Forecasting & Evaluating Fatigue in a Shiftwork Setting

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Phase 1: Schedule Fatigue Analysis

April 2019

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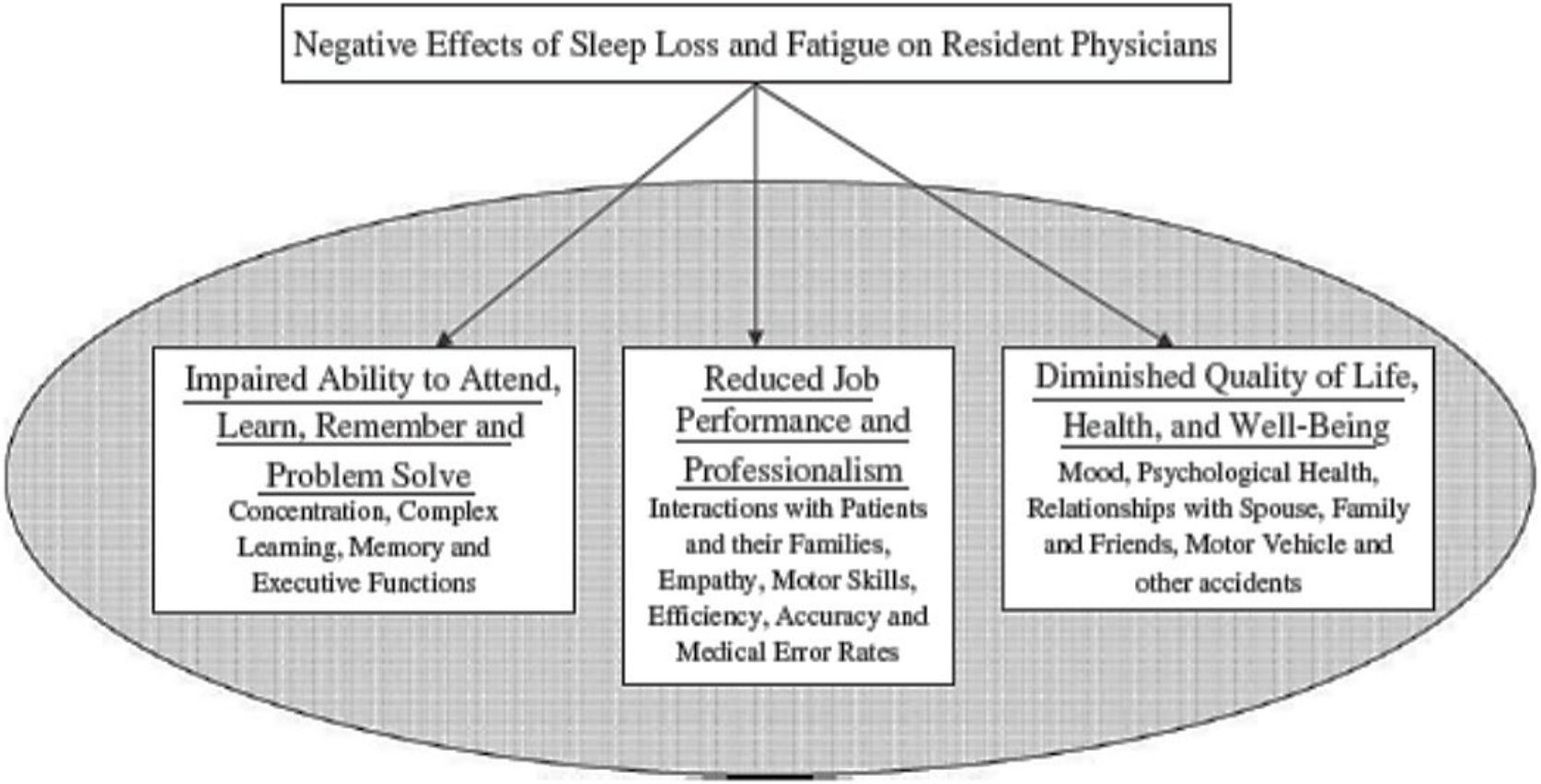
Why Worry About Fatigue in Residents?

- Patient Safety
- Resident Safety and Well-Being

Consequences of Sleep Loss and Fatigue in Residents



Sleep Med Rev. 2006 Oct;10(5):339-45

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Phase 1: Work Schedule Modeling

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Method

- Shift schedules from the Residency Management System
- 6-12 month schedules
- Analyzed by individual schedules and grouped by service lines
- 89 schedules
- Estimated sleep using assumptions based on round the clock operations
- Evaluated effectiveness relative to a criterion line of 77
- Evaluated with no naps and varied hypothetical naps from 30 to 90 min
  - Shifts between 12 and 18 hours – one nap
  - Shifts longer than 18 hours – two naps

Overall Performance Estimates

Model Outputs for No-Nap and Nap Conditions

	No Naps	30 min. naps	60 min. naps	90 min. naps
Avg. Effectiveness	88.29	89.40 (1%)	90.75 (3%)	92.01 (4%)
Avg. minimum Effectiveness	56.44	59.52 (5%)	63.81 (13%)	66.86 (18%)
Avg. minimum Reservoir	60.83	64.99 (7%)	68.75 (13%)	71.39 (17%)
Avg. % below criterion (77)	9.76	9.20 (-6%)	8.26 (-15%)	6.35 (-35%)

Note: Percent change from no-nap condition shown in parentheses.
Note: Reservoir refers to the sleep debt in a schedule. Lower scores indicate more sleep debt.

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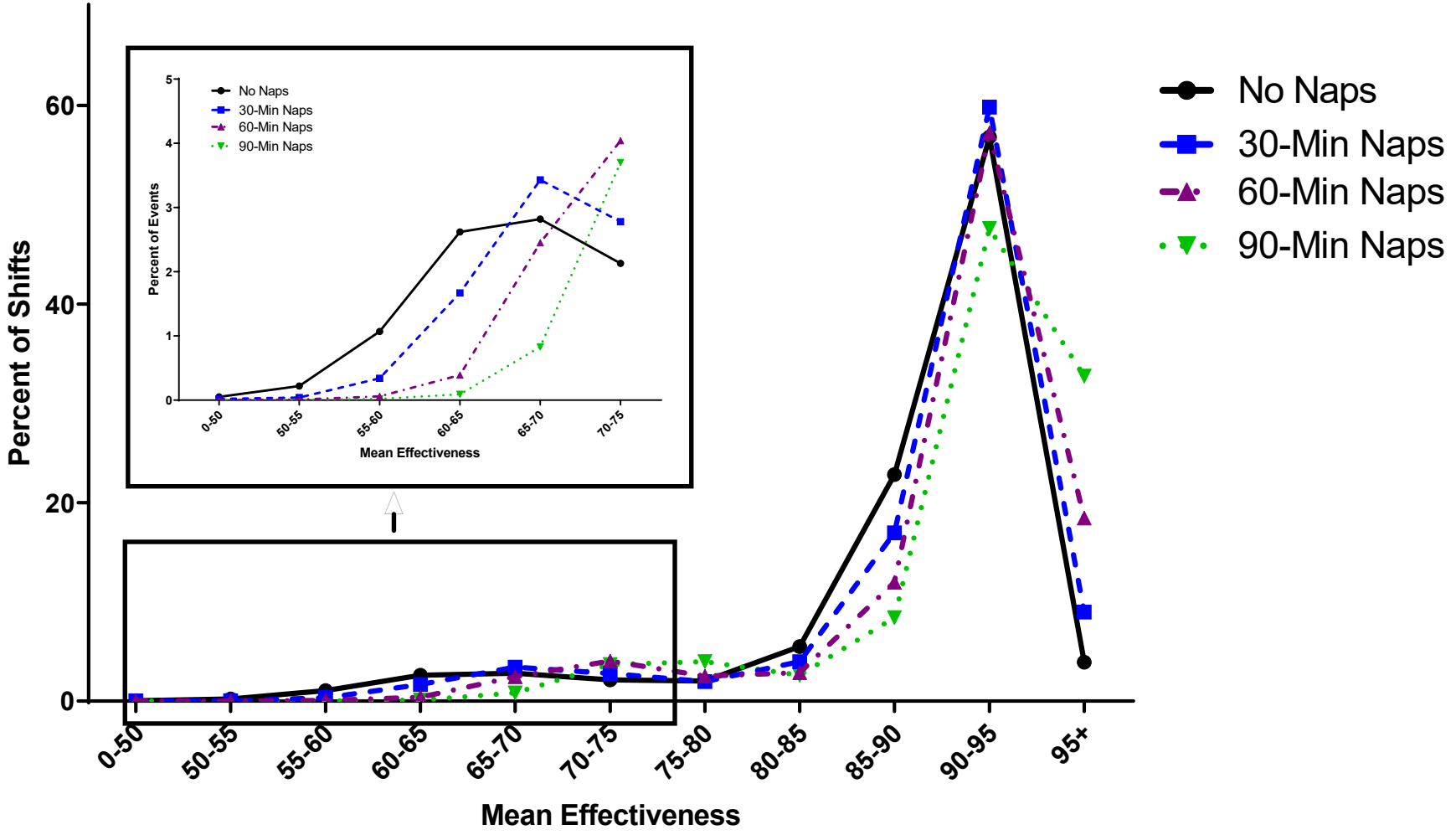
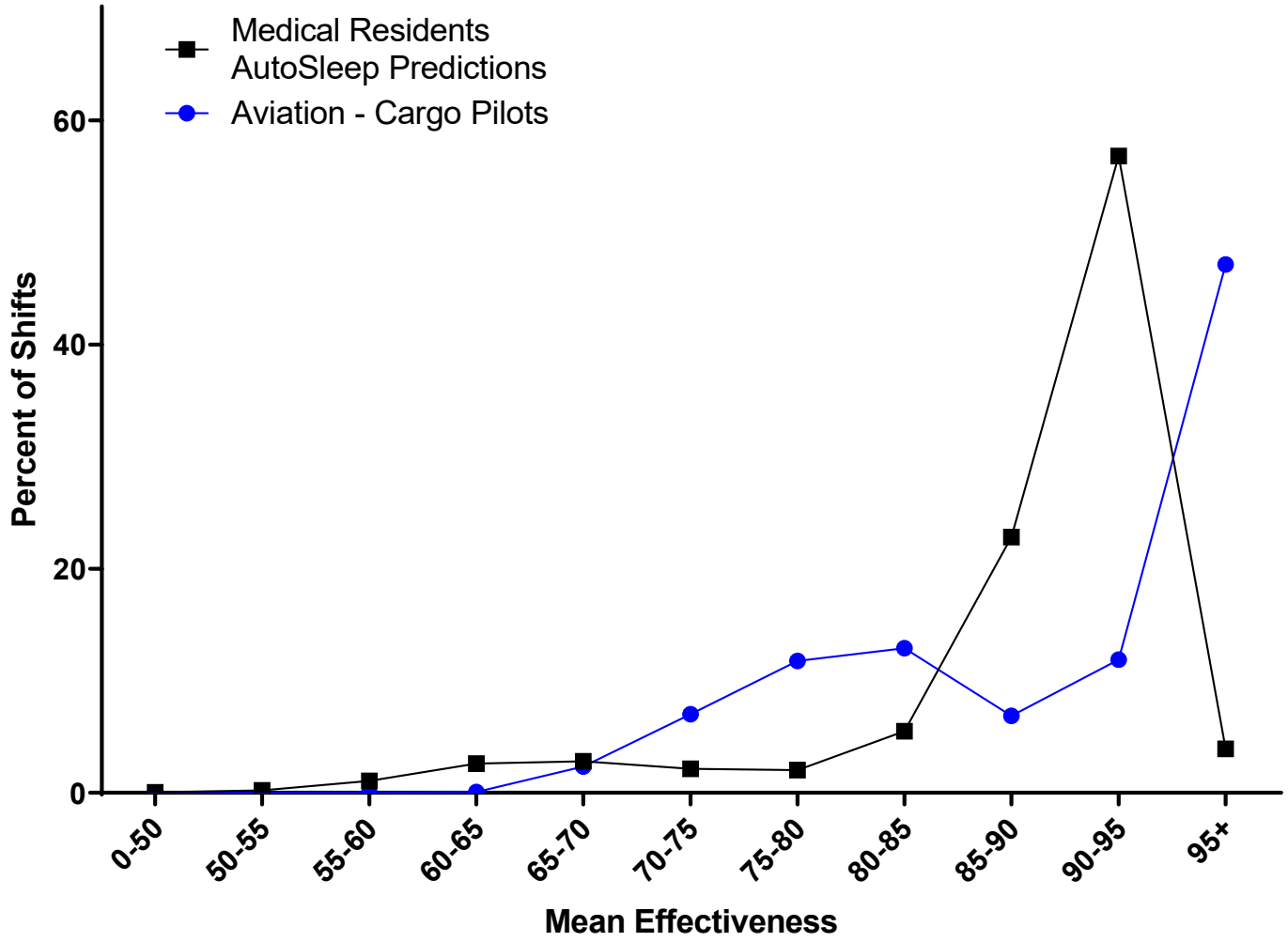
Effectiveness Profile by Nap Condition



Comparative Cargo Pilot Profile

- *Note that the FAA considers 77 the benchmark for fatigue*



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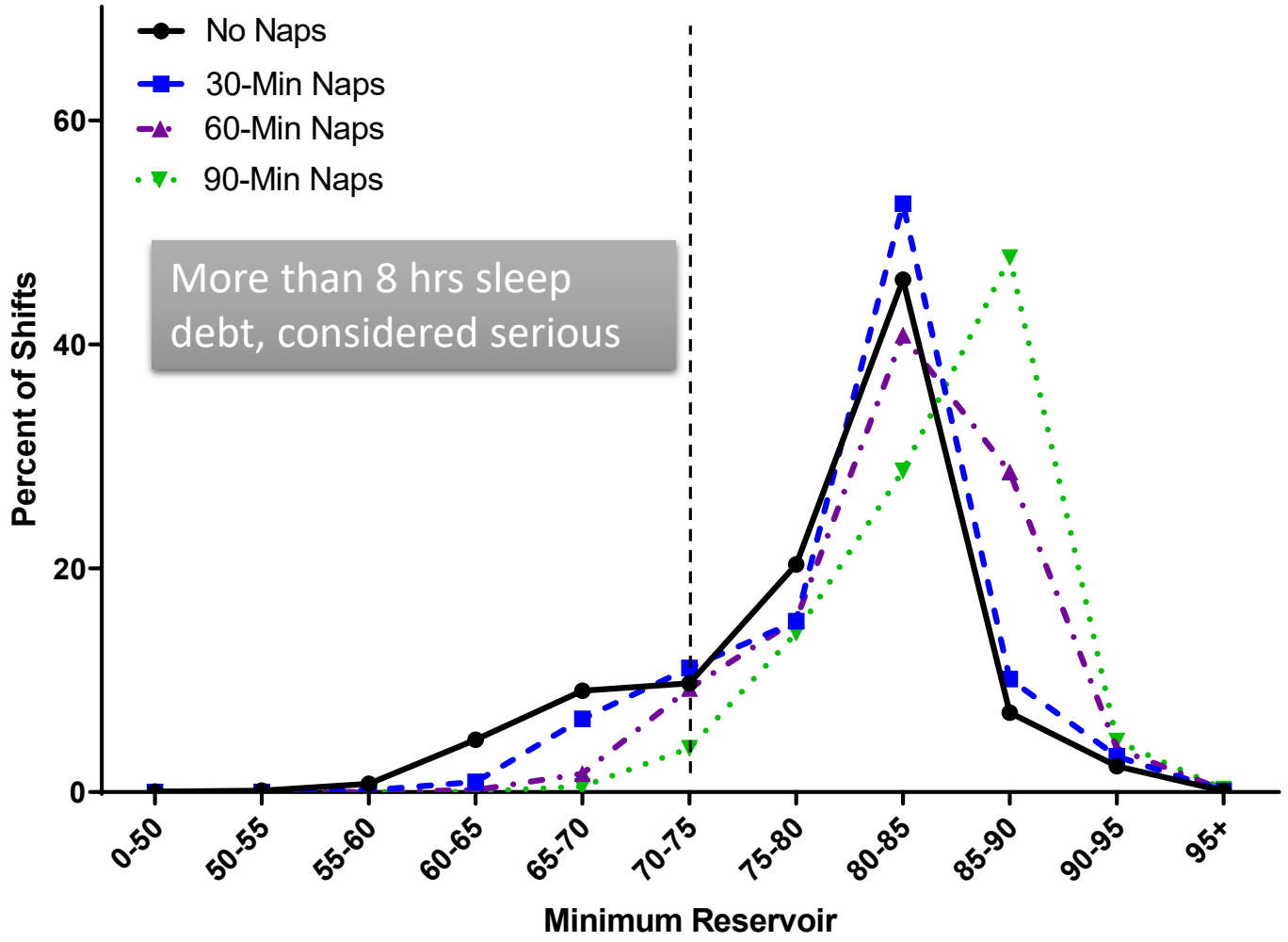
Minimum Sleep Reservoir by Nap Condition



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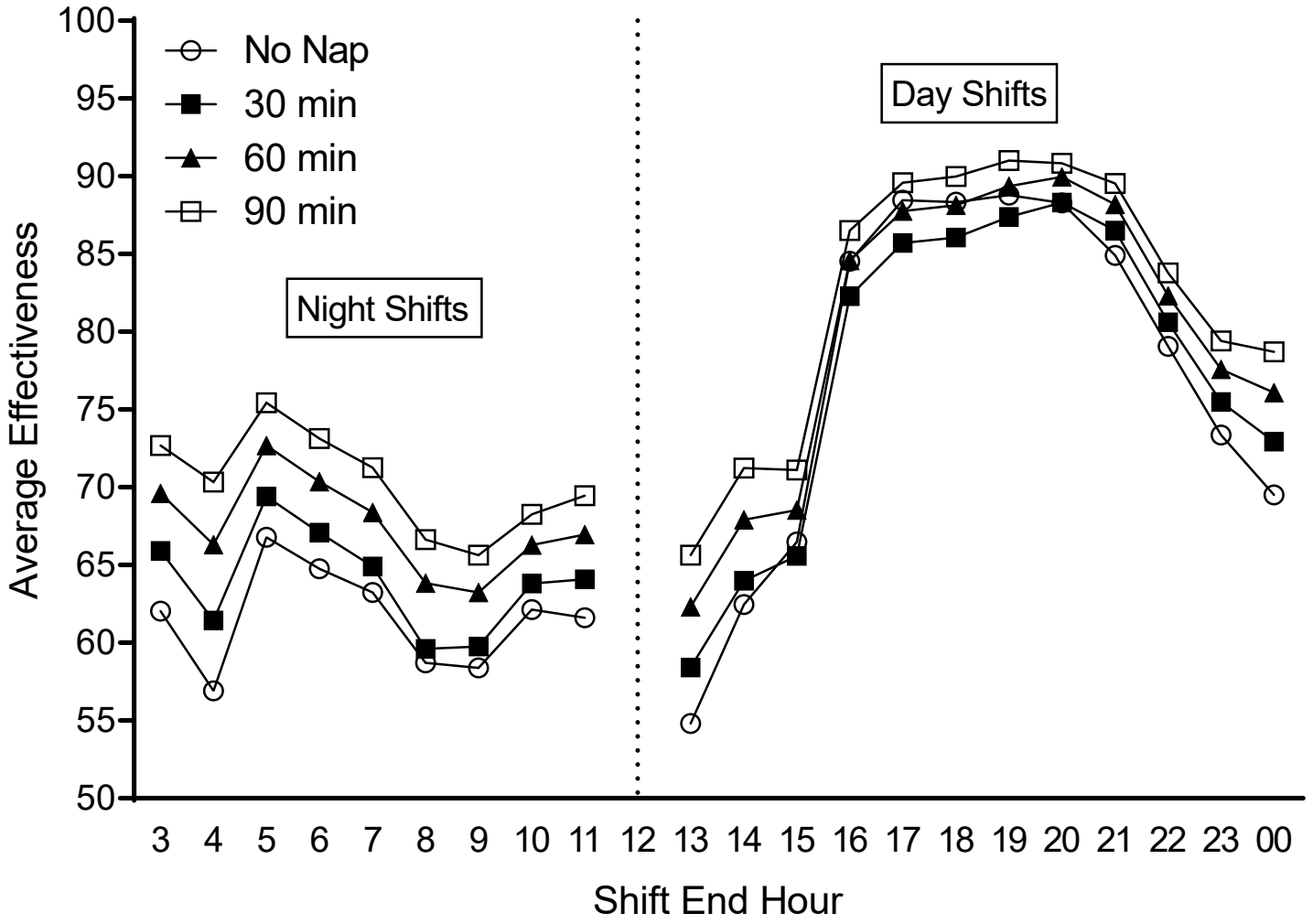
Effectiveness by Time of Day (Shift End Hour)



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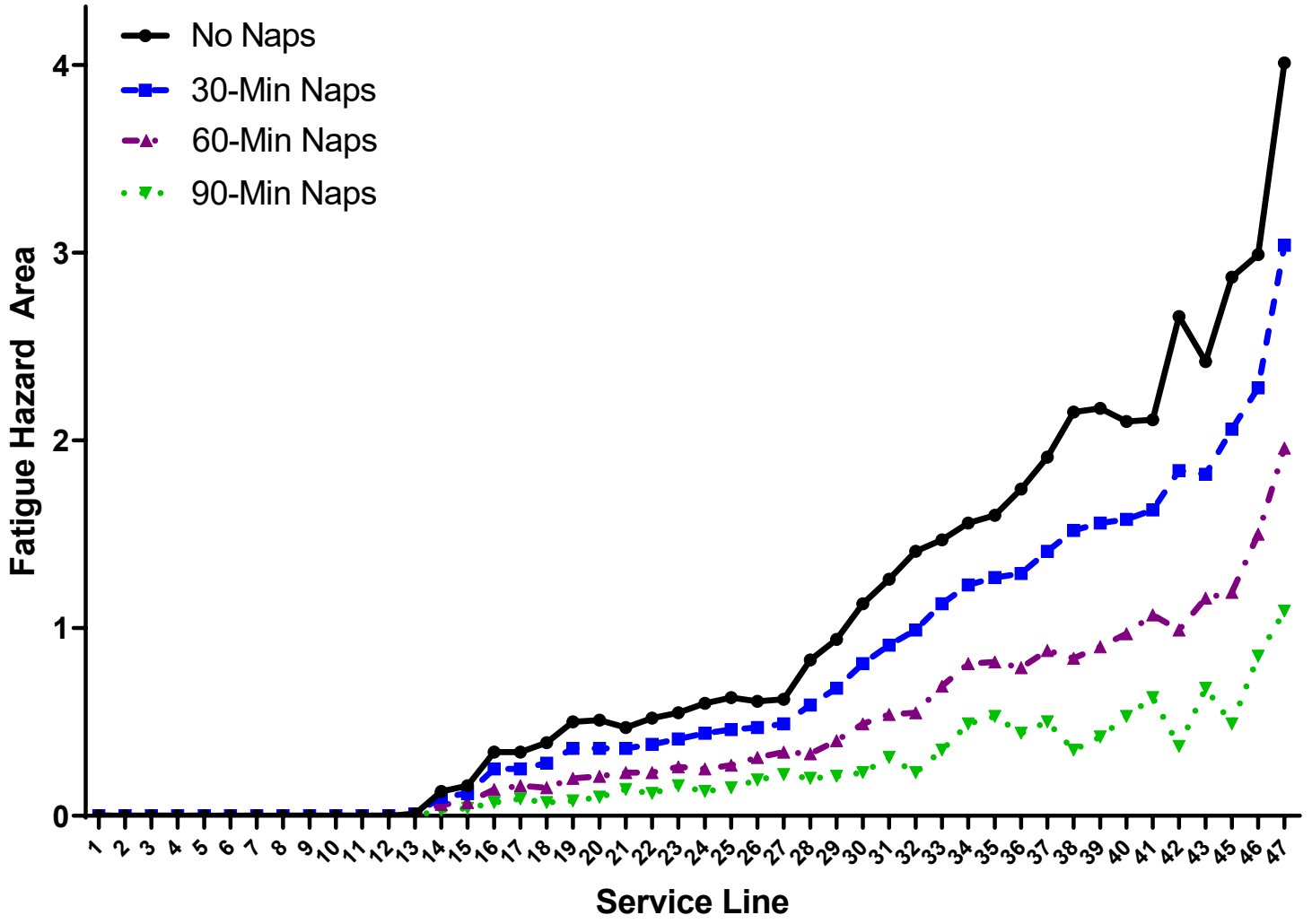
- *> 0 without naps*

Fatigue Hazard Area by Service – Nap Impact



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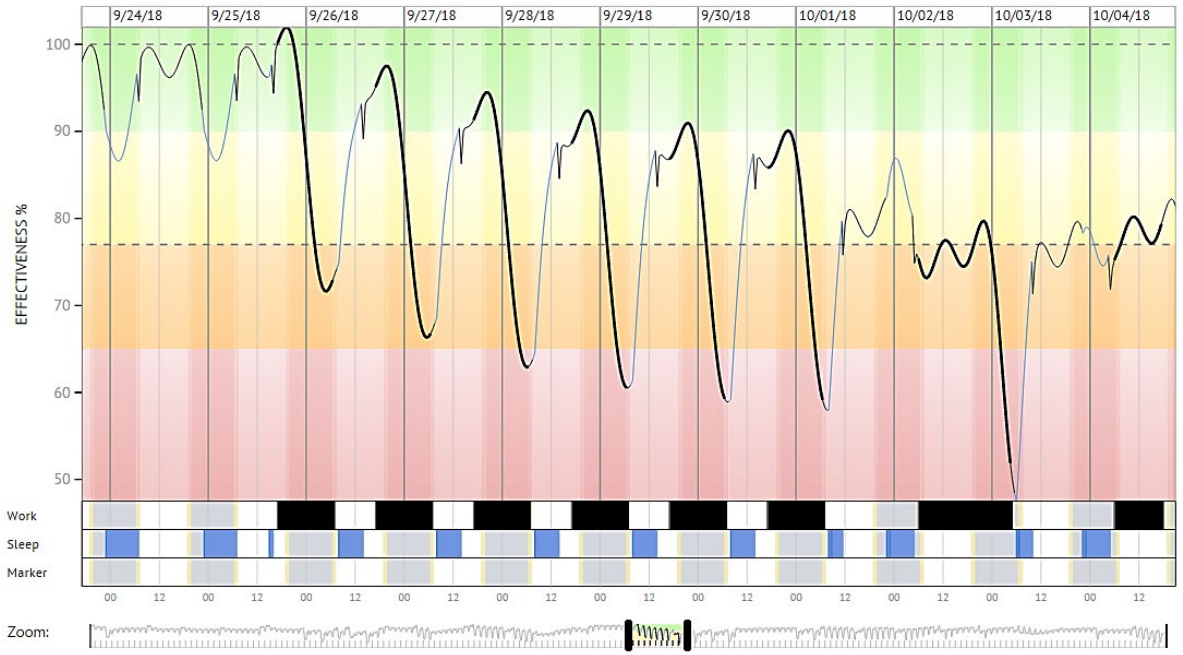
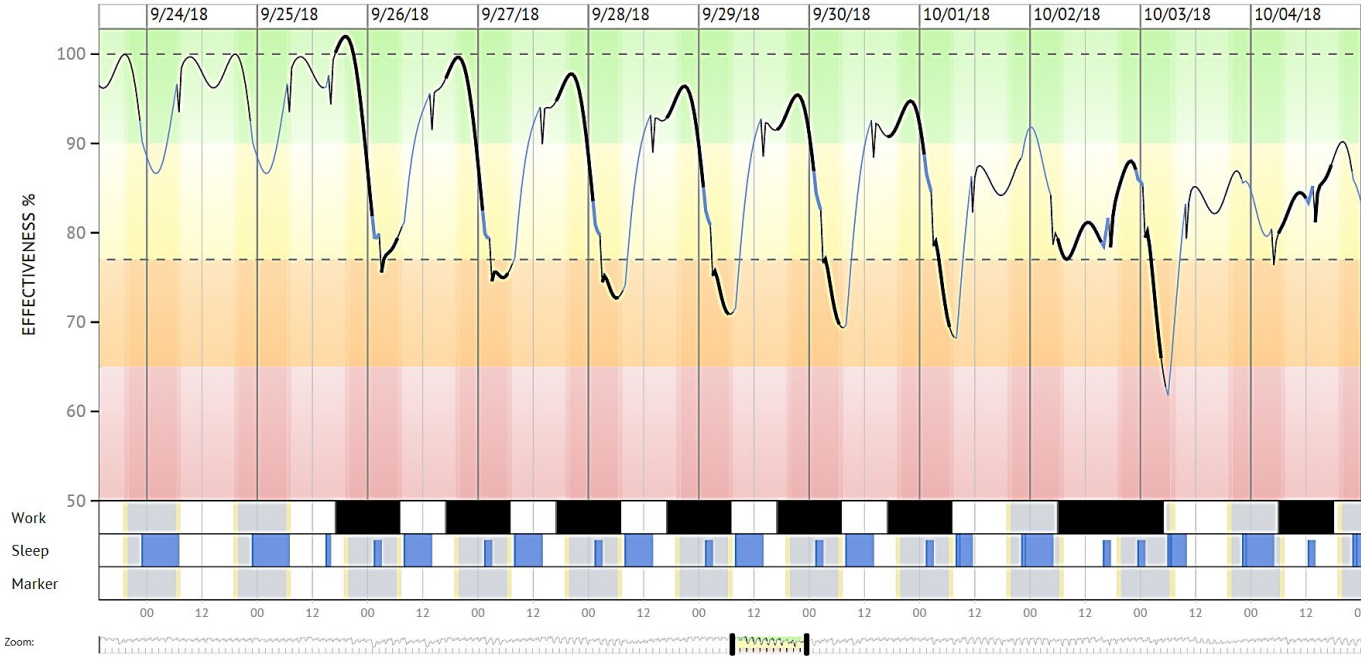
Comparison of No Naps to 90-min Naps

No Naps



90 min Naps – when possible



In this case, naps eliminate time in the red (< 65) and most time below 70

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Phase 2: Resident Fatigue Analysis

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Reminder: Phase 1 Results

- There is fatigue risk in medical resident schedules that should be mitigated
- Hypothetical naps help to reduce this risk
- The longer the schedule, the greater the fatigue risk
- Performance is especially low during night shifts
- Some services lines (Trauma, Night Float) have increased fatigue risk compared to other service lines

Phase 1 included only schedules. Actual resident sleep is necessary to confirm our predictions.

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Phase 2: Resident Sleep Modeling

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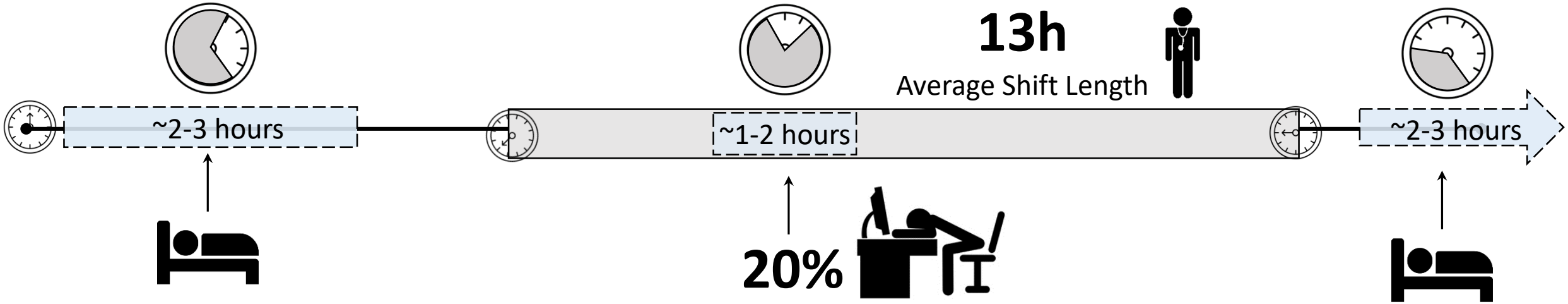
Method

- Resident sleep was monitored using our Zulu watches
  - Watches use actigraphy (movement) to determine sleep periods
- Shift schedules from the Residency Management System
- 2-month schedules
- Analyzed by individual schedules and grouped by service lines
- 24 Participants
- Evaluated effectiveness relative to a criterion line of 77
- Ran Phase 2 schedules with same AutoSleep settings as Phase 1

Residents' Sleep on an Average Work Day

70%

Days during Phase 2 When Residents Worked a Shift



13h

Average Shift Length

Twice

Times Residents Slept Each Day

20%

Days during Phase 2 When Residents Slept on Shift

Average Nap = 1h42m
Interquartile Range: 42m to 2h15m

5h 45m

Amount Residents Slept in One Day*

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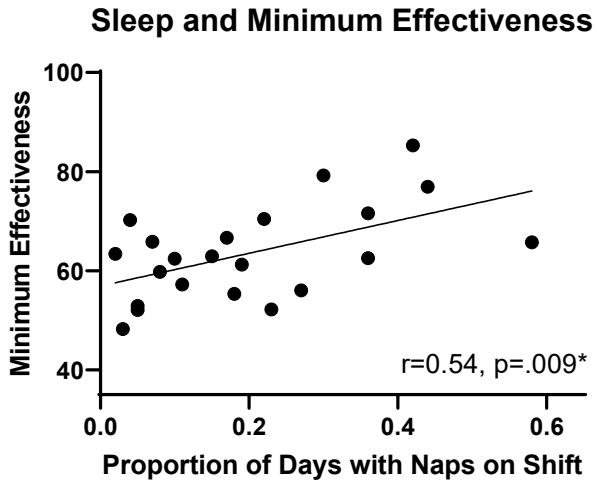
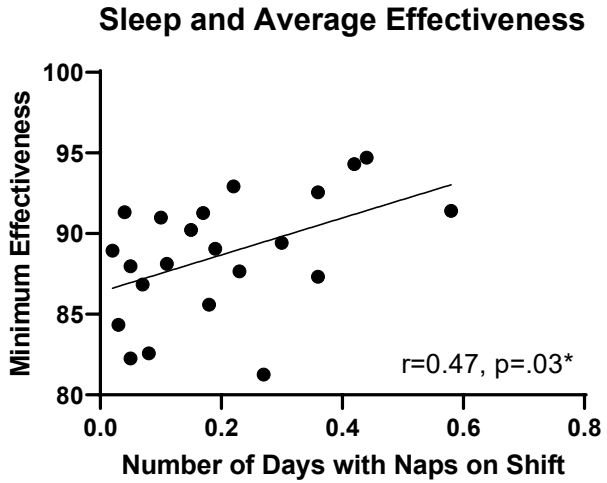
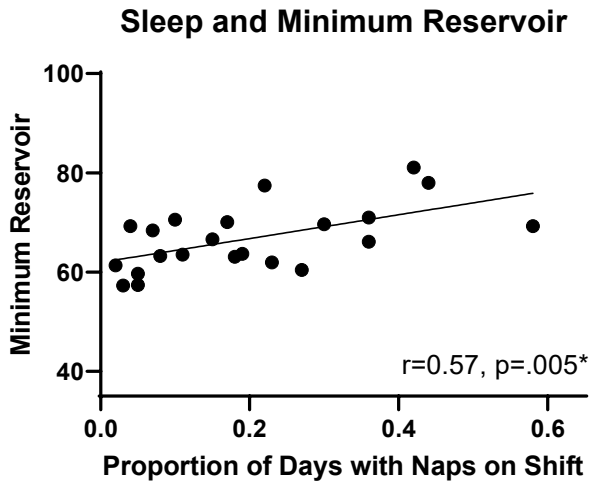
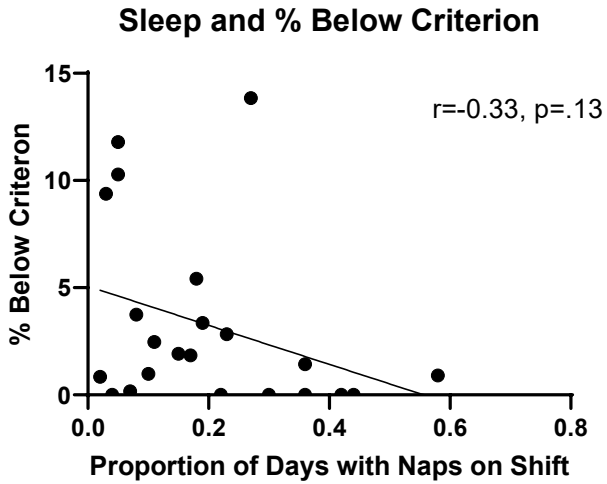
How do naps affect predicted performance?









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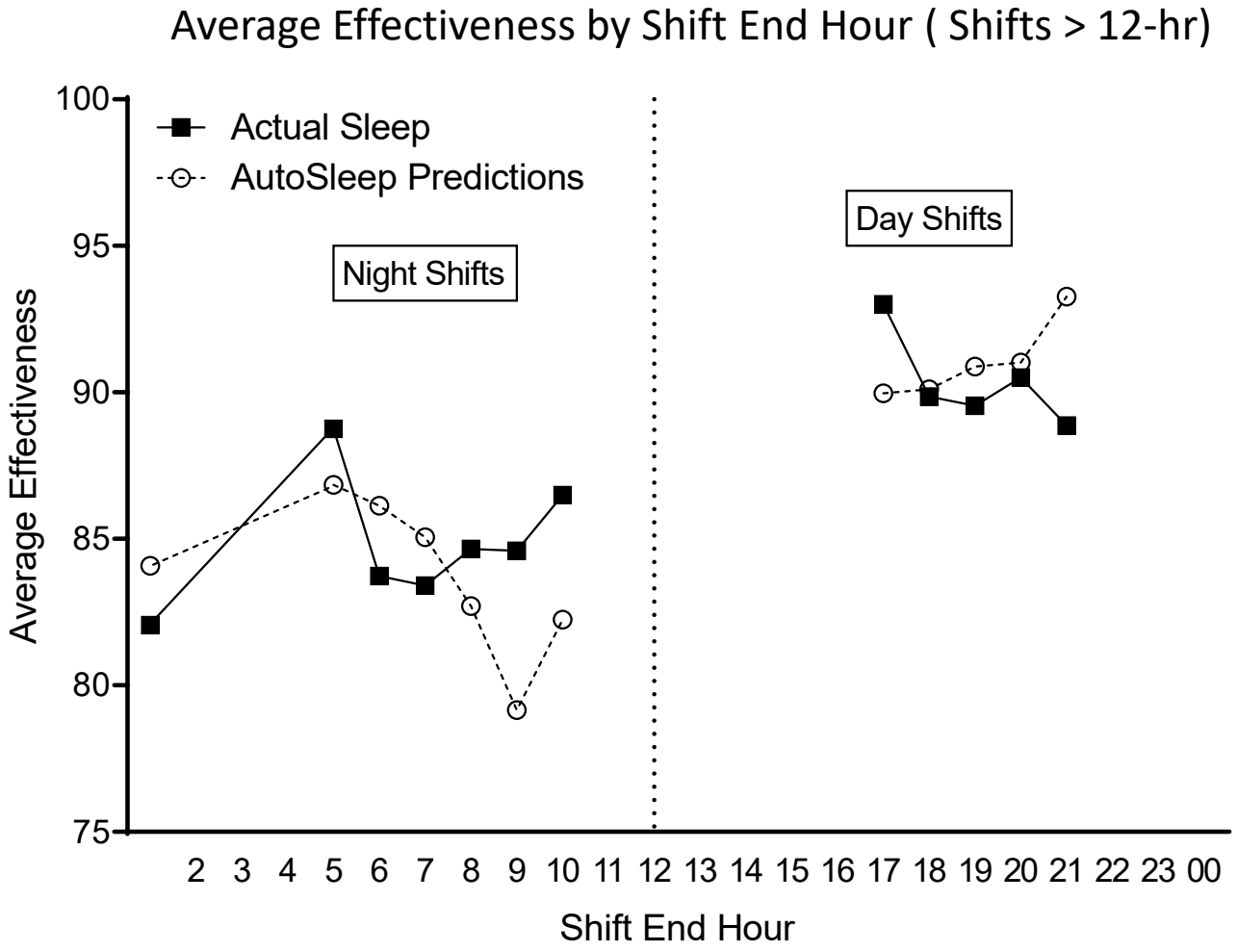
Effectiveness by Time of Day



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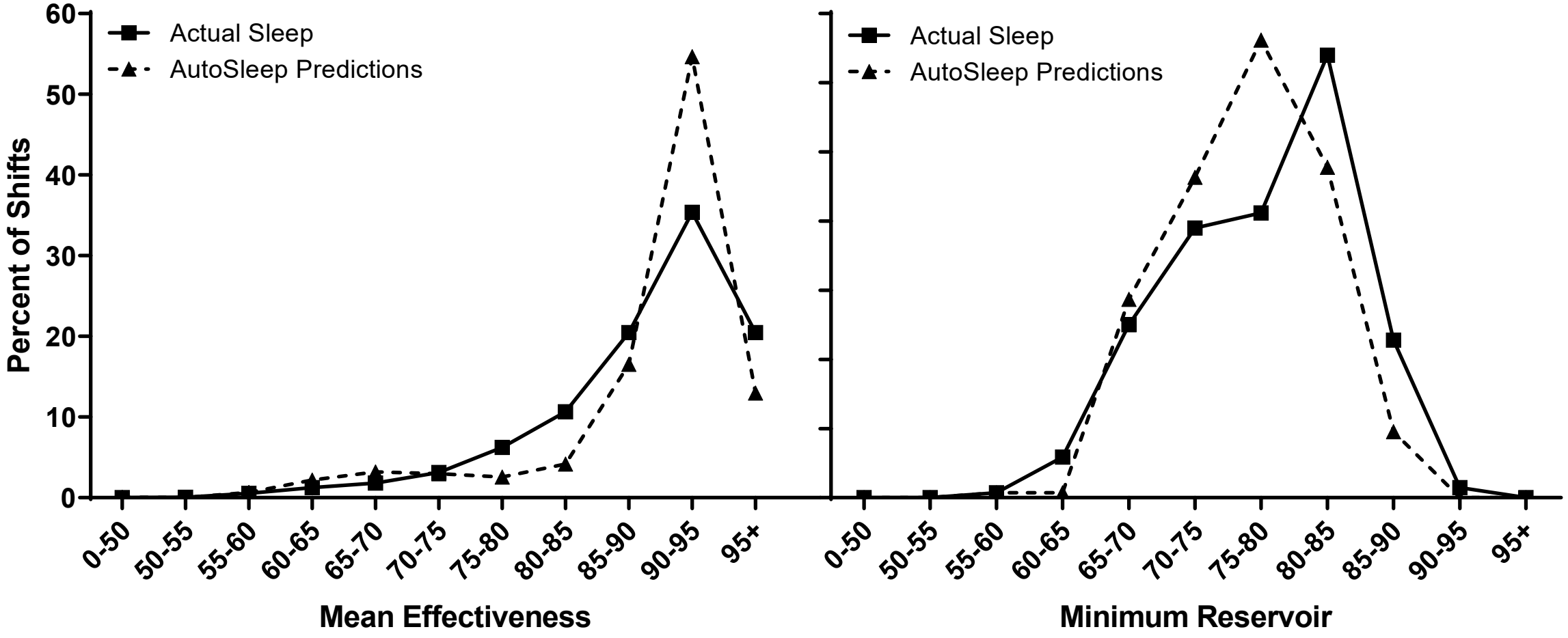
Effectiveness & Reservoir Distributions



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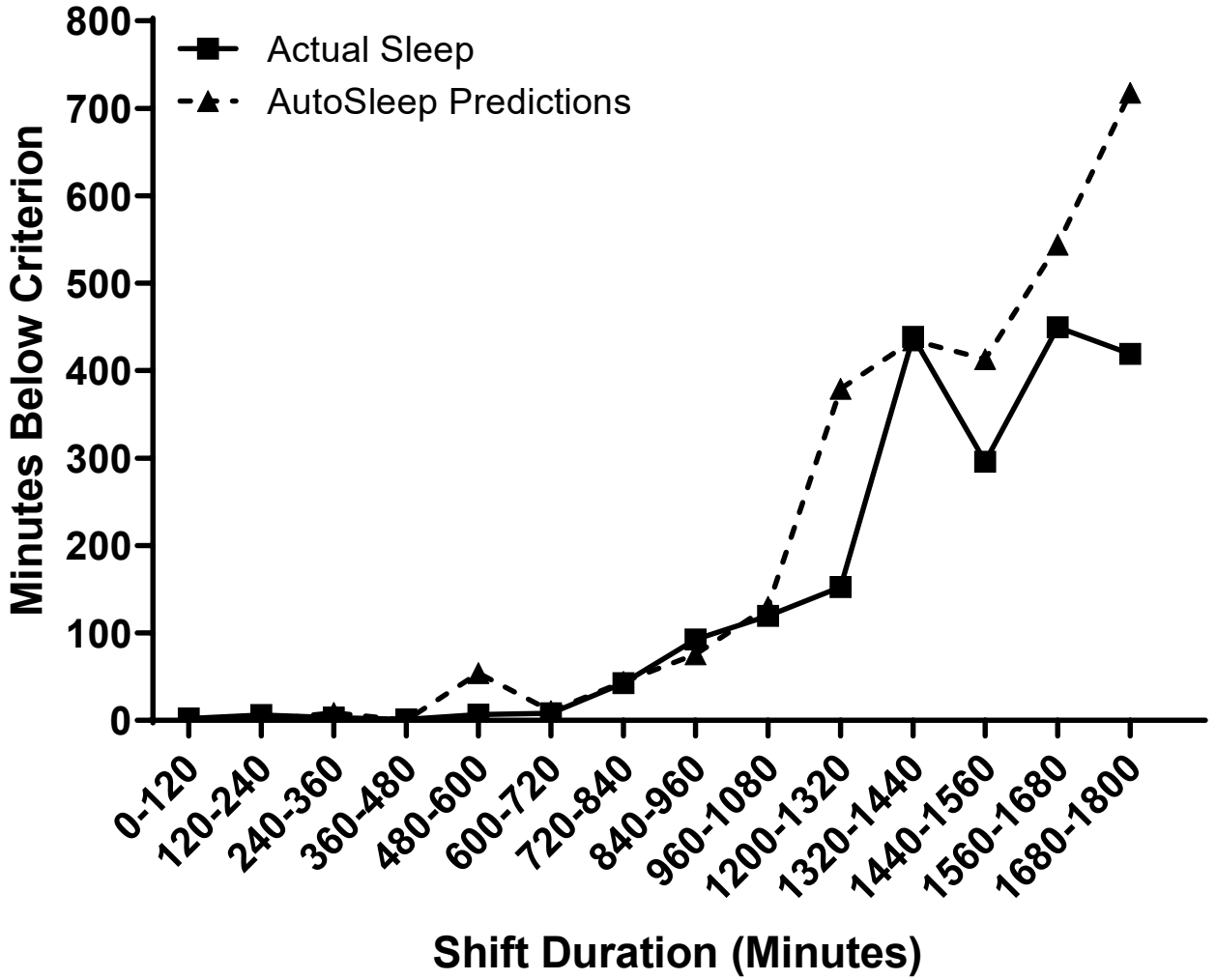
Minutes Below Criterion



Harmonized SAFTE-FAST AutoSleep

- Shifted Awake Zone One Hour Later, from 1600-1900 to 1700-2000.
- Removing “advance bedtime” on nights before early day shifts.
- Added in 30-min naps, as in Phase 1.

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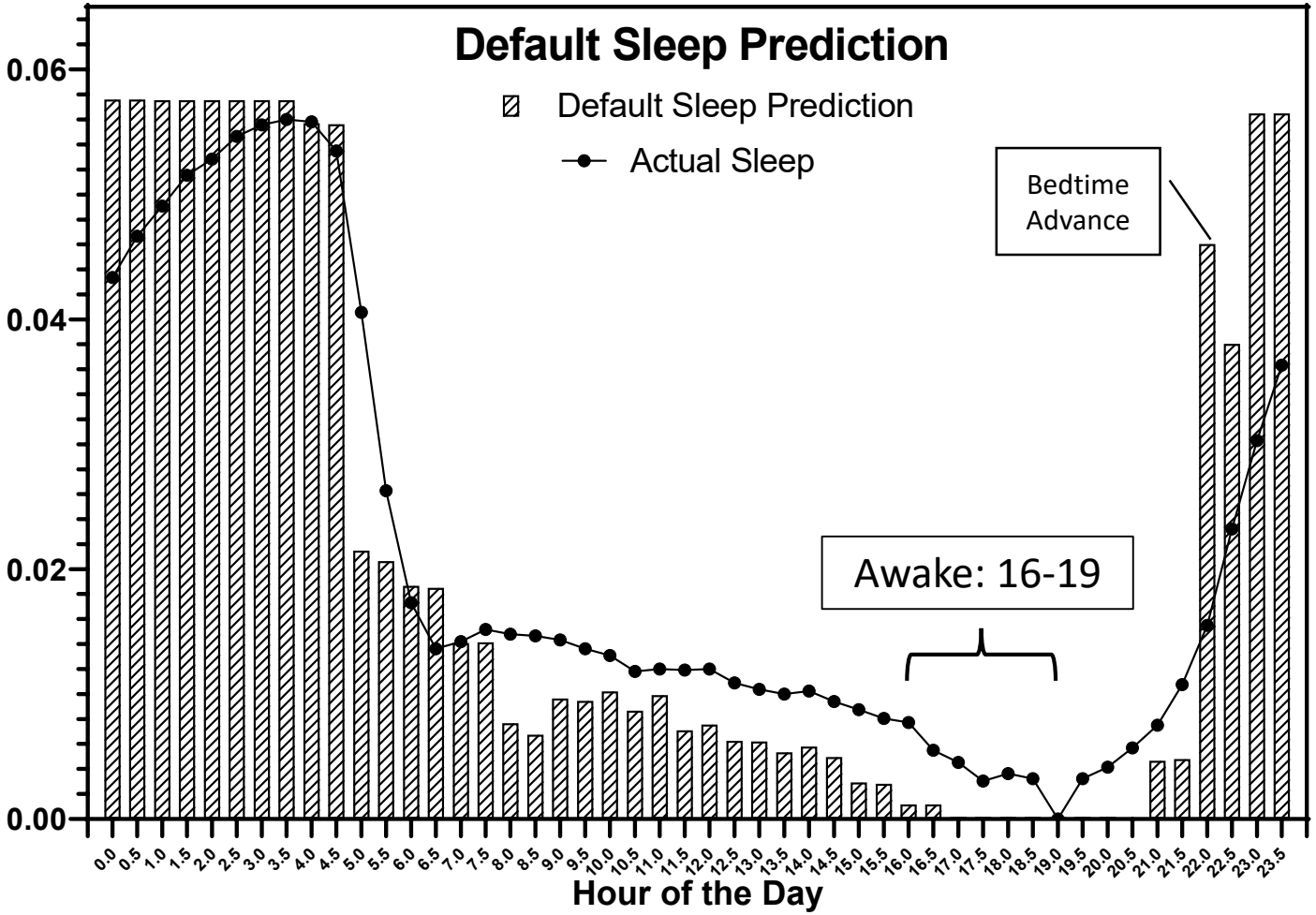
Actual Sleep vs Estimated Sleep - Time of Day Pattern



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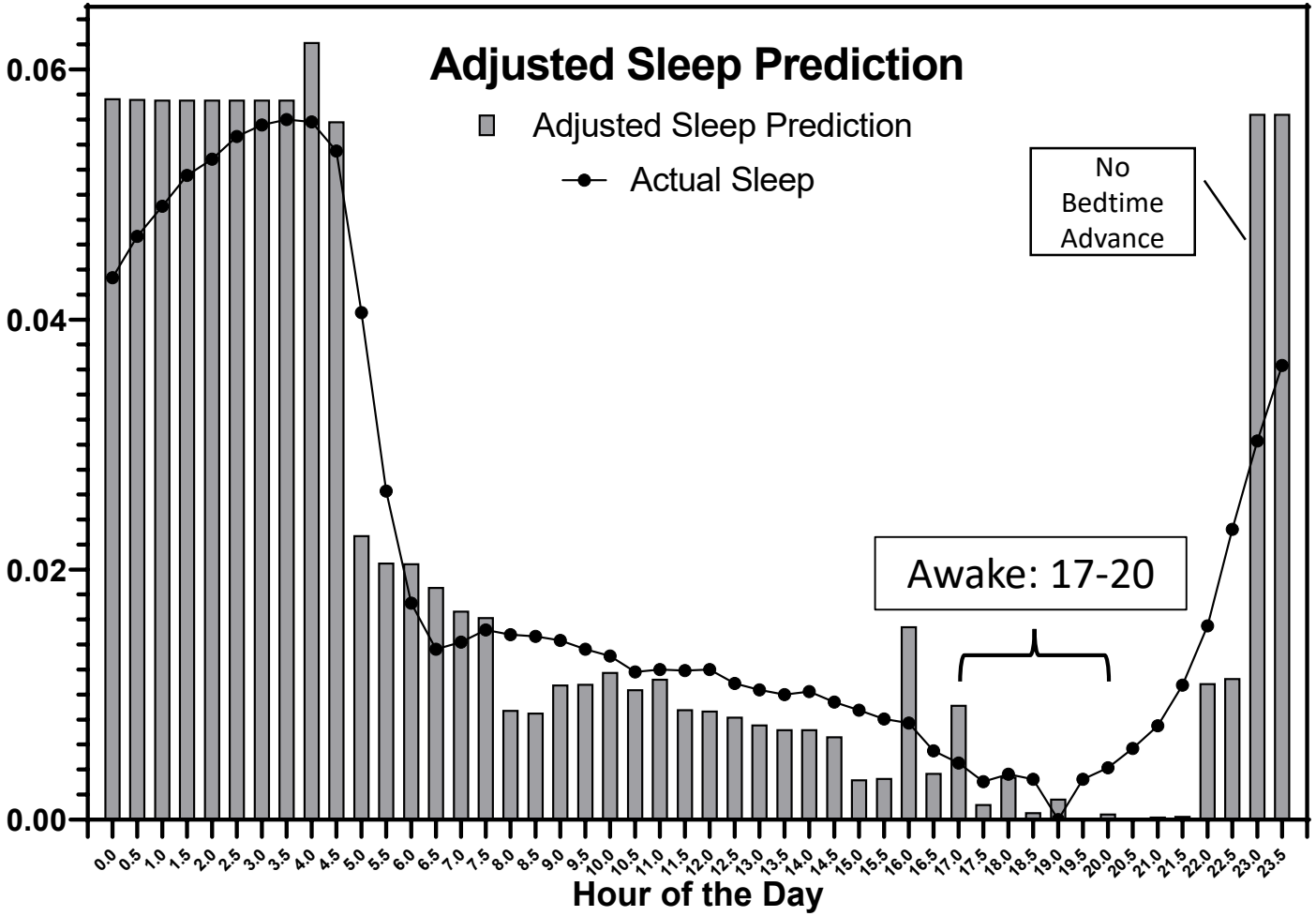
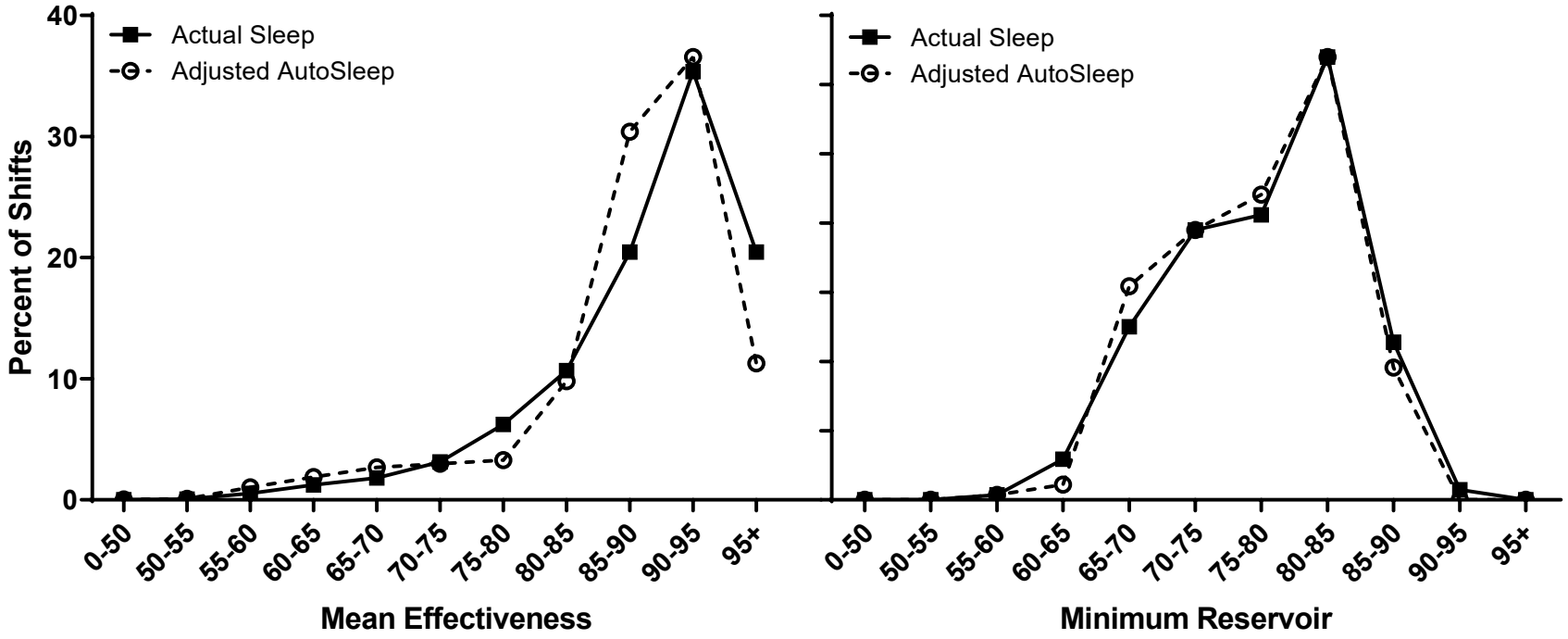


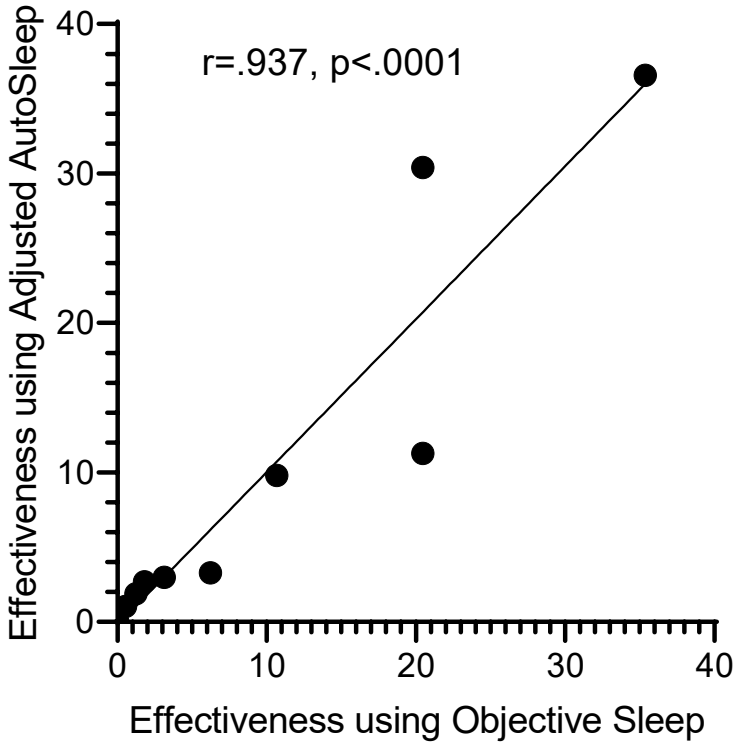
Actual vs AutoSleep

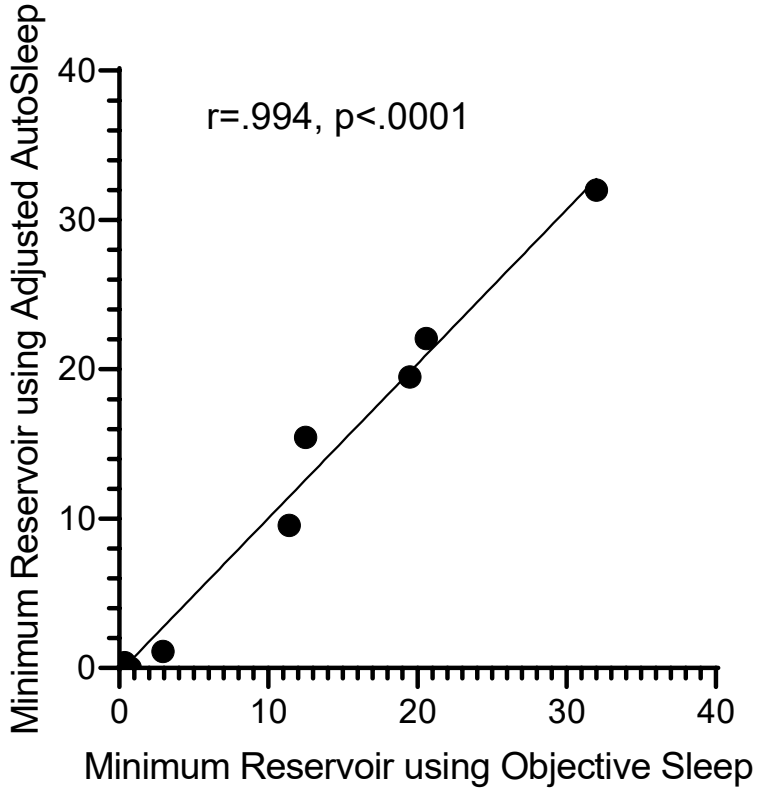
- 30-Min Naps, No Advance Bedtime, and Awake Zone Change



% Shifts Effectiveness & Minimum Reservoir

- AutoSleep vs Objective Sleep





Conclusions

- Residents have high levels of daytime sleepiness and have room to improve their sleep hygiene.
- SAFTE-FAST does an excellent job of modeling resident sleep.
- SAFTE-FAST can be used to optimize schedules to reduce risk for fatigue
- Improvement of resident sleep at home and the increase of naps will also be beneficial.

Take-away

- SAFTE-FAST is very effective as a predictor of fatigue under shift work schedules.
- Planned and actual schedules can be modeled for fatigue hazard.
- The benefits of mitigations can be modeled and objectively evaluated.
- SAFTE-FAST in conjunction with a shift work scheduling system could be an effective component of a shiftwork FRMS.

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Questions?

Conclusion of Presentation