

## **Supplemental Digital Content**

### **Variation in initial U.S. hospital responses to the COVID-19 pandemic**

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## Collaborators

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### **The National Heart, Lung, and Blood Institute Prevention and Early Treatment of Acute Lung Injury (PETAL) Clinical Trials Network:**

**ALIGN Clinical Center:** Baystate Medical Center— Jay S. Steingrub\*, Mark A. Tidswell, Lori-Ann Kozikowski, Cynthia Kardos, Lesley DeSouza; Brigham and Women's Hospital – Rebecca M. Baron, Mayra Pinilla-Vera, David M. Rubins, Antonio Arciniegas; Maine Medical Center—Richard Riker, Christine Lord; University of Florida — Marie-Carmelle Elie;

**BOSTON Clinical Center:** Beth Israel Deaconess Medical Center— Daniel Talmor\*, Nathan Shapiro\*, Valerie Banner-Goodspeed; Massachusetts General Hospital— Kathryn A. Hibbert, Kelsey Brait, Natalie Pulido; University of Mississippi Medical Center— Alan Jones, James Galbraith, Utsav Nandi, Rebekah Peacock, Jenna Davis; Hennepin County Medical Center— Matthew Prekker, Michael Puskarich, Seth Jones, Anne Roerhl, Audrey Hendrickson

**CALIFORNIA Clinical Center:** UCSF San Francisco— Michael Matthay\*, Kirsten Kangelaris, Kathleen Liu, Kimberly Yee, Hanjing Zhuo; UCLA Ronald Reagan Medical Center— Gregory Hendey\*, Steven Chang, Nida Qadir, Andrea Tam, Rebecca Beutler, Trisha Agarwal; Stanford University Hospital— Joseph Levitt, Jennifer G. Wilson, Angela Rogers, Jonasel Roque, Rosemary Vojnik; UC Davis—Timothy E. Albertson, James A. Chenoweth, Jason Y. Adams, Brian M. Morrissey, Skyler J. Pearson; UCSF Fresno— Eyad Almasri, Alyssa Hughes;

**COLORADO Clinical Center:** University of Colorado Hospital— Marc Moss\*, Adit Ginde\*, Jeffrey McKeehan, Lani Finck, Michelle Howell, Carrie Higgins; Denver Health Medical Center—Jason Haukoos, Stephanie Gravitz,Carolynn Lyle, Ivor S. Douglas, Terra Hiller, Audrey Goid; National Jewish Health | Saint Joseph's Hospital— James Finigan;

**MICHIGAN Clinical Center:** University of Michigan Medical Center— Robert Hyzy\*, Pauline Park\*, Michael Sjoding, Stephen Kay, Kristine Nelson, Kelli McDonough; Henry Ford— Namita Jayaprakash, Emanuel P Rivers, Jennifer Swiderek, Jasreen Kaur Gill, Jacqueline Day; Sinai Grace Hospital— Robert Sherwin, James Wooden, Thomas Mazzoco;

**MONTEFIORE-SINAI Clinical Center:** Montefiore Moses— Michelle Ng Gong\*, Michael Aboodi, Ayesha Asghar, Omowunmi Amosu, Hiwet Tzehaie; Montefiore Weiler— Aluko A. Hope, Jen-Ting Chen, Rahul Nair, Brenda Lopez, Obiageli Offor; University of Arizona— Jarrod M. Mosier, Cameron D. Hypes, Elizabeth Salvagio, Christian Bime, Elaine Cristan; Ichan School of Medicine at Mount Sinai— Lynne D. Richardson\*, Kusum S. Mathews, Neha Goel, Patrick Maher, Samuel Acquah, Donald Cardone, Gary Oldenburg, Andrew Dunn

**OHIO Clinical Center:** University of Cincinnati Medical Center— Duncan Hite\*, Kristin Hudock, Jose Gomez Arroyo, Tammy Roads; Cleveland Clinic Foundation— Abhijit Duggal, Eduardo Mireles-Cabodevila;

**PACIFIC NORTHWEST Clinical Center:** Harborview Medical Center— Bryce R.H. Robinson\*, Nicholas J. Johnson, Stephanie Gundel; University of Washington— Laura Evans; Swedish Medical Center— D. Shane O'Mahony, Julie A. Wallick; Cedars-Sinai Medical Center— Isabel Pedraza; Oregon Health and Science University— Catherine L Hough\*, Akram Khan, Olivia Krol, Milad Karami Jouzestani, Kelly Vranas

**PITTSBURGH Clinical Center:** UPMC— Donald M. Yealy\*, Derek C. Angus\*, Alexandra Weissman, David T. Huang, Aimee Boeltz-Skrtich; Penn State Hershey Medical Center—Steven Moore; Temple University Hospital— Derek Isenberg;

**SOUTHEAST Clinical Center:** Wake Forest Baptist Health— D. Clark Files\*, Chadwick Miller\*, Kevin Gibbs, Lori Flores, Mary LaRose, Lauren Koehler, Leigha Landreth; University of Kentucky— Peter Morris, Evan Cassity, Jamie Sturgill, Kirby Mayer, Ashley Montgomery-Yates; Virginia Commonwealth University Medical Center—Marjolein de Wit, Jessica Mason; Medical University of South Carolina— Andrew Goodwin, Abigail Grady, Patterson Burch; University of Virginia Health— Kyle B. Enfield, Jeffrey M. Sturek, Mary Marshall;

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**Clinical Coordinating Center:** Massachusetts General Hospital Biostatistics Center (CCC)— Nancy Ringwood, Alexander Nagrebetsky, Laura Fitzgerald

**Steering Committee Chair:** Johns Hopkins Hospital Roy G. Brower

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Table E1: Survey Instrument, Missingness per question and definitions

Question	% Missing Response of eligible respondents
<b>Respondent Information</b>	
Contributor(s) to survey completion?	0%
<b>Hospital and ICU Characteristics BEFORE COVID-19</b>	
Operational adult inpatient beds prior to COVID-19?	0%
Average proportion of adult inpatient beds occupied on a typical day prior to COVID-19?	4.4%
Operational adult ICU beds prior to COVID-19?	0%
Average proportion of adult ICU beds occupied on a typical day prior to COVID-19?	2.2%
Average number of patients on invasive mechanical ventilation on a typical day prior to COVID-19?	4.4%
<b>Staffing in Medical ICUs BEFORE COVID-19</b>	
Was an intensivist always the primary physician for all critically ill patients in Medical ICUs?	0%
What type(s) of formal training do the Medical ICU attending physicians have?	0%
What types of providers work on the primary clinical team in Medical ICUs?	0%
<b>Emergency Response Changes at Your Hospital DURING COVID-19</b>	
When did your hospital first admit a patient with COVID-19?	6.7%
Has an Incident Command Center or System, specific for COVID-19, been activated?	0%
On which date was the Incident Command first activated?	2.3%
Were ALL elective procedures at your hospital cancelled at any time in response to COVID-19?	0%
On what date did the cancellation of elective procedures first go into effect?	4.6%
Does your hospital have a centralized system for case-by-case triage of resources during times of emergency?	4.4%
On what date was this system first activated?	47.5%
During the COVID pandemic, have plans been developed to use alternative devices or strategies for invasive mechanical ventilation?	0%
Have these alternative ventilatory devices and/or strategies been utilized/implemented?	0%
On which date was the first patient managed on one of these alternative ventilator devices or strategies?	0%
<b>Changes to Non-ICU Inpatient Care at your Hospital DURING COVID-19</b>	
<i>(In March)</i> On a single day, what was the highest census of inpatients?	26.7%
<i>(April 1-today)</i> On a single day, what was the highest census of inpatients?	28.9%
Have plans been developed to add or repurpose additional locations to expand capacity for non-ICU inpatient care if needed?	0%
At any time since March 1st, were non-ICU inpatients cared for in overflow, surge, or expansion beds that were added or repurposed in response to COVID-19 pandemic?	11.1%
At any time since March 1st, were any non-ICU inpatients cared for in beds repurposed or added within any of the following clinical areas?	0%
When was the first non-ICU inpatient cared for in beds any of these clinical areas?	11.8%
At any time since March 1st, were non-ICU inpatients cared for in non-clinical areas that were not routinely used for patient care prior to the pandemic?	11.1%

When was the first non-ICU inpatient cared for in any of these non-clinical areas?	0%
<b>Changes to ICU Care at your Hospital DURING COVID-19</b>	
<i>(In March)</i> On a single day at your hospital, what was the highest census of ICU patients?	26.7%
<i>(April 1-today)</i> On a single day at your hospital, what was the highest census of ICU patients?	24.4%
At any time since March 1st, were ICU patients cared for in overflow, surge, or expansion ICU beds that were added or repurposed in response to COVID-19 pandemic?	6.7%
When was the first ICU patient cared for in overflow, surge, or expansion beds within these clinical areas?	0%
When was the first ICU patient cared for in these non-clinical areas?	0%
<b>Changes to Staffing at Your Hospital DURING COVID-19</b>	
Did staffing models for primary ICU teams caring for ICU patients with COVID-19 differ from staffing models used in any Medical ICUs prior to the pandemic?	4.4%
Was an intensivist always the primary attending for all ICU patients with COVID?	4.4%
What type(s) of formal training do the attending physicians who cared for ICU patients with COVID have?	4.4%
Which providers have worked on the primary clinical teams caring for ICU patients with COVID?	4.4%
Have plans been developed at your hospital for tiered-staffing models to expand staffing capacity if needed to care for ICU patients?	6.7%
Have tiered-staffing models been implemented for any of these roles for ICU patients?	6.7%
On which date was a tiered-staffing model for any ICU staff first implemented?	6.7%
At any time since March 1st, have temporary staff aided in the care for hospitalized patients?	4.4%
On which date did any temporary staff begin caring for ICU patients?	4.8%
On which date did temporary staff begin caring for acute care patients?	0%
From where did the temporary MDs caring for patients during the pandemic originate?	0%
Compared to the pre-COVID period, did provider-to-patient ratios increase for any of the following providers?	4.4%

\*N.B. Questions have been shortened and simplified from their original format.

**Table E2: Frequency of planned and implemented hospital operational and structural changes in response to the COVID-19 pandemic**

	<b>Responses (n)</b>	<b>Implemented N (%)</b>	<b>Planned N (%)</b>	<b>Not planned N (%)</b>
Incident Command System Activation	45	44 (97.8%)	-	-
Cancellation of Elective Procedures	45	43 (95.6%)	-	-
Central Triage System	43	38 (88.4%)	4 (9.3%)	1 (2.3%)
ICU Clinical Expansion	42	26 (61.9%)	15 (35.7%)	1 (2.4%)
Ward Clinical Expansion	41	20 (48.8%)	21 (51.2%)	0 (0%)
ICU Non-Clinical Expansion	43	1 (2.3%)	8 (18.6%)	34 (79.1%)
Ward Non-Clinical Expansion	41	2 (4.9%)	16 (39.0%)	23 (56.1%)
Tiered Staffing Model	42	20 (47.6%)	16 (38.1%)	6 (14.3%)
Alternative Ventilator Strategies	45	9 (20.0%)	29 (64.4%)	7 (15.6%)

**Table E3: Survey respondent estimation of average hospital capacity, occupancy, and mechanical ventilation use by U.S. census region reported by participating sites between December 2019 and February 2020**

Region	Site	Adult Inpatient beds (wards):  Number (Average percent daily occupancy)	Adult ICU beds:  Number (Average percent daily occupancy)	Adult patients requiring invasive mechanical ventilation*:  Average daily count
Northeast	Baystate Medical Center (Springfield, MA)	751 (90-99%)	62 (90-99%)	40
	Beth Israel Medical Center (Boston, MA)	550 (90-99%)	77 (80-89%)	35
	Brigham and Women's Hospital (Boston, MA)	783 (90-99%)	98 (80-89%)	45
	Maine Medical Center (Portland, ME)	507 (90-99%)	54 (80-89%)	30
	Massachusetts General Hospital (Boston, MA)	900 (80-89%)	115 (80-89%)	50
	Montefiore Medical Center (Montefiore Hospital—Moses Campus and Jack D. Weiler Hospital) (New York, NY)	1120 (90-99%)	106 (90-99%)	70
	Mount Sinai Hospital (New York, NY)	759 (90-99%)	96 (90-99%)	67
	Penn State Milton S. Hershey Medical Center (Hershey, PA)	548 (90-99%)	70 (90-99%)	35
	Temple University Hospital (Philadelphia, PA)	879 (80-89%)	99 (80-89%)	44
	University of Pittsburgh Medical Center Presbyterian (Pittsburgh, PA)	1954 (80-89%)	272 (80-89%)	150
	Midwest	Cleveland Clinic (Cleveland, OH)	1300 (90-99%)	223 (90-99%)
Hennepin County Medical Center (Minneapolis, MN)		425 (90-99%)	63 (90-99%)	31
Henry Ford Medical Center (Detroit, MI)		877 (80-89%)	156 (90-99%)	82
Sinai-Grace Hospital (Detroit, MI)		400 (80-89%)	20 (80-89%)	20
University of Cincinnati Medical Center (Cincinnati, OH)		550 (80-89%)	140 (80-89%)	40
University of Michigan Medical Center (Ann Arbor, MI)		1043 (90-99%)	96 (90-99%)	50
South		Duke University Medical Center (Durham, NC)	1019 (100-109%)	180 (100-109%)
	Medical University of South Carolina (Charleston, SC)	395 (90-99%)	89 (90-99%)	33
	University Medical Center (New Orleans, LA)	330 (80-89%)	44 (80-89%)	16
	University of Florida Health Shands Hospital (Gainesville, FL)	1030 (>110%)	250 (90-99%)	20
	University of Kentucky (Lexington, KY)	950 (100-109%)	155 (>110%)	70
	University of Mississippi Medical Center (Jackson, MS)	451 (>110%)	92 (>110%)	53
	University of Virginia Medical Center (Charlottesville, VA)	400 (90-99%)	80 (90-99%)	45
	Vanderbilt University Medical Center (Nashville, TN)	950 (100-109%)	220 (100-109%)	75
	Virginia Commonwealth University Medical Center (Richmond, VA)	718 (90-99%)	108 (90-99%)	70
	Wake Forest Baptist Health (Winston-Salem, NC)	630 (missing)	124 (missing)	50
	West — Mountain	Denver Health Medical Center (Denver, CO)	534 (90-99%)	54 (90-99%)
Intermountain Medical Center (Murray, UT)		454 (70-79%)	90 (60-69%)	25

	LDS Hospital (Salt Lake City, UT)	246 (< 50%)	16 (< 50%)	2
	McKay-Dee Hospital (Ogden, UT)	239 (60-69%)	50 (70-79%)	11
	St. Joseph Hospital (Denver, CO)	450 (80-89%)	30 (70-79%)	15
	University of Arizona Medical Center (Tucson, AZ)	281 (80-89%)	86 (80-89%)	50
	University of Colorado Hospital (Aurora, CO)	561 (100-109%)	132 (90-99%)	missing
	University of Utah Hospital (Salt Lake City, UT)	585 (90-99%)	96 (90-99%)	20
	Utah Valley Regional Medical Center (Provo, UT)	317 (60-69%)	48 (50-59%)	14
West — Pacific	Cedars-Sinai Medical Center (Los Angeles, CA)	712 (>110%)	108 (<50%)	40
	Community Regional Medical Center (Fresno, CA)	875 (80-89%)	108 (80-89%)	60
	Harborview Medical Center (Seattle, WA)	413 (80-89%)	89 (70-79%)	40
	Oregon Health and Science University Hospital (Portland, OR)	480 (90-99%)	80 (90-99%)	30
	Ronald Reagan UCLA Medical Center (Los Angeles, CA)	520 (90-99%)	109 (90-99%)	23
	Stanford University Medical Center (Stanford, CA)	605 (missing)	99 (70-79%)	35
	Swedish Hospital – First Hill (Seattle, WA)	525 (80-89%)	32 (80-89%)	14
	UC Davis Medical Center (Davis, CA)	625 (100-109%)	84 (100-109%)	30
	UCSF Medical Center (San Francisco, CA)	600 (80-89%)	94 (80-89%)	25
	University of Washington Medical Center (Seattle, WA)	456 (80-89%)	79 (80-89%)	30

\* Excludes patients on mechanical ventilation in operating rooms or procedure suites.



**Figure E1a & E1b: Peak ICU census (a) and ward census (b) as a percentage of pre-pandemic bed numbers in ICU and wards, respectively, stratified by region. Maximum census values reported between March to August 2020 for 34 sites (missing n=11).**

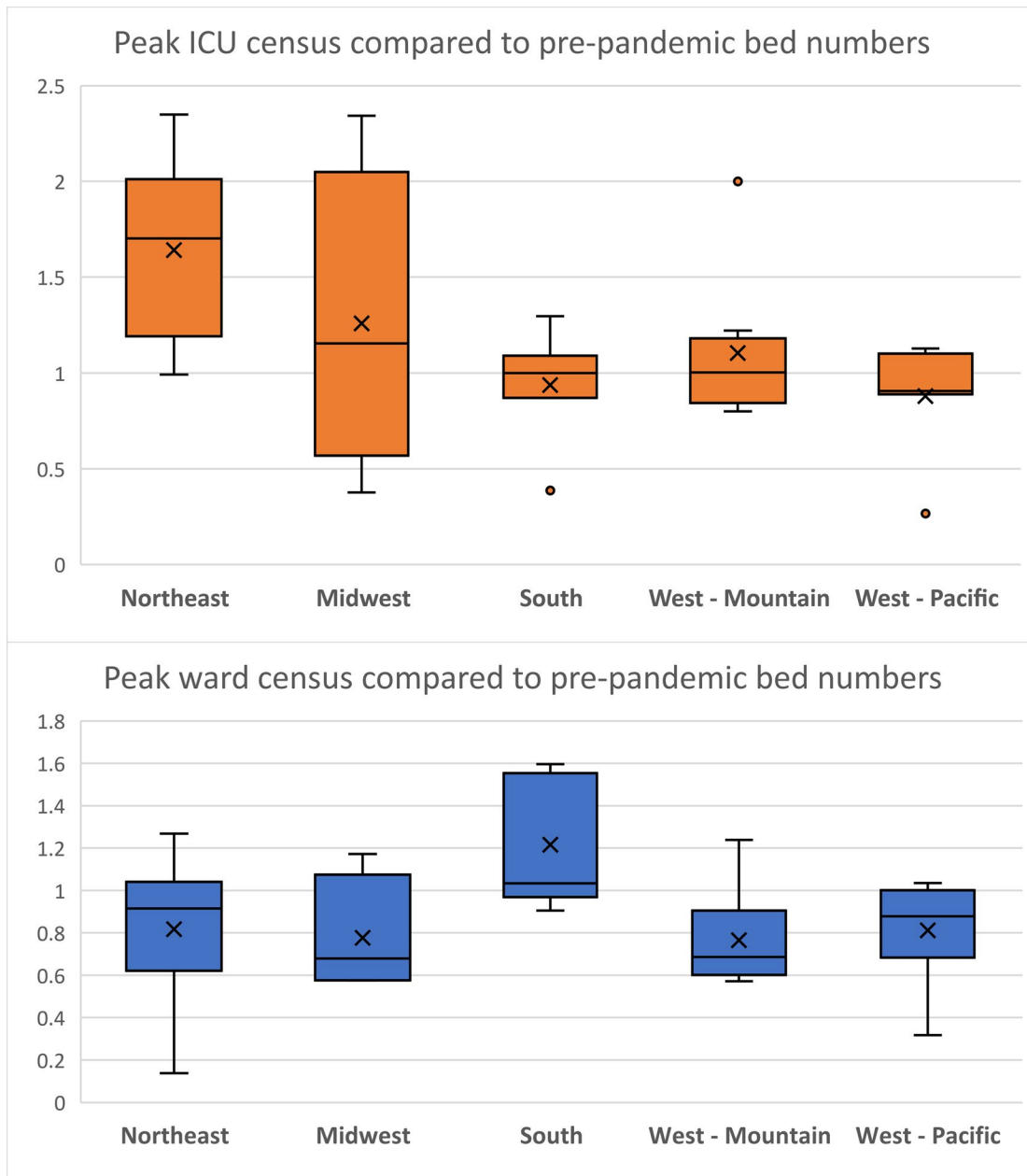


Figure E2: Hospital variation in operational changes in response to the COVID-19 pandemic, stratified by region (Solid color: Implemented change; Striped color: planned change; Gray: no change planned or implemented; White: Missing data)

Region	Site	Structure	Space				Staffing	Equipment
		Central Triage	ICU Clinical Expansion	Ward Clinical Expansion	ICU Non-Clinical Expansion	Ward Non-Clinical Expansion	Tiered Staffing Model	Alternative Vents
Northeast	1	Solid Red	Striped Yellow	Striped Yellow	Striped Yellow	Striped Yellow	Striped Green	Striped Blue
	2	White	Striped Yellow	Striped Yellow	Solid Black	Striped Yellow	Solid Black	Solid Blue
	3	White	Striped Yellow	Striped Yellow	Solid Black	Striped Yellow	Solid Black	Striped Blue
	4	Solid Red	Striped Yellow	Striped Yellow	Solid Black	Striped Yellow	Striped Green	Striped Blue
	5	Solid Red	Striped Yellow	Striped Yellow	Solid Black	Striped Yellow	Striped Green	Striped Blue
	6	Solid Red	Striped Yellow	Striped Yellow	Solid Black	Striped Yellow	Striped Green	Striped Blue
	7	Solid Red	Striped Yellow	Striped Yellow	Solid Black	Striped Yellow	Striped Green	Striped Blue
	8	Solid Red	Striped Yellow	Striped Yellow	Solid Black	Striped Yellow	Striped Green	Striped Blue
	9	Solid Red	Striped Yellow	Striped Yellow	Solid Black	Striped Yellow	Striped Green	Striped Blue
	10	Solid Red	Striped Yellow	Striped Yellow	Solid Black	Striped Yellow	Striped Green	Striped Blue
Midwest	1	Solid Red	Striped Yellow	Striped Yellow	Striped Yellow	Striped Yellow	Striped Green	Striped Blue
	2	Solid Red	Striped Yellow	Striped Yellow	Striped Yellow	Striped Yellow	Striped Green	Striped Blue
	3	Solid Red	Striped Yellow	Striped Yellow	Solid Black	Solid Black	Striped Green	Solid Black
	4	Solid Red	Striped Yellow	Striped Yellow	Solid Black	Solid Black	Striped Green	Solid Black
	5	Solid Red	Striped Yellow	Striped Yellow	Solid Black	Striped Yellow	Striped Green	Solid Black
	6	White	White	White	White	White	White	Solid Black
South	1	Solid Red	Striped Yellow	Striped Yellow	Solid Black	Striped Yellow	Striped Green	Striped Blue
	2	Solid Red	Striped Yellow	Striped Yellow	Solid Black	Striped Yellow	Striped Green	Striped Blue
	3	Solid Red	Striped Yellow	Striped Yellow	Solid Black	Striped Yellow	Striped Green	Striped Blue
	4	Solid Red	Striped Yellow	Striped Yellow	Solid Black	Solid Black	Striped Green	Solid Black
	5	Striped Red	Striped Yellow	Striped Yellow	Solid Black	Solid Black	Striped Green	Solid Black
	6	Striped Red	Striped Yellow	Striped Yellow	Solid Black	Solid Black	Striped Green	Solid Black
	7	Striped Red	Striped Yellow	Striped Yellow	Solid Black	Solid Black	Striped Green	Solid Black
	8	Solid Red	Striped Yellow	Striped Yellow	Solid Black	Solid Black	Striped Green	Striped Blue
	9	Solid Red	Striped Yellow	Striped Yellow	Solid Black	Solid Black	Striped Green	Striped Blue
	10	Solid Red	Striped Yellow	Striped Yellow	Solid Black	Solid Black	Striped Green	Striped Blue
West - Mountain	1	Solid Red	Striped Yellow	Striped Yellow	Solid Black	Solid Black	Striped Green	Striped Blue
	2	Solid Red	Striped Yellow	Striped Yellow	Solid Black	Solid Black	Striped Green	Striped Blue
	3	Solid Red	Striped Yellow	Striped Yellow	Solid Black	Solid Black	Striped Green	Striped Blue
	4	Solid Red	Striped Yellow	Striped Yellow	Solid Black	Solid Black	Striped Green	Striped Blue
	5	Solid Red	Striped Yellow	Striped Yellow	Solid Black	Solid Black	Striped Green	Striped Blue
	6	Striped Red	Striped Yellow	Striped Yellow	Solid Black	Striped Yellow	Striped Green	Striped Blue
	7	Solid Red	Striped Yellow	Striped Yellow	Solid Black	Striped Yellow	Solid Black	Striped Blue
	8	Solid Red	Striped Yellow	Striped Yellow	Solid Black	Solid Black	Striped Green	Striped Blue
	9	Solid Red	Striped Yellow	Striped Yellow	Solid Black	Solid Black	Striped Green	Striped Blue
West - Pacific	1	Solid Red	Striped Yellow	Striped Yellow	Solid Black	Striped Yellow	Striped Green	Striped Blue
	2	Solid Red	Striped Yellow	Striped Yellow	Solid Black	Striped Yellow	Striped Green	Striped Blue
	3	Solid Red	Striped Yellow	Striped Yellow	Solid Black	Striped Yellow	Striped Green	Striped Blue
	4	Striped Red	Striped Yellow	Striped Yellow	Solid Black	Solid Black	Striped Green	Striped Blue
	5	Solid Red	Striped Yellow	Striped Yellow	Solid Black	Solid Black	Striped Green	Striped Blue
	6	Solid Red	Striped Yellow	Striped Yellow	Solid Black	Solid Black	Striped Green	Striped Blue
	7	Solid Red	Striped Yellow	Striped Yellow	Solid Black	Striped Yellow	Striped Green	Striped Blue
	8	Solid Red	Striped Yellow	Striped Yellow	Solid Black	Solid Black	Striped Green	Striped Blue
	9	Solid Red	Striped Yellow	Striped Yellow	Solid Black	Solid Black	Striped Green	Solid Black
	10	Solid Red	Striped Yellow	Striped Yellow	Solid Black	Solid Black	Striped Green	Solid Black