Lessons from the Darkness: What We Can Learn from 5000+ Days and Nights of Pilots' Sleep, Fatigue and Performance Data

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Background

- Research involving airline pilots has been accumulating for more than 50 years with many categories of insight
- Short- versus long-haul impacts on sleep, fatigue, etc.

  Accid Anal Prev. 2017 Jan; 98:320-329

  Sleep, alertness and alertness management among commercial airline pilots on short-haul and long-haul flights.

  Sallinen M, Sihvola M, Puttonen S, Ketola K, Tuori A, Härmä M, Kecklund G, Åkerstedt T

  Short- versus long-haul impacts on sleep, fatigue, etc.

- In-flight sleep in long and ultra-long haul operations

  J Sleep Res. 2013 Dec; 22(6):697-706

  In-flight sleep, pilot fatigue and Psychomotor Vigilance Task performance on ultra-long range versus long range flights.

  Gander PH, Signal TL, van den Berg MJ, Mulrine HM, Jay SM, Mangie J

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Background

- Layover sleep following Eastward versus Westward travel

  Aviat Space Environ Med. 1986 Dec; 57(12 Pt 2): B10-3

  International cooperative study of aircrew layover sleep: operational summary.

  Graeber RC, Dement WC, Nicholson AN, Sasaki M, Wegmann HM

- The cognitive/mental value of breaks on the flight deck

  Aviat Space Environ Med. 2002 Jul; 73(7): 654-64

  Controlled breaks as a fatigue countermeasure on the flight deck.

  Neri DF, Oyung RL, Colletti LM, Mallis MM, Tam PY, Dinges DF

- Effects of consecutive duty periods on self-report and objective performance data

  Aerosp Med Hum Perform. 2019 May 1; 90(5): 466-474

  Risk of Fatigue Among Airline Crew During 4 Consecutive Days of Flight Duty.

  Goffeng EM, Wagstaff A, Nordby KC, Meland A, Goffeng LO, Skare Ø, Lilja D, Lie JS

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Background

- However, relatively little is known about sleep, fatigue and performance in other parts of the industry

- This includes fixed and rotary wing aeromedical services, fixed and rotary wing fire fighting operations, rotary wing offshore transfer/transport, emergency service air support (e.g. police), etc.
- **Are patterns universal (human) or context-dependent?**

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Context

- 10 mission profiles | 7 European countries | 4 years
- Fixed- & Rotary-Wing Mission Critical Services

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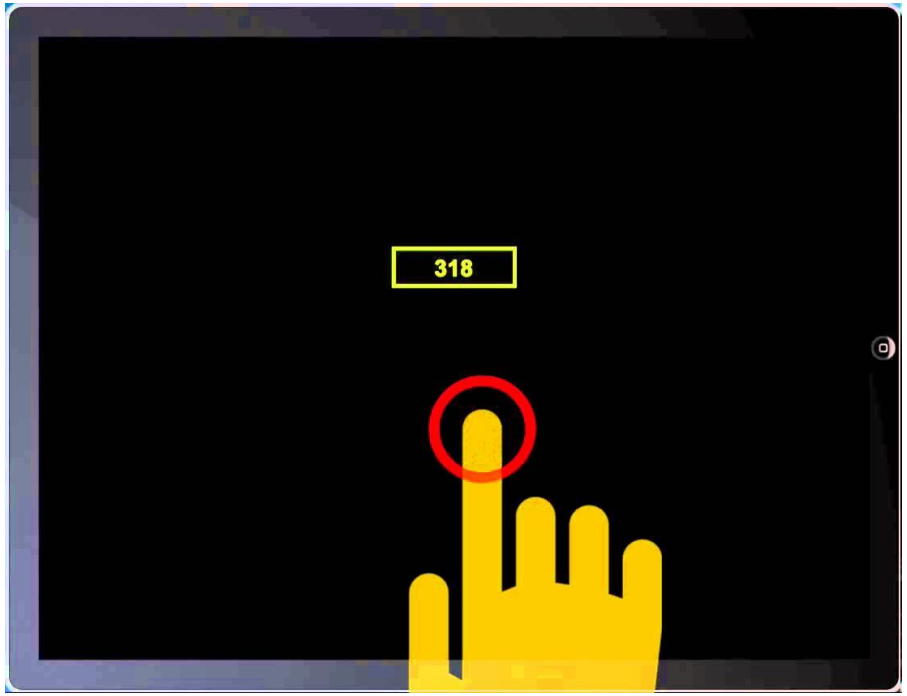
Study design

- Naturalistic design: the vast majority of activity completed by volunteer participants was their normal role including duty times
- Participants were asked to collected data for 21 days and nights both at work and away
- Sleep was measured objectively using wrist-worn actigraphs and self-reports using diaries (either iPad or paper-based)
- Self-reported fatigue ratings and KSS scores were provided in the diaries before and after individual sleep periods

Study design

- As a measure of objective cognitive/mental performance capacity participants were also asked to contribute 5-8 5-minute Psychomotor Vigilance Task (PVT) tests per day while on duty and/or off duty



- The capacity to do these tests on duty was much less available in some operations than others (e.g. rotary wing offshore transport, fire fighting)

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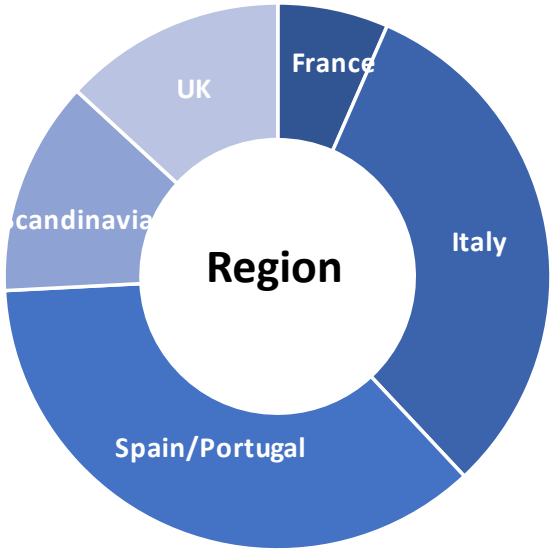
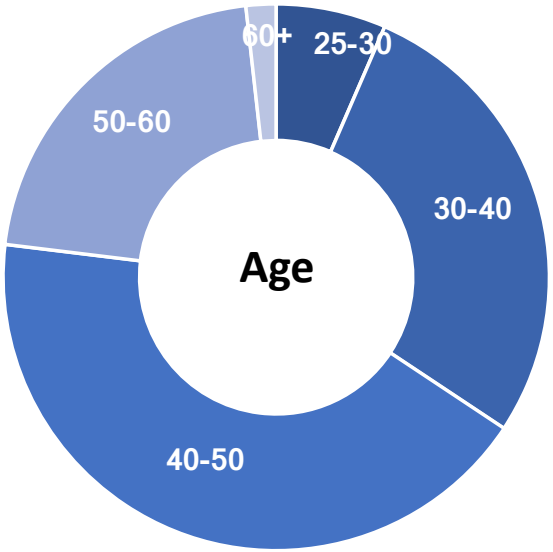
Studies and Demographics

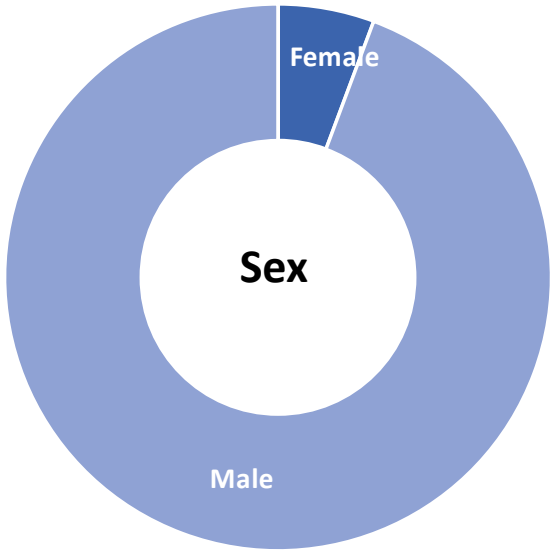
Region	Start month	Daylight h	Operation	Focus Roles	Mode	24h Roster	Consecutive workdays
Italy	Nov	10:13	HEMS	Pilots, Crew	On-Call	Y	12
Italy	Jun	15:06	HEMS	Pilots, Crew	On-Call	Y	8
Italy	July	15:05	HEMS	Technicians	Continuous	Y	8
Italy	Jan	09:15	HEMS	Technicians	Continuous	Y	15
Italy	Aug	14:10	Fire	Pilots, Crew	Continuous	N	6
Scandinavia	Apr	14:00	HEMS	Pilots, Crew	On-Call	Y	8
UK	Jan	08:00	HEMS	Pilots, Crew	On-Call	Y	4
Spain	Mar	11:30	HEMS	Pilots, Crew	On-Call	Y	5
UK	Feb	09:20	Transfers	Pilots, Crew	Continuous	N	8
France	May	14:50	HEMS	Pilots, Crew	On-Call	Y	12
Spain	Aug	14:10	Fire	Pilots, Crew	Continuous	N	24
Spain	Sep	12:55	SAR	Pilots, Crew	On-Call	Y	11
Portugal	5May	14:00	HEMS	Pilots, Crew	On-Call	Y	4

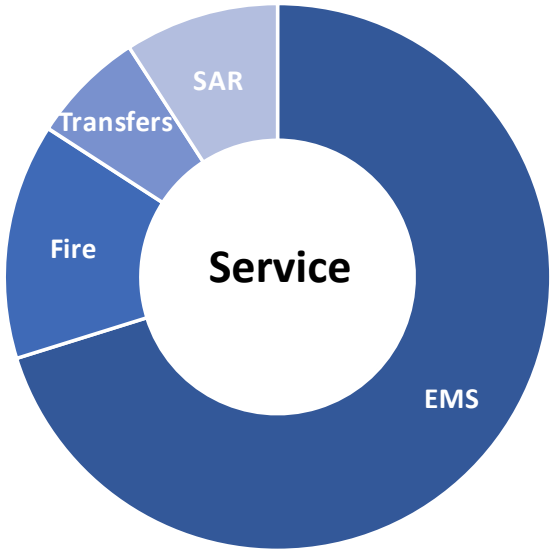
HEMS=Helicopter Emergency Medical Service; Fire=Firefighting; Transfers=Air Transport; SAR=Search and Rescue

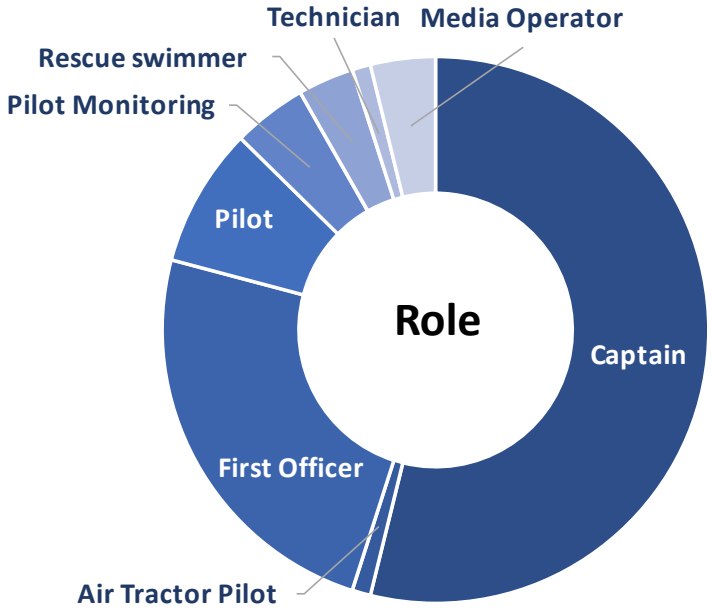
Sample Description











- Participants = 210
- Sleep Periods = 3,090
- Duty Periods = 2,707
- PVT Trials = 11,130

Statistical Analysis (Initial)

Descriptive and univariate analyses

- Describe distributions of sleep and work in each of the studies
- Describe and test differences by season
  - For Italy HEMS Pilots and Technicians we have data collection in Winter and in Summer
- Examine sleep and response times on duty days versus days off
- Following these initial analyses, we will examine multivariate models (to identify measured differences while controlling for the influence of other variables)

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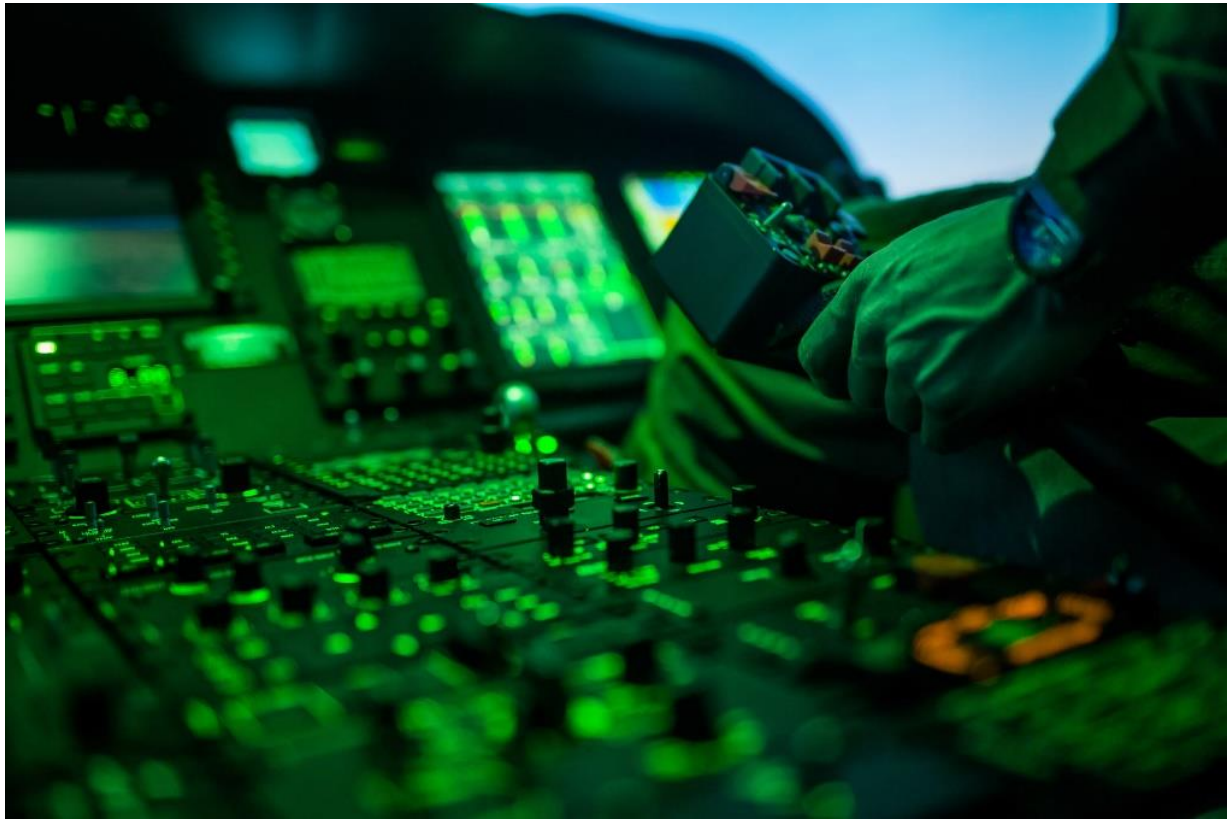
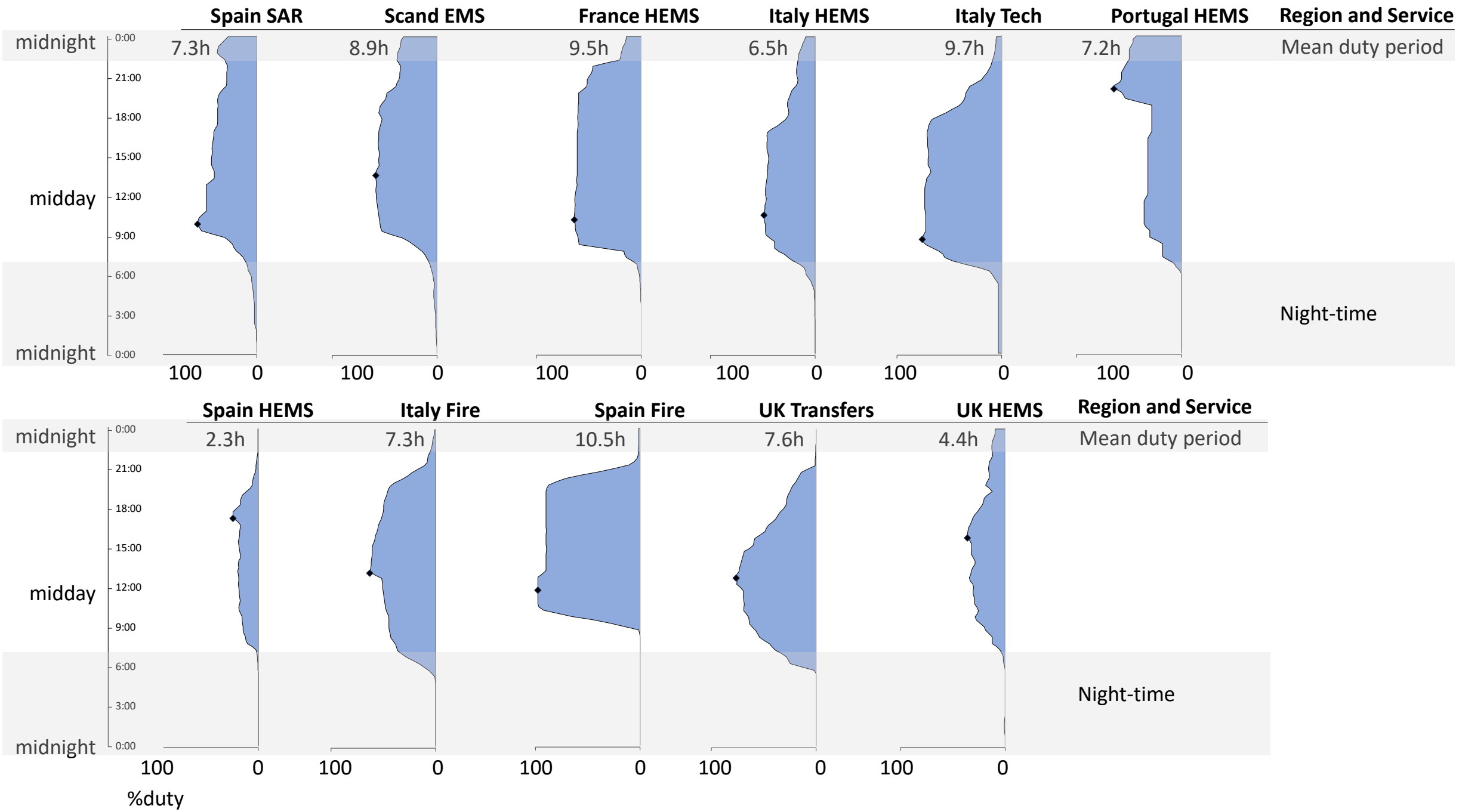
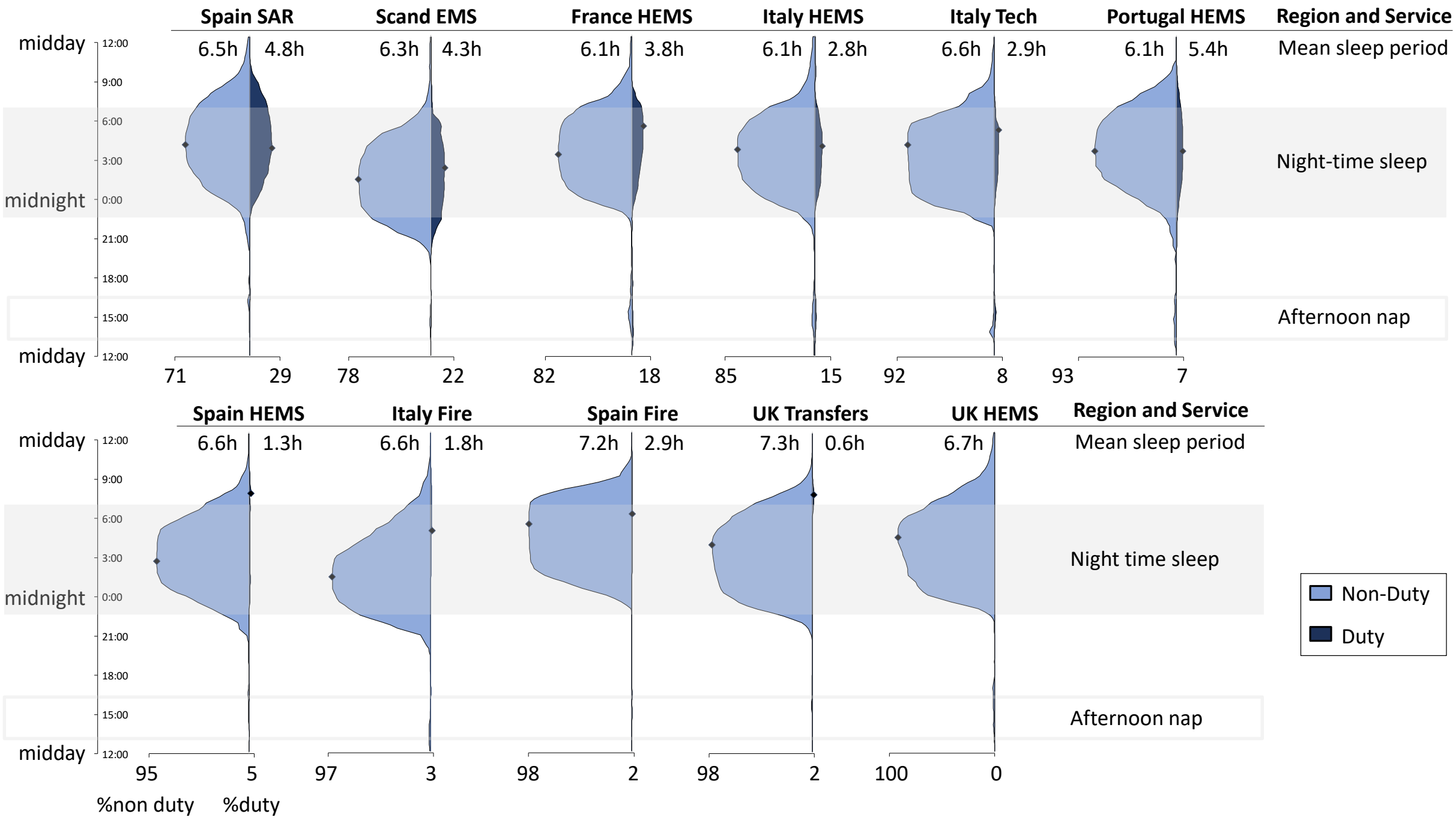
Finding 1: The overwhelming majority of work occurred during the day even in 24h operations



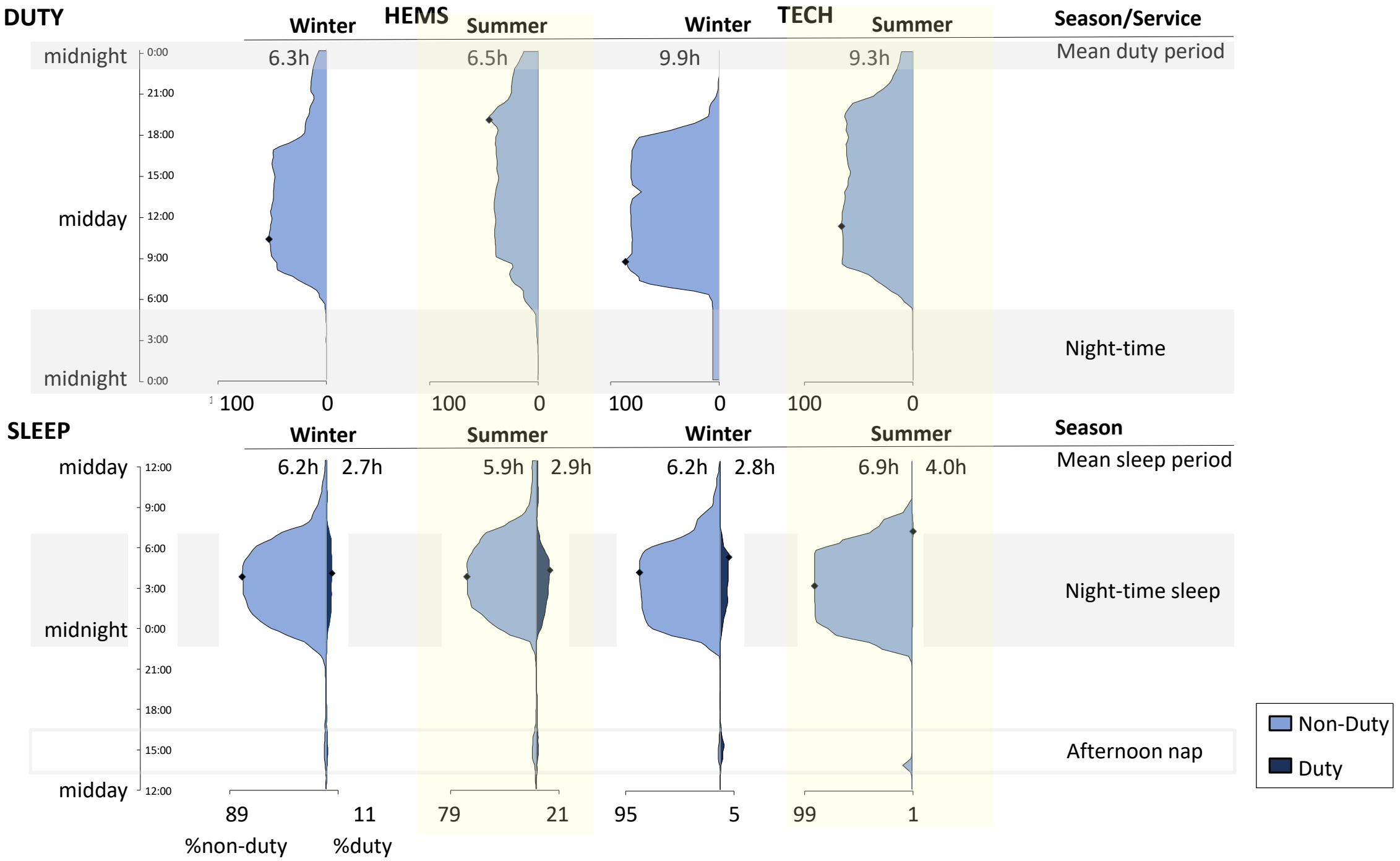

Spain SAR
Scand EMS
France HEMS
Italy HEMS
Italy Tech
Portugal HEMS
Region and Service
midnight
midday
midnight
0:00
21:00
18:00
15:00
12:00
9:00
6:00
3:00
0:00
7.3h
8.9h
9.5h
6.5h
9.7h
7.2h
Mean duty period
Night-time
100
0
Spain HEMS
Italy Fire
Spain Fire
UK Transfers
UK HEMS
Region and Service
2.3h
7.3h
10.5h
7.6h
4.4h
Mean duty period
Night-time
%duty

Finding 2: The overwhelming majority of sleep happens at night (including during on-call)

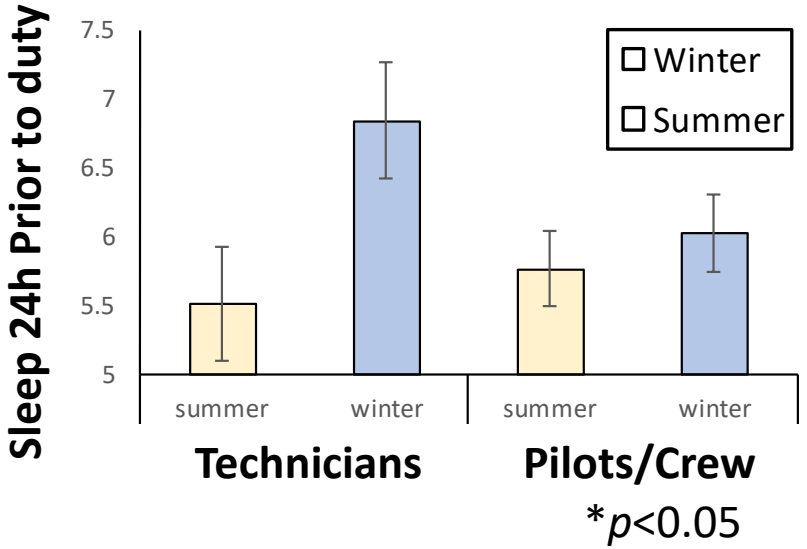

Spain SAR
Scand EMS
France HEMS
Italy HEMS
Italy Tech
Portugal HEMS
Region and Service
6.5h
4.8h
6.3h
4.3h
6.1h
3.8h
6.1h
2.8h
6.6h
2.9h
6.1h
5.4h
Mean sleep period
midday
12:00
9:00
6:00
3:00
midnight
0:00
21:00
18:00
15:00
midday
12:00
Night-time sleep
Afternoon nap
71
29
78
22
82
18
85
15
92
8
93
7
Spain HEMS
Italy Fire
Spain Fire
UK Transfers
UK HEMS
Region and Service
6.6h
1.3h
6.6h
1.8h
7.2h
2.9h
7.3h
0.6h
6.7h
Mean sleep period
midday
12:00
9:00
6:00
3:00
midnight
0:00
21:00
18:00
15:00
midday
12:00
Night time sleep
Afternoon nap
95
5
97
3
98
2
98
2
100
0
%non duty
%duty
Non-Duty
Duty

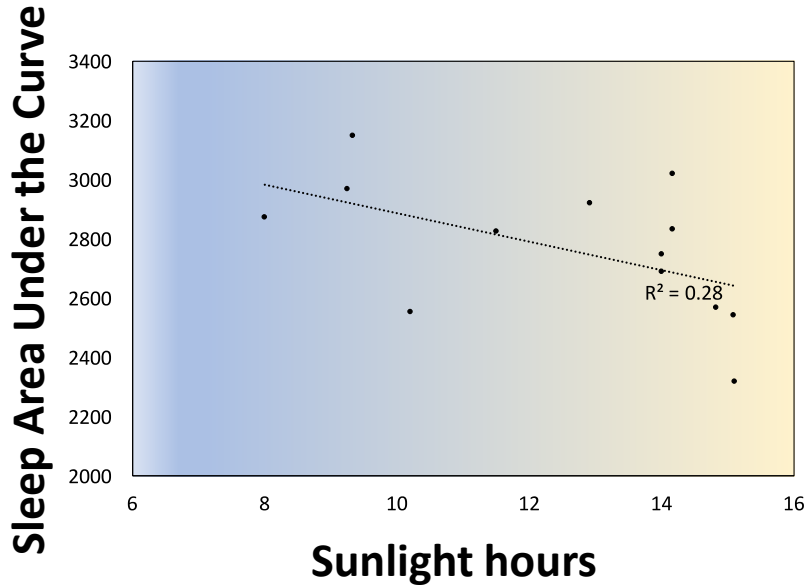
Finding 3: Sleep was longer and earlier in Winter

Season and Sunlight - Italy



Season and Sunlight - Italy





- Summer was associated with greater spread of work and of sleep across the day
- For technicians, sleep duration was significantly shorter in summer
- Across all studies, increasing sunlight was associated with less sleep

Statistical Analysis (detailed)

Multivariate Analyses

- Examine differences in Sleep in 24h and 48h prior to duty start, total wake time at duty end, and Mean Response Time on the Psychomotor Vigilance Task (PVT)
- Linear mixed effects models (random effect of ID on the intercept) with predictors of Operation, Region, Shift Start Hour, Role, First day-on, Role*First day-on interaction term
- Results presented by predictor (rather than by dependent variable as is typical)
- Figures show estimated means from the models with their standard errors

Predictor	Levels	%
Operation	EMS	71
	Other	29
Region	France	11
	Italy	41
	Spain/Portugal	28
	Scandinavia	9
	UK	11
Shift Start Hour	0600-0759h	27
	0800-0959h	36
	1000-1659h	18
	1700-0559h	19
Role	Crew	9
	Fixed Wing Pilot	13
	Rotary Wing Pilot	64
	Technician	14
First day on	First day after day off	22
	Between consecutive shifts	78

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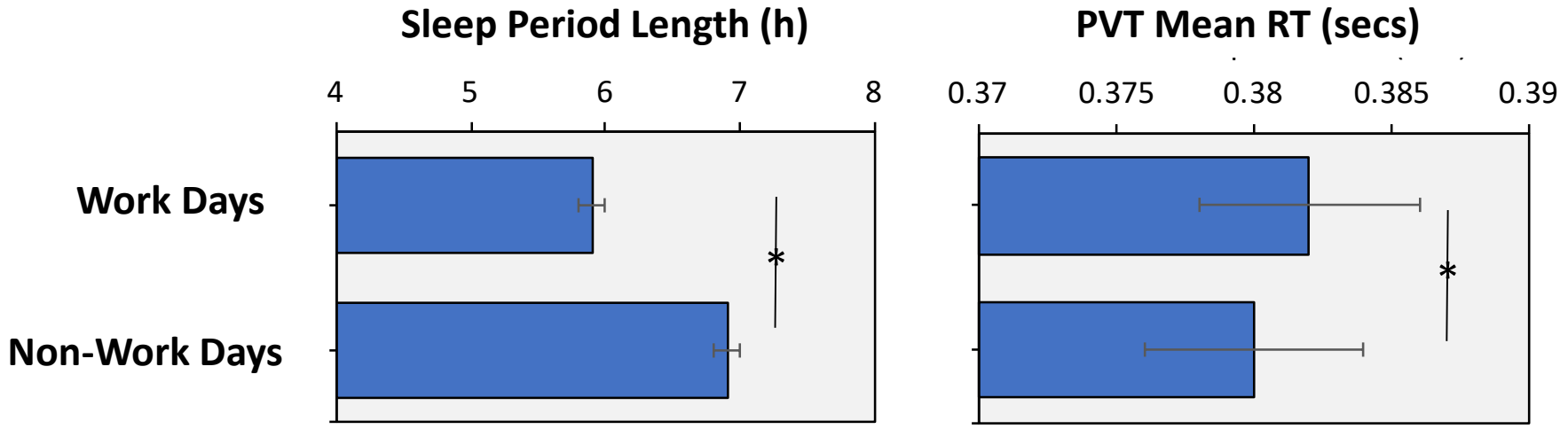
Finding 4: Sleep is an hour shorter per 24-hour day on duty days than days off

Work versus Non Work Days



- Sleep was approximately one hour longer on non work days
- Mean response times were significantly longer on work days, but only by a very small amount

*p<0.05

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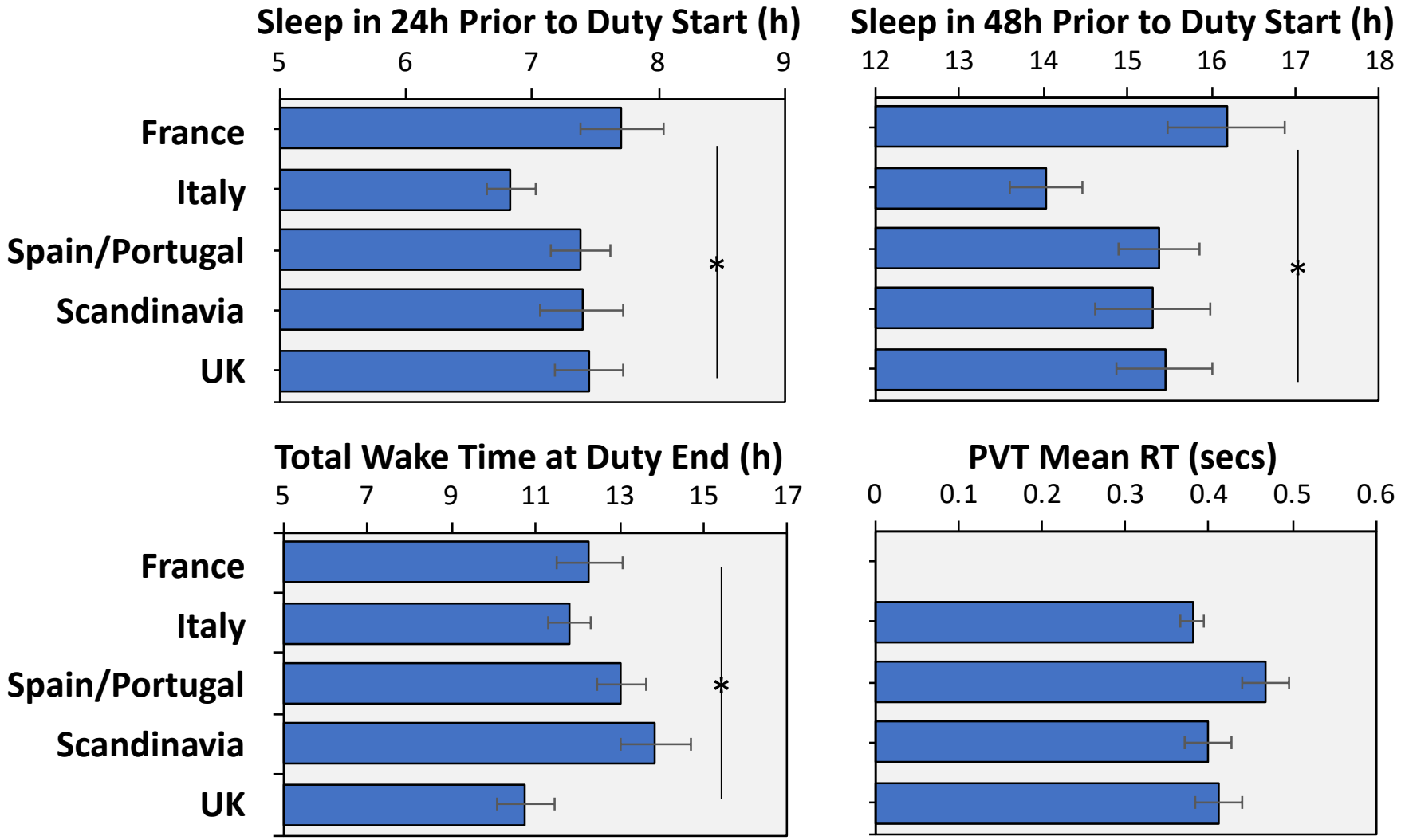
Finding 5: Difference between regions/countries existed but all within normal shift work ranges

Region



- Longest sleep in France and shortest in Italy
- Longest wake time in Scandinavia

*$p<0.05$

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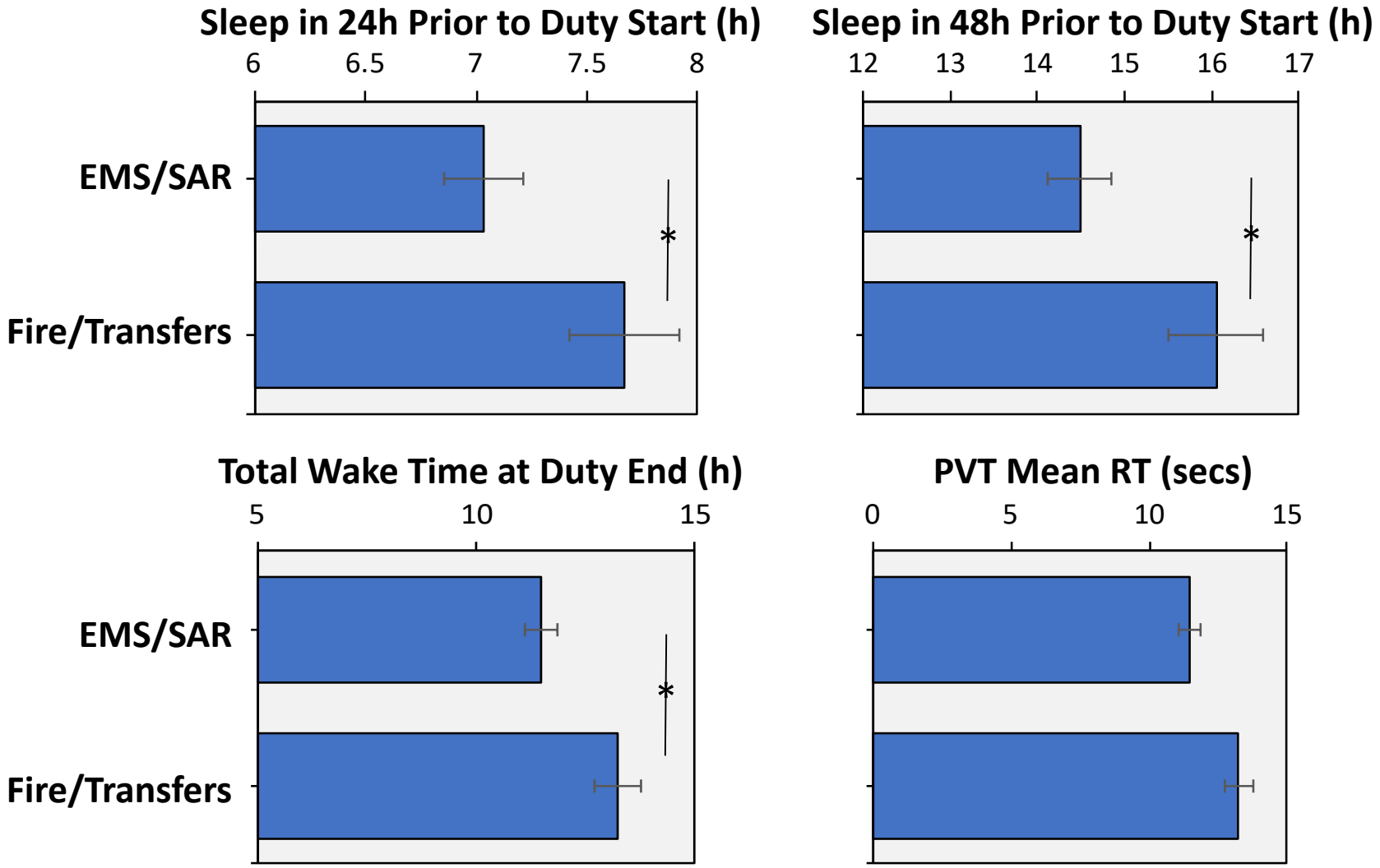
Finding 6: EMS sleep periods were shorter but so were periods awake (due to more 24h coverage)

EMS versus others



- For EMS, sleep was shorter, as was time awake (24h coverage with more sleeping at work)

*$p<0.05$

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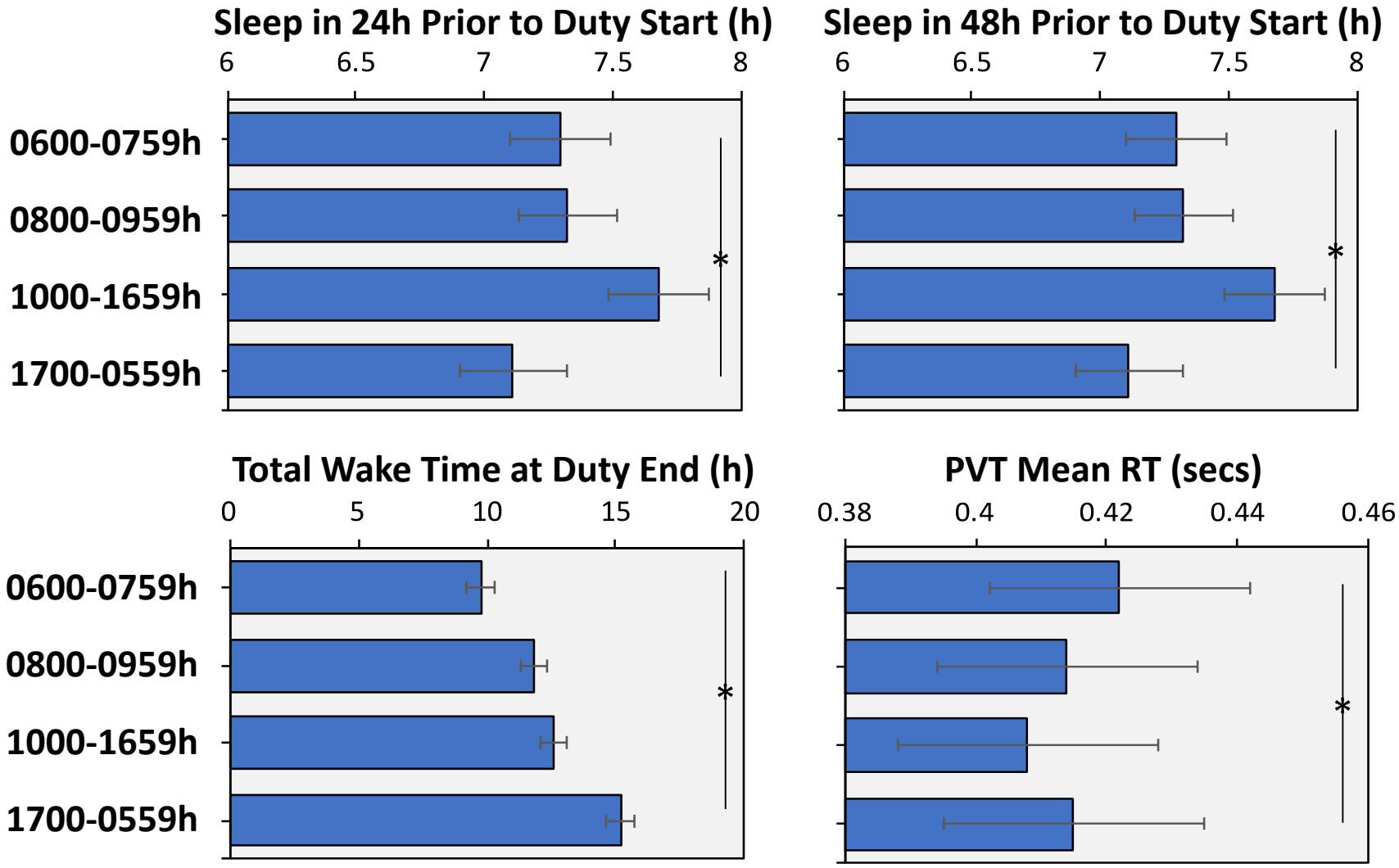
Finding 7: Duties starting during the day (1000h-1659h) were associated with longer prior sleep

Shift Start Hour



*p<0.05

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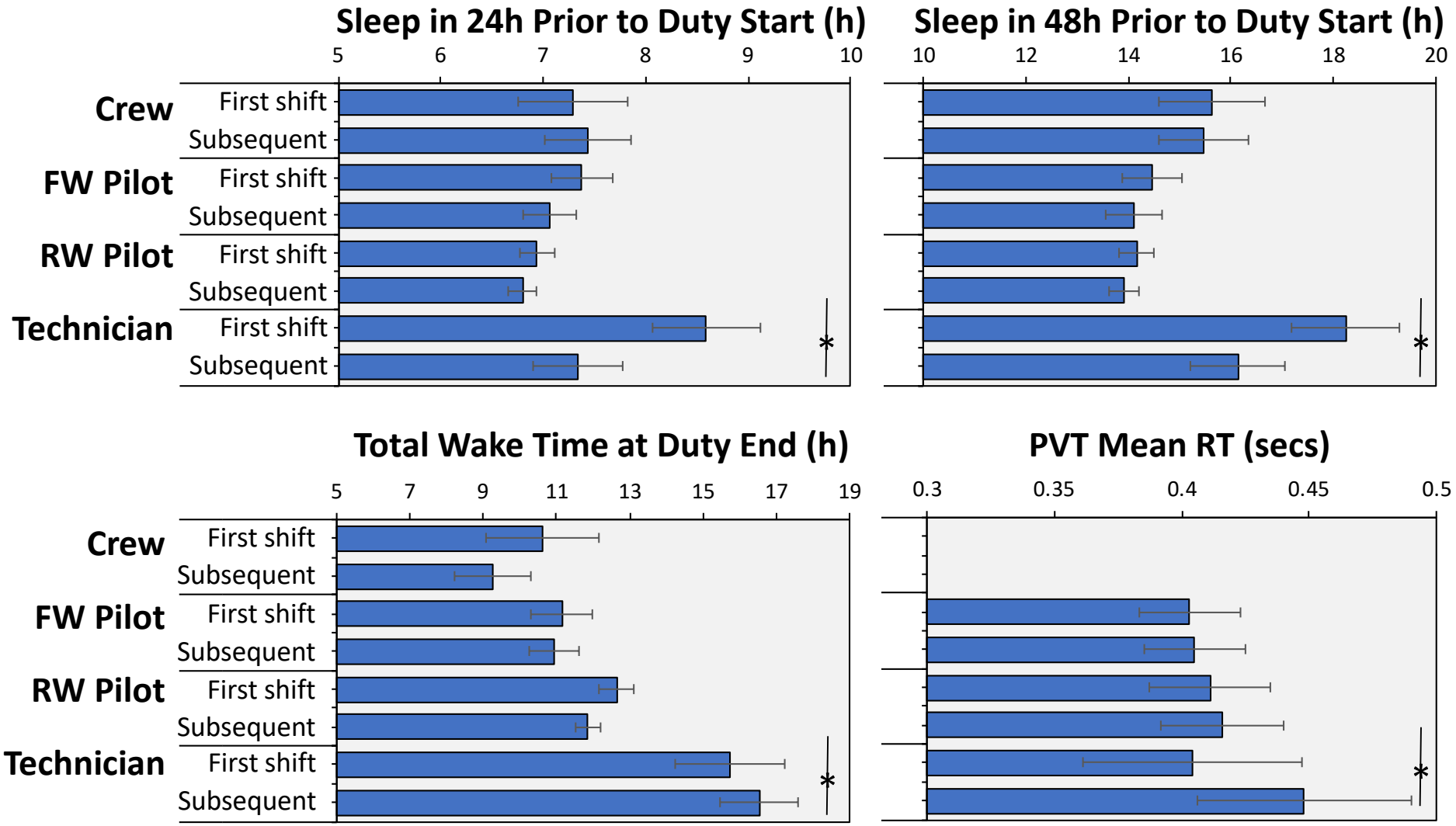
Finding 8: Technicians prepared more for blocks of work (but work longer blocks)

Job Role by Shift Transition



- The only significant differences were for the technicians who work the longest duty periods and many consecutive days

*$p<0.05$

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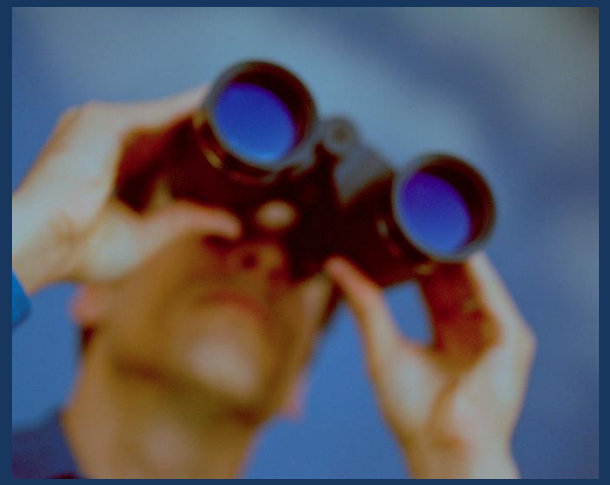
Concluding statements

- Despite major differences in mission profiles, countries/cultures, season and roles the levels of objective sleep and performance are within (and often better) than what would be expected of normal shift workers
- Significant amounts of sleep occur during on-call duty hours, especially at night
- Treatment of on-call hours in similar operations appear to be treated very conservatively by regulators in light of the data, analysis and findings



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Thank you

- All of the volunteer participants (Babcock) and their families
- Simon Stewart and all country/region managers (Babcock)
- Karen Heathcote and Juanita Diaz (Integrated Safety Support)
- Associate Professor Jill Dorrian (University of South Australia)
- Peter Page and Len Pearson (InterDynamics)

Q & A / Discussion

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