patients.

- If both patients (all arrive exactly at the appointed time) and provider (no consultation duration deviates from its scheduled duration) are punctual the pre-COVID-19 blueprint schedules satisfies the waiting room capacity

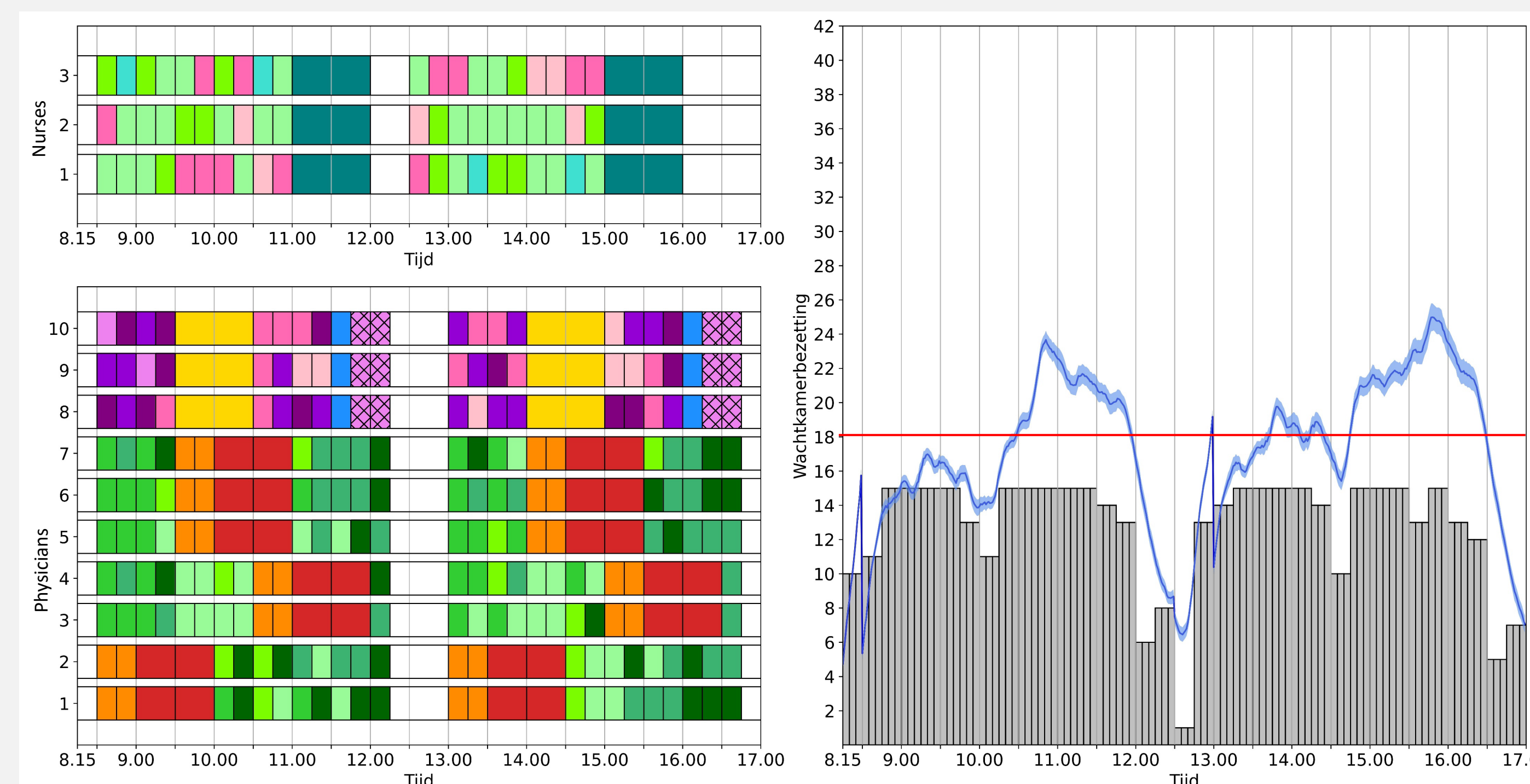- If unpunctuality is considered, this is no longer true

Fig 2. Pre-COVID-19 blueprint schedule. Left: blueprint schedules with along x-axis the time, along y-axis the staff. Right: Waiting area occupancy. Grey bars depict the occupancy if both patient and provider are punctual, blue line (shaded area is 95% confidence interval) depicts occupancy including unpunctuality.

To obtain COVID-19-proof blueprint schedule we force:
- Punctual waiting area occupancy (grey bars) to be less or equal to 14 between 10:30 – 11:15
- ... to be less or equal to 8 between 11:15 – 12:00
- ... to be less or equal to 12 between 14:00 – 15:00
- …

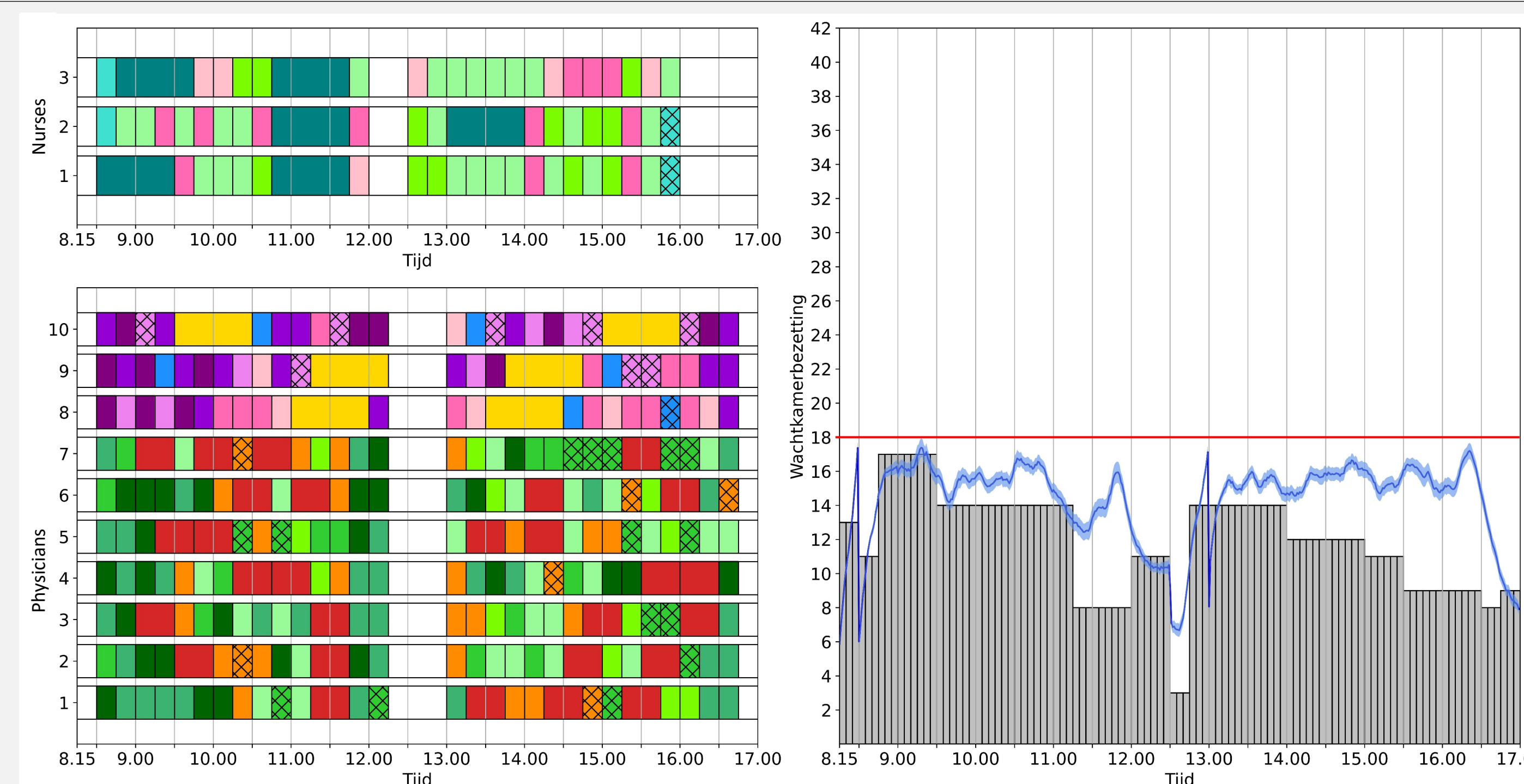So that the waiting area occupancy including unpunctuality drops below capacity

- This blueprint schedule is COVID-19-proof: the waiting area occupancy including unpunctuality of both patient and provider is below capacity all day

- This can be done without decreasing (i.e. cancellations) the number of appointments

- 88% of appointments can be scheduled in-person (so 12% is replaced by digital alternative)

Fig 3. COVID-19-proof blueprint schedule. See caption Fig. 2.

Conclusions

- We evaluated an intervention for blueprint design, enabling clinics to schedule as many in-person appointments as possible given a maximum waiting area capacity

- The intervention **showed effective in two case studies** (both more than 80% in-person appointments)

- The method is **generically applicable to a wide range of healthcare services** with elective care that schedule a (series of) appointment(s) for their patients beforehand

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