

PRACTICALITIES OF A CPAP STRATEGY IN THE COVID-19 PANDEMIC

How to deliver CPAP at scale

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CHALLENGES

Environment

VIE (oxygen) capacity

Local flow capacity

Equipment (CPAP device and masks)

Staff training

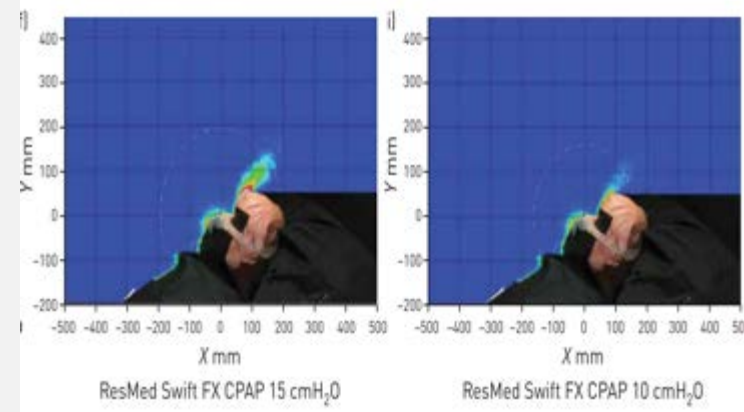
ENVIRONMENT

Issues

- Concern regarding risk of droplet spread and aerosolization, and risk to healthcare workers
- Lack of side rooms making cohorting in bays necessary

Evidence

- Droplet dispersion low with CPAP
- Interfaces differ: Helmet > FFM > nasal pillow > HFNC
- “Leakage from the oronasal mask was negligible”
- “There was no significant leakage from the Quattro Air mask when CPAP was applied at 5, 10, 15 or 20 cmH₂O”



Simonds et al Health Technol Assess 2010 Oct;14(46):131-172

Hui et al Chest 2015 May;147(5):1336-134

Hui et al Eur Respir J 2019 Apr 11;53(4):1802339

ENVIRONMENT

Mitigation

- Use non-vented full-face masks or hoods
- Pay attention to mask fitting (i.e. reduce leak)
- Apply an antiviral filter on the exhalation port
- Understand hierarchy of available environments:
 - Negative pressure side room >
 - Neutral pressure side room >
 - Cohorting in open bays with high air change rate/hr
- Healthcare workers should wear level 3 PPE



OXYGEN SUPPLY

Issues



- Most hospitals store oxygen in vacuum insulated evaporators (VIEs)
- Modern VIEs with modern pipe systems can often produce around 3000L/min O₂, but older systems can produce as little as 1500L/min O₂
- If the demand through multiple wall outlets exceeds the maximum capacity of the VIE delivery system, there is a risk of a rapid pressure drop in oxygen supply pipes
- In London, VIE capacity was breached in a number of hospitals owing to the large number of patients on face mask oxygen

VIE OXYGEN SUPPLY: MITIGATION

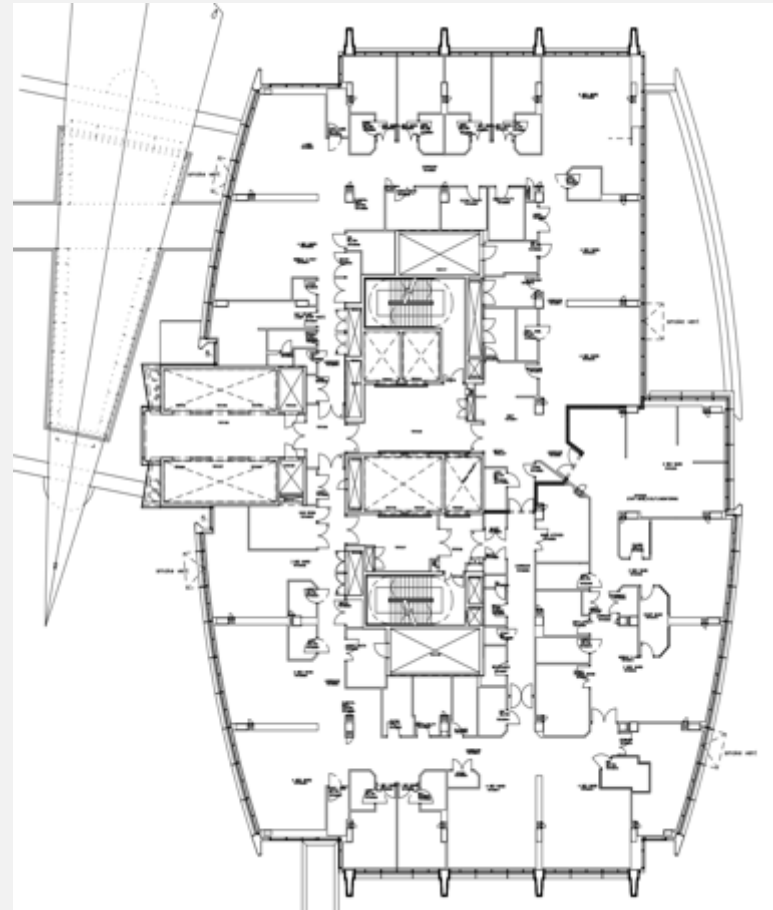
- Set up an Oxygen Task Force for the hospital
- Engage with your engineers and medical gas supplier:
 - What is the VIE capacity at your institute?
 - Can VIE capacity be increased? (we increased from 3000L/min to 5000L/min)
- Monitor oxygen usage:
 - Telemetry readings from the VIE on 6 hourly basis
 - Set system alarms e.g. at 80% capacity
 - Twice daily review of data with appropriate governance
 - Daily averaging of usage to look for trend
- Contingency plans for lack of capacity
 - Lower saturation aims
 - Switch to less oxygen demanding equipment

Date/Time	Oxygen Usage (L/min)	% of Total Capacity (100% = 5000L/min)
29/3 00:00-06:00	990	20%
29/3 06:00-12:00	668	13%
29/3 12:00-06:00	797	16%
29/3 18:00-00:00	826	17%
30/3 00:00-06:00	823	16%
30/3 06:00-12:00	914	18%
30/3 12:00-06:00	703	14%
30/3 18:00-00:00	1128	23%

Date	Oxygen Usage (L/min)	% of Total Capacity (100% = 5000L/min)	Change in % Utilisation from Previous Day
27th March	723.75	14%	N/A
28th March	748.00	15%	0.5%
29th March	820.25	16%	1.4%
30th March	892.00	18%	1.4%
31st March	1089.75	22%	4.0%

OXYGEN SUPPLY: LOCAL ENVIRONMENT

- Capacity for oxygen delivery depends on the potential flow rates of local environments
- Factors including pipework calibre and layout can determine flow capacity
- Flow capacity can vary across a hospital, and within areas (e.g. wards)
- Tree-like branching network of pipes means terminal points more exposed to low flow than proximal points



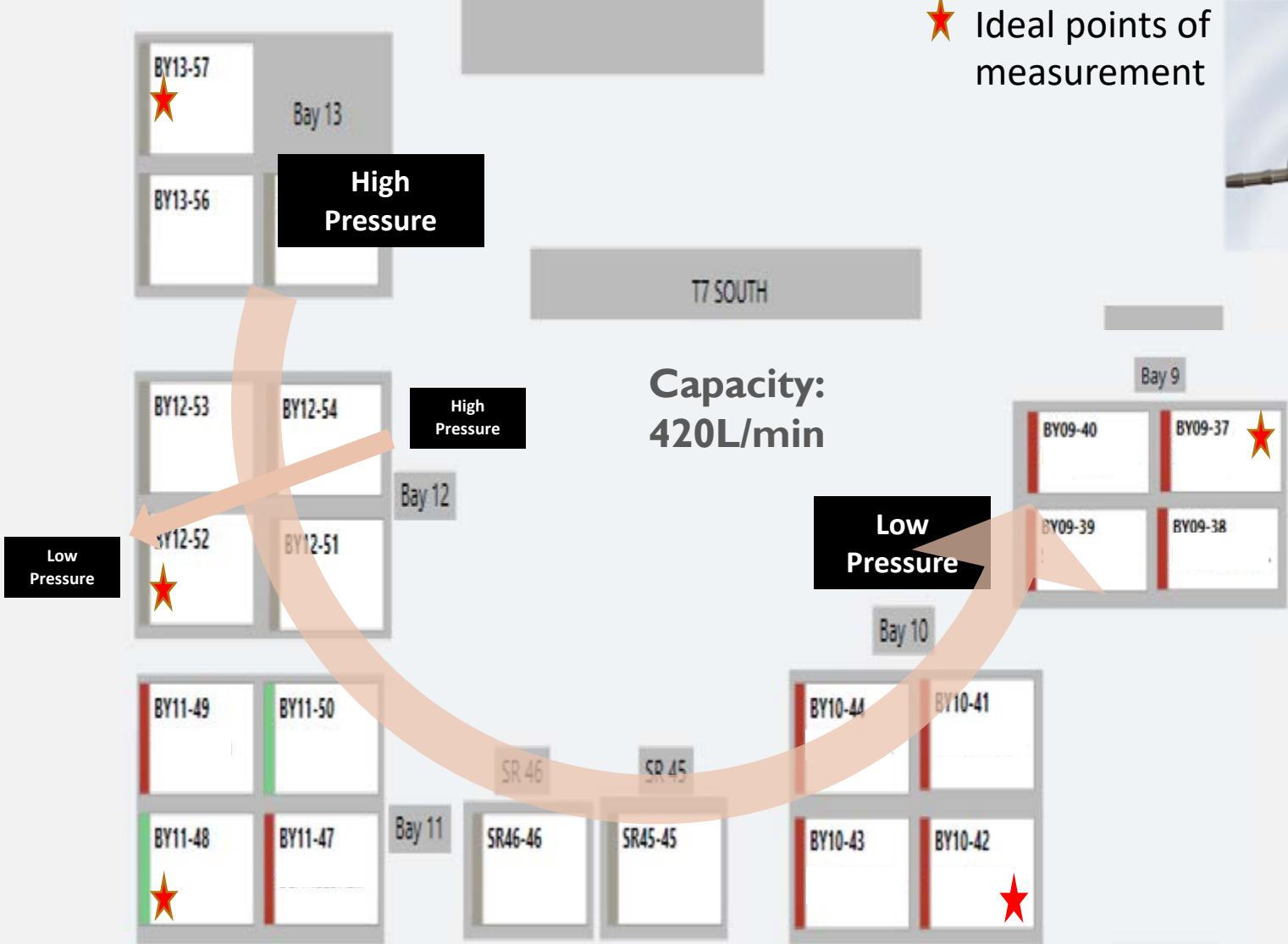
OXYGEN SUPPLY: LOCAL ENVIRONMENT

- Understand the flow capacity of the local ward environment
- Assess the safest physical location to treat multiple patients with CPAP
- Understand the flow demand of various CPAP devices and determine the maximum number deployed per area
- Develop systems to enable oversight of number of CPAP devices in use in given ward (flow) areas.
- Monitor the oxygen wall pressure and set appropriate thresholds for alarm (3.5Bar)



OXYGEN SUPPLY: LOCAL ENVIRONMENT

★ Ideal points of measurement



EQUIPMENT

Issue

Not all CPAP is equal.

Devices vary in their ability to provide assured levels of FiO_2 and PEEP, their flow demand, and their cost



Device	Assured (and high) FiO_2	Pressure range	O_2 flow demand	Cost
Hospital dedicated device (high flow)	+++	+++	Low	High
Domiciliary device (low flow)	+	++	Low	Moderate
UCL Ventura	+++	+	Moderate	Low
Disposable CPAP E.g. Pulmodyne/vygon	+++	++	High	Low (but single use)

OXYGEN DEMAND OF HOSPITAL CPAP DEVICES

PEEP	Inspired FIO2 (%)	Respiratory Rate	O2 (L/min)
10	60	12	14
10	90	12	20
10	60	40	16
10	90	40	30
12	60	12	13
12	90	12	23
12	60	40	15
12	90	40	30



With unintentional leak of 60L/min

PEEP	Inspired FIO2 (%)	Respiratory Rate	O2 (L/min)
10	90	40	58.1

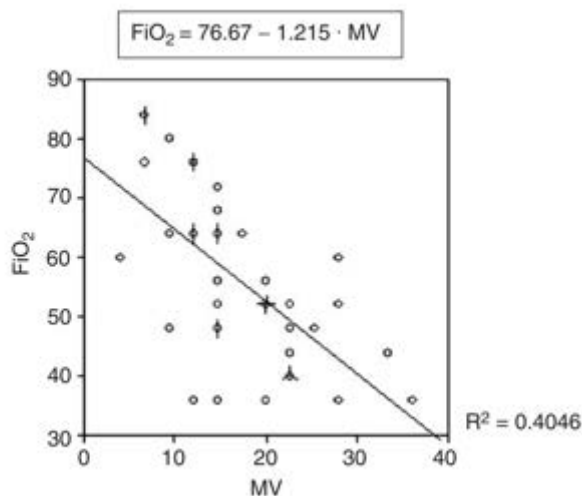
UNRELIABLE FIO2 PROVISION WITH DOMICILIARY CPAP

Delivered FiO2 using domiciliary CPAP devices with entrained oxygen

PEEP	O2 (L/min)	Respiratory Rate	Inspired FIO2 (%)
12	10	12	40
12	15	12	60
12	10	40	30
12	15	40	40



Oxygen entrained at the mask



OXYGEN DEMAND OF WALL CPAP DEVICES

Oxygen flow demand using Pulmodyne disposable device

FiO ₂ (%)	O ₂ L/min
30	22
60	57
90	130



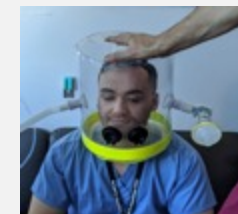
Oxygen flow demand using UCL Ventura

PEEP	Inspired FIO ₂ (%)	Respiratory Rate	O ₂ (L/min)
10	60	16	14
10	60	30	21.4
10	90	16	31.9
10	90	30	47



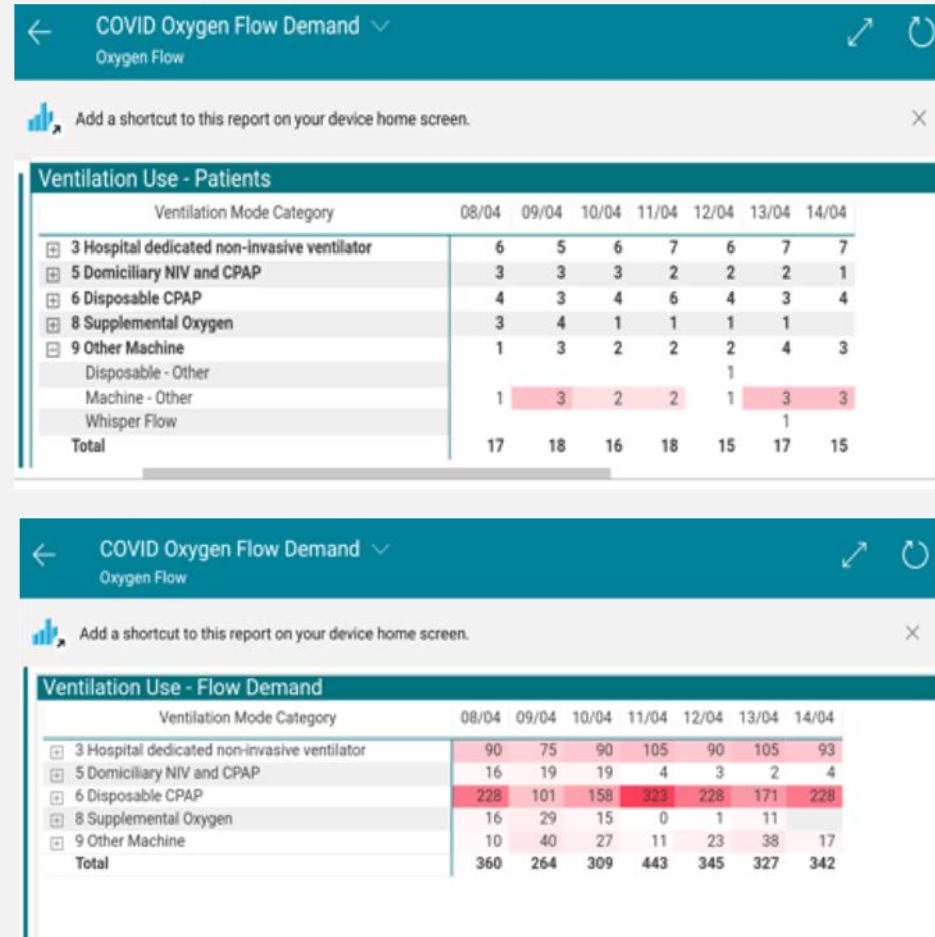
With helmet interface

PEEP	Inspired FIO ₂ (%)	Respiratory Rate	O ₂ (L/min)
10	60	12	22.5



MONITORING CPAP DEPLOYMENT AND FLOW DEMAND

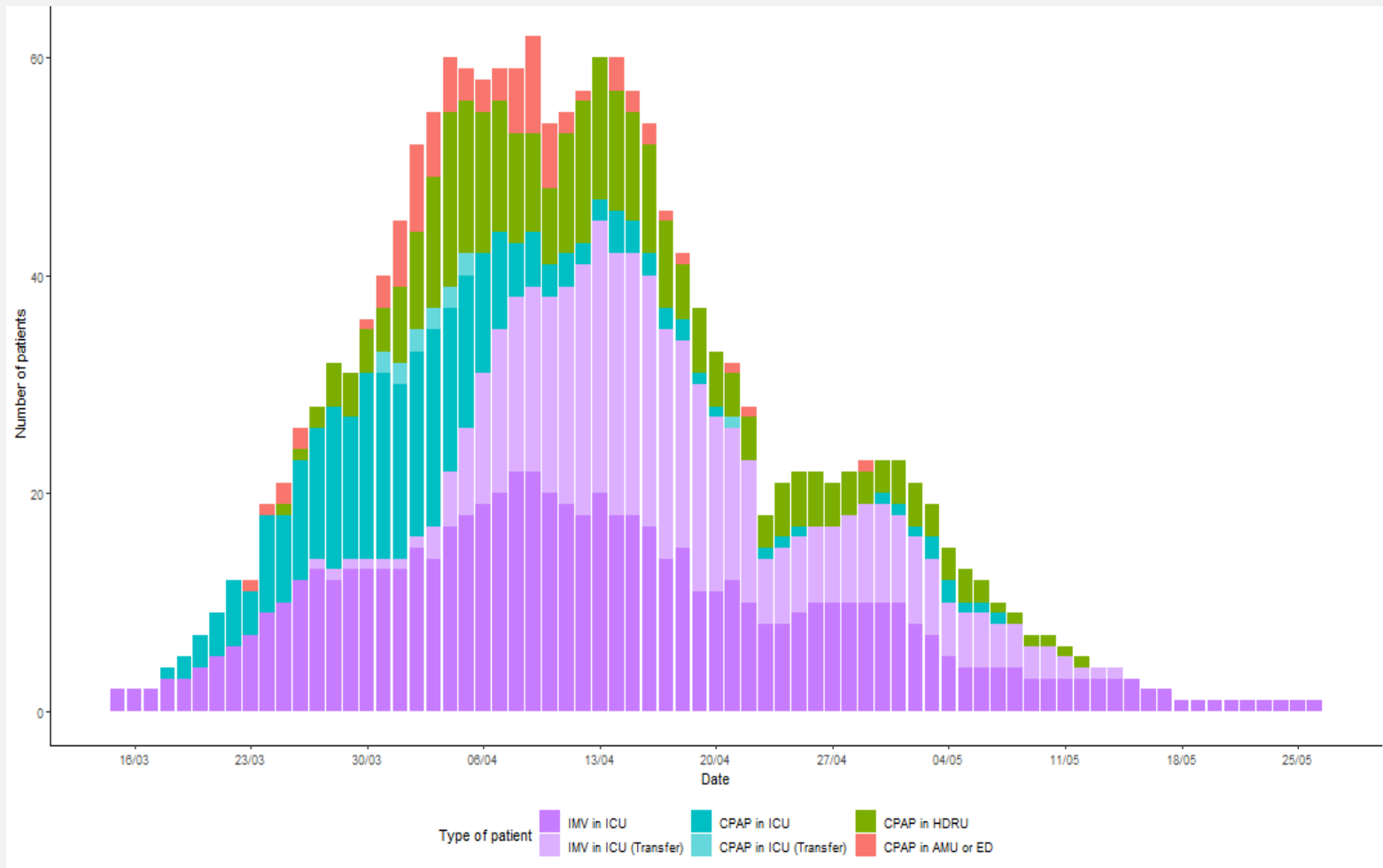
- We developed a digital dashboard using data entered into an electronic health record system.
- Detailed the number of each CPAP device in any given area.
- Each device associated with a flow demand at a given FiO_2 , allowing calculation of total flow demand.
- This can be done manually



STAFF TRAINING

- Given lack of ICU capacity, and need to deploy CPAP across the hospital, it is likely that staff will need to be trained in new skills (doctors, nurses, therapists)
- We trained 100 nurses (ward nurses, outpatient department nurses, research nurses) over 10 days
 - 2 hour teaching session on theory of CPAP therapy
 - Bedside competency and support session (30-60 minutes)
 - Further specific training sessions on individual CPAP devices
- We deployed a limited number of highly-trained nurses (ICU, Respiratory specialist nurses) per shift to offer supervision and support – seeding skills
- Close links with the ICU provided opportunity for nurses to gain experience in ICU settings
- We began with a 1:2 nurse: patient ratio, moved to 1:3 and had planned to slip to 1:4

SYSTEM BENEFITS OF A CPAP STRATEGY DELIVERED OUTSIDE ICU



Q&A