AUCKLAND
DISTRICT HEALTH BOARD
Te Toka Tumai

ADHB adult ICU surge capacity plan

Estimated resource requirements to reach 300% capacity (102 beds)

Auckland District Health Board

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Executive summary

Increasing ADHB adult ICU capacity to 300% baseline to cope with a pandemic surge is the maximum recognised surge capacity an adult ICU can be expected to try to achieve. To achieve this in ADHB will require considerable resources in terms of staffing and equipment. This report is an initial attempt to scope the scale of these requirements.

In order for ADHB to increase adult ICU bed capacity up to three fold in the face of a surge of critically ill patients with COVID 19 the following steps should be taken as soon as possible:

- Secure 54 of the ventilators on order with the MOH. Ideally, these ventilators would be from the same providers that ADHB is currently using i.e. Draeger and Servo.
- Urgent consideration needs to be given now as to how the two ICUs' floor space can be reconfigured (with walls, doors and air conditioning) so that various combinations of COVID19 positive, possible and negative patients can be cared for simultaneously, in a safe environment, without loss of intensive care bed capacity.
- Develop a plan to source untrained bed side 'helper' staff (effectively Health Care Assistants or HCAs) on the ICU
    - Ensure that a pathway exists to recruit or redeploy, and orientate these staff to the ICUs rapidly. Up to 340 FTE may be required.
- Stock take of all ICU experienced nurses who are cleared by occupational health to work in COVID 19 areas.
    - Ensure that there is the capacity to redeploy 60 ICU experienced FTE from other areas. If not, new ICU RNs need to be employed and commence training now.
- Stock take of all ICU experienced RMOs and SMO anaesthetists who are cleared by occupational health to work in COVID 19 areas.
- Urgent stock take of monitors, infusion pumps, pressure transducing sets, feeding pumps and ICU suitable hospital beds. Establishing exactly how many of each of these ADHB has available is problematic as these devices are not 'tagged' and circulate around the hospital.
- Order up to 52 further beds and 56 multiwave monitors.
- Order up to 52 capnographs, 52 pressure transducing sets, 52 feeding pumps and 156 infusion pumps. If not ordered, the supply chain should be explored to define the likely lag time from ordering to arrival.
- Consider purchase of up to 8 Prismaflex dialysis machines, 3 standing hoists and 3 patient hoists.
- One ward area, (with 81, 83 or 42 being the most likely), should be designated for possible conversion into a 20 bedded ICU facility. A detailed plan should be drawn up, with a best case time line for the conversion to occur established. The budget for this conversion should be preapproved so that work can proceed at pace when a predefined trigger point is hit.
- Plans need to be drawn up for walls and doors to enclose both level 8 PACU and level 4 PACU. Air conditioning needs to be assessed for adequacy and potential for turning area into negative pressure area. A PPE station for entry/exit needs to be defined for each.
- Further work is required to define what expansion of allied health professional FTE will be required to provide adequate levels of care to the expanded ICU beds.
- The supply chain for essential intensive care consumables such as intravenous drugs, PPE and oxygen needs to be explored and made as resilient as possible.

What is the purpose of this report?

The purpose of this report is to define what staff, equipment and floor space will be required to increase the adult intensive care bed capacity at Auckland City Hospital from its previous level of 34 beds (18 on CVICU and 16 on DCCM) to 102 beds in total. This increase represents an increase of 200%.

This report does not specifically look at the requirement for an adequate reticulated oxygen delivery infrastructure, PPE for staff or an adequate supply of intravenous and enteric drugs required for care of these critically sick patients. Clearly all of these need to be addressed separately in order for capacity to be increased. This report also will not explore the increase in allied health professionals (AHPs) including physiotherapists, radiographers, speech and language therapists, cleaners and laundry workers, that will be required. However, it is clear that the numbers of these AHPs will also need to be expanded significantly.

Patients requiring high dependency care are not considered further here. Should the ICU expansion to 102 beds occur, then these patients will need to be cared for in a new HDU area on one of the standard wards. The ICU RNs who are not cleared by occupational health to work in COVID 19 areas would provide the initial nursing staff nucleus that could be used to train further nurses as required in these areas. The medical staffing of this/these HDU areas is not considered further in this paper. Monitoring would have to occur using the M540 monitors only as multiwave form monitors would be a scare resource at this level of expanded intensive care capacity.

What is current best intensive care practice?

Current best practice in intensive care units is laid out in the College of Intensive Care Medicine's policy document ICM-1. This includes recommendations on minimum staffing, equipment and floor space. In the face of escalating demand from a pandemic, these minimum standards may not be possible to maintain. The risk of strict adherence to these standards is that patients who might otherwise be treated, are not, and as a result some die who otherwise might not.
However, degrading the recommended model of care (MOC) or accepting lesser standards, also runs some risk. Specifically, that the treatment provided is so subpar, that harm outweighs the potential benefit. The degraded MOC where this may occur is not known. Harm may be suffered not just to the patient, but, perhaps more importantly, may occur to staff. This harm can include post traumatic stress disorder and severe depression, as well as physical harm, including infection with SARS-CoV 2 as a result of fatigue and failure to adhere to strict PPE donning and doffing guidance when working in such testing conditions.

What is required to deliver intensive care in a pandemic?

1) **Staff**. This includes nursing staff, both skilled and relatively unskilled. Medical staff, both specialist and junior doctors. Allied health professionals such as physiotherapists, speech and language therapists, dieticians, pharmacists. Health care assistants. Cleaners. Laundry workers.
2) **Equipment**. A ventilator. Intravenous drug infusion pumps (3 minimum per patient). Multi wave monitors including capnography and at least one pressure transducing set. A hospital bed, preferably an intensive care bed (these will help to ensure that pressure injury morbidity is kept to a minimum). Patient lifting hoists (1 per area) and other mobilising equipment (e.g. a standing hoist). A proportion of beds will also require a 'dialysis machine', usually in ACH a Prismaflex for supporting patients with acute kidney failure.
3) **Physical floor space**. Adequate access to uninterruptable power source (UPS) and standard power, oxygen and medical air, and suction. Ideally this would be in an area where air flow (air conditioning) can be controlled to provide a negative pressure room / area with 12+ air changes per hour, which will serve to protect staff from infection. There will also need to be a clearly defined PPE donning and doffing area, an adequately sized staff break room and office/computer space.

What tradeoffs can reasonably be made in the face of this pandemic?

1. **Nursing Model of care**

The first barrier to an expanded number of intensive care beds is likely to be the nursing MOC. In other jurisdictions outside Australia and New Zealand one ICU nurse regularly looks after more than one ventilated patient. It is likely that having one ICU nurse per two ICU patients or one ICU nurse buddied with a non ICU nurse (or other AHP) will provide a reasonable level of care to these patients, who will often have single organ failure and require many days in an ICU (admission and discharge paper work etc is much reduced). Benefit is likely to exceed the additional risk of such a degraded MOC.

This MOC can be degraded further to ratios of 1 ICU nurse to 3 or 4 patients with 0 or 1 assistant (either a ward nurse or other AHP). In the United Kingdom currently, many intensive care facilities are now operating with 1 ICU RN per 4 patients. This is the lowest model of care that is considered in this report. With these degraded MOCs 'turning teams' can be employed to mitigate the risk of pressure injury from patients not being turned regularly by the reduced staff. A group of 3-4 AHPs/Health Care Assistants (HCAs)/non ICU doctors are employed who move from patient to patient turning them regularly to reduce pressure injury. In some of the sickest patients these turning teams are used to place the patient prone. A 'proning team' will require 6 persons.

2. **Equipment**

Operating room ventilators and transport ventilators may be used in the short term, but are not ideal for prolonged ventilation of patients with sick lungs. Purpose built intensive care ventilators synchronise better with patient's own breathing when they are in the recovery phase of their illness. ICU nursing staff may not be familiar with anaesthetic machine ventilators and this poses a specific risk, which is likely to be able to be largely mitigated by deploying anaesthetists and anaesthetic technicians to educate these nurses. Infusion pumps are required to provide sedation and cardiovascular support, and whilst the number of pumps can be reduced, the minimum number probably lies at three per patient, and many patients will require more. Additional equipment that will be needed for the expanded number of beds will include one multiwave monitor, one capnography and one pressure transducing set per additional bed. Further haemodialysis machines and patient hoists will also be needed.

3. **Medical Staffing**

The medical staffing model will likely next become degraded. The CICM guide of one SMO intensivist and one RMO per 12-15 patients will need to be breached. This can be mitigated by use of 'intubation' teams, staffed by other non-ICU SMOs who can carry out time consuming procedures under the direction of an intensivist. Other SMOs (such as anaesthetists) will be able to direct the intensive care of patients under the supervision of an SMO intensivist. With the support of anaesthetist SMOs it is likely that an SMO intensivist could appropriately supervise the care of a much expanded cohort of patients.

4. **Physical floor space and equipment**

Once the ICUs' physical bed space capacity is filled, then patients will need to be cared for in one or both of the PACU areas (levels 4 and 8). These bed spaces will be smaller than ideal, but the services will be adequate. The level 4 PACU (PACU4) will need doors put onto an open doorway and the level 8 PACU (PACU8) will need to be sealed off from the rest of the operating theatre complex with a combination of temporary walls and doors.

Once this floor space is being used, another ward area will need to be identified for a further 20 bed spaces (see below). The option of placing patients in an operating room will likely exacerbate the staffing problems as only two patients will be able to be placed in each room. This would make MOCs lower than one ICU nurse per two patients impossible to achieve. Ideally, the ward into which the intensive care beds will expand should be identified now and plans drawn up to facilitate its rapid modification into a suitable intensive care environment, should it be required.

Table 1: Physical bed spaces and equipment

Step	COVID patient numbers	Phase	Total Ventilated Beds	Total ICU bed spaces	Total HDU Beds in the CVICU or DCCM	ICU bed availability variation dependent on breakdown COVID / non COVID*	Medical staff	Nursing MOC	Kit requirements	Notes
1a	0 - 5	BAU/Prepare	18 + 16	18 + 18	8 +6	No loss		standard	none	
1b			18 + 18		8 + 6			standard	2 ventilators 2 capnographs	
1c		ANZICS min impact at up to 3 patients	18 + 24		8 + 0			standard	6 friend of Fiji ventilators deployed into DCCM HDU beds 6 capnographs	
2	6-13	ANZICS moderate impact at 3-8 patients	26 + 18	26 + 18	0 + 6	Loss of up to 7 beds if wrong case mix	? on site 24/7 ICU SMO or SMOs	standard	8 capnographs for CVHDU	CVHDU becomes COVID cohort room
3a	14-17 18-26	ANZICS severe impact at up to 8-17 patients	26 + 18	26 + 24	0 + 0	Loss of up to 11 beds if wrong case mix. COVID patients in DCCM main area		MOC 1:1	none	6 HDU beds converted to clean ICU in DCCM. Level 8 PACU ⇨ HDU
3b	27-32	18 + patients ANZICS says overwhelming	26 + 24	26 + 24	0 + 0	Loss of up to 5 beds if wrong case mix	Additional RMOs required for ICU rosters	MOC 1:1	none	All DCCM beds are COVID ICU Others ⇨ CVICU
4	33-39	Severe impact				Loss of up to 3 beds with wrong case mix	Additional RMOs required for ICU rosters	MOC 1:1	none	COVID patients in CVICU rooms 5,6,7?
At this level either fill CVICU with COVID patients and non COVID in PACU8 OR put COVID ICU patients in PACU8 and keep remaining CVICU beds for non COVID patients requiring emergency or urgent surgery (preferred). Convert level 8 PACU to 20 ICU beds. ALTERNATIVE PLAN would be to convert PACU4 (step 6 below) to ICU beds before PACU8 i.e. step up to 62 beds first.										
5	Total ICU patients now 40 – 70. COVID and non COVID	Severe impact	26 + 24 + 20	26 + 24 + 20	(12)		Anaesthesia provide medical staff	Degraded Min2	20 ventilators# 20 capnographs 20 beds 60 pumps ? monitors** Patient lifting hoist x 1 and standing hoists x1	HDU now in level 4 PACU 12 beds. Place temporary walls / doors to isolate the PACU space. Air changes?
Convert level PACU4 to ICU. Once level 8 PACU transitioned to ICU need to begin converting another ward area (81,83 or 48) to become an ICU area.										
6	Total ICU patients now 70 – 82. COVID and non COVID	Severe impact	26 + 24 + 20 + 12	26 + 24 + 20 + 12	HDU provided in ward setting		Anaesthesia provide medical staff	Degraded Min2	12 ventilators 12 capnographs 12 Beds 36 pumps ? monitors** Up to 8 new Prisma Flex ## Patient lifting hoist x 1 and standing hoists x1	HDU level care moved to a ward. Level 4 PACU now ICU beds. New door put on level 4 PACU. Air changes?
7	83-102 (3 x original capacity)	Maximum impact	26 + 24 + 20 + 12 + 20	26 + 24 + 20 + 12 + 20	HDU provided in ward setting		Anaesthesia provide medical staff	Degraded min	20 ventilators 20 capnographs 20 beds 60 pumps ? monitors** Patient lifting hoist x 1 and standing hoists x1	New floor space required or ICU provided in the ORs

Table 1 key:
Colour coding reflects the levels of impact as outlined in the ANZICS COVID-19 guidelines version 2 https://www.anzics.com.au/wp-content/uploads/2020/04/ANZI_3367_Guidelines_V2.pdf
* When COVID patients begin to be cohorted in a new multi-bedded area, there is the potential for loss of ICU capacity, as non COVID patients cannot be managed in the same area. This column details the maximum loss in capacity at each stage.
**Once ICU capacity is increased beyond 50 beds there is the possibility of inadequate monitoring provision. Pressure cables for invasive pressure monitoring are required, as are multi waveform monitors, and ideally capnography. It is unknown how many of these pressure cables / capnography units are available. There needs to be an urgent inventory performed and additional devices acquired.
transport ventilators and anaesthesia machine ventilators have not been counted in this plan. In extremis these devices could be used in the short term to provide invasive ventilation, but are not ideally suited to the task. Transport ventilators may well be needed for transport of patients to CT scanning etc. Stock of transport ventilators is 5 DCCM and 3 CVICU.
assuming need for RRT is 20% of ICU bed capacity. Current stock of machines is 8+4.

Nursing Models of Care

Standard Nursing Model of Care

In accordance with CICM guidelines, the standard model of care is 1 ICU experienced RN per patient, with 1 RN runner per 8-10 patients and 1 CNC per 12-15 patients. The runner and CNC ratios will also vary with the workload and experience of the bedside nurse. With COVID patients necessitating the use of PPE, there is a requirement for a PPE spotter/trainer per area where PPE is in use.

Degraded Nursing Models of Care

A degraded model of care will allow successful intensive care treatment of more patients with minimal/acceptable risk. As outlined above, these degraded MOCs may entail using non ICU trained RNs, or other allied health workers / health care assistants, or no one. They may also entail using non ICU experienced SMOs/ RMOs and/or a degraded standard of equipment/monitoring. The nursing MOC could be altered to 1 ICU RN buddied with 1 non ICU RN (1:1 ratio) or 1:2 or 1:3 ratios, or potentially an allied health professional (AHP) or health care worker (HCA) in place of a non ICU RN (as has happened in the UK). At an extreme it may even involve staffing beds with 1 ICU nurse to 2,3 or 4 ICU patients with no additional staff allocated in the bed spaces per se. With this degree of degraded MOC, 'turning teams' (of 4-6 HCAs/AHPs) will need to be deployed to mitigate the risk of pressure injury from patients not being able to be turned by the limited bedside staff.

In the following degraded nursing MOCs, the runners are still assumed to be ICU experienced RNs, as is the CNC, but the PPE spotter could well be an AHP. Of course, the runner numbers could also be reduced further, but these staff will become increasingly important for providing break relief to ICU nurses already looking after 2, 3 or 4 patients (cross cover will not be possible without significant risk to patients wellbeing). For the purposes of determining FTE required, I have calculated using the following numbers in each intensive care area.

Table 2: Staff numbers and roles in each unit using various nursing MOCs

	Beds	CNC	Runner	Spotter	ICU RN	Ward RN / AHP/HCA
CVICU current	18+8	2	3	0	22	
CVICU (std MOC)	26	2	4	1 or 2 RN	26	0
CVICU (1:1)	26	1	4	2 AHP	13	13
CVICU (1:2)*	26	1	4	2 AHP	9	17
CVICU min2	26	1	3	1 AHP	9	9
CVICU (1:3 combo 1:2)	26	1	4	2 AHP	7	19
CVICU min	26	1	3	1 AHP	7	7

DCCM current	18+6	2	3	0	21	
DCCM (std MOC)	24	2	4	1 or 2 RN	24	0
DCCM (1:1)	24	1	4	2 AHP	12	12
DCCM (1:2)	24	1	4	2 AHP	8	16
DCCM min2	24	1	3	1 AHP	8	8
DCCM min**	24	1	3	1 AHP	7**	7**
PACU 8 (1:1)	20	1	3	1 AHP	10	10
PACU 8 (1:2)	20	1	3	1 AHP	7	13
PACU 8 min2	20	1	3	1 AHP	7	7
PACU 8 min	20	1	3	1 AHP	5	5
PACU 4 (1:1)	12	1	1	1 AHP	6	6
PACU 4 (1:2)	12	1	1	1 AHP	4	8
PACU 4 min2	12	1	2	1 AHP	4	4
PACU 4 min	12	1	2	1 AHP	3	3
EXTRA (1:3)	20	1	3	1 AHP	5	15
EXTRA min	20	1	3	1 AHP	5	5

*because of bed geography a 1:2 MOC is impossible to achieve in the 3x4 bedded rooms
**2 sets of 6 beds and a 12 bed area, needs 4 + 3 teams

Std MOC - 1 ICU RN per patient

MOC 1:1 - 1 ICU RN per 2 patients assisted by up to 1 other

MOC 1:2 - 1 ICU RN per 3 patients assisted by 2 others – unlikely to ever be realised due to the high number of others needed unless escalation was extremely slow and sustained.

MOC 1:3 - 1 ICU RN per 4 patients assisted by 3 others – unlikely to ever be realised due to the high number of others needed unless escalation was extremely slow and sustained.

MOC min2- 1 ICU RN per 3 patients assisted by 1 other

MOC min - 1 ICU RN per 4 patients assisted by 1 other

Roving turning teams will be needed for the min MOCs.

RN / AHP / HCA staffing

Each ICU bed/position requires 4.2 FTE to staff 24/7 without annual leave being taken. 5.3 FTE with leave allowance. 5.8 with 10% sick leave. 6.4 with 20% sick leave and 6.9% with 30% sick leave. A worst case scenario of 30% sick leave has been included in the calculations.

ICU RN / ward RN / AHP / HCA Staffing requirements for different numbers of ICU beds and differing nursing MOCs

OH = occupational health; OT = over time.

Current State (2 additional DCCM beds staffed from baseline)

Table 3: All beds in ICU open as ICU or HDU bed as designed. See table 2. Assumes that staff take annual leave, but there is either no sick leave at all or 30 % sick leave:

Current MOC	No sick leave ICU RN	30% sick leave ICU RN
CVICU 18+8	143.1	186.3
DCCM 18+6	137.8	179.4
TOTAL FTE required	280.9	365.7
Actual FTE across 2 units not OH restricted*	259.6	259.6
Deficit to run all 50 beds (34 ICU and 14 HDU) ideal MOC	21.3	106.1
	Need to recruit/pay OT for 21.3 FTE	Need to recruit/pay OT for 106.1 FTE

*numbers as supplied on 8/4/20 by AG

This means that 36 ICU and 14 HDU beds may be run across the 2 ICU units with 3 runners on each unit with the current OH cleared staff provided there is no staff sickness, with some overtime. With 30% staff sickness there would be a significant short fall in staffing of these beds and a degraded MOC would be needed to keep them all open.

All 50 beds run as ICU beds

Table 4: To run all 50 beds with degraded MOC not worse than 1:1 (all numbers in FTE)

MOC 1:1	No sick leave ICU RN	No sick leave RN/AHP/HCA	30% sick leave ICU RN	30% sick leave RN/AHP/HCA
CVICU 26	95.4	79.5	124.2	96
DCCM 24	90.1	74.2	117.3	89.6
TOTAL FTE required	185.5	153.7	241.5	185.6
Actual ICU RN FTE across 2 units not OH restricted	259.6	0	259.6	0
Deficit to run all 50 beds ideal MOC	Surplus 74.1	Need to recruit/pay OT 79.6 FTE	Surplus 18.1	Need to recruit/pay OT 167.5 FTE
		ICU RN surplus used to fill RN/AHP/HCA positions so MOC better than 1:1		ICU RN surplus used to fill RN/AHP/HCA positions but numbers mean MOC effectively 1:1

In order to get to 50 ICU beds with MOC 1:1, the organisation would have to recruit/redeploy ~167 FTE of RN/AHP/HCA to the ICUs. If these were RN, then these RNs would be learning on the job to become proficient ICU RNs, and after a period of weeks (? 6 weeks) would be able to be considered as proficient enough ICU RNs for further bed expansion (preferred). Alternatively, a 'proning team' of 6 persons could be deployed per shift (= to 41.2 FTE) which could be recruited and deployed with little training and the 50 beds run with the majority of beds staffed as 1 ICU RN per 2 patients. With sudden expansion of the ICU capacity and little time to train staff, this would be the preferred way of staffing for treatment of up to 50 ICU patients.

All ICU and PACU beds used as ICU beds

Table 5: To run 82 beds with degraded 'MOC min 2' (1:1:3 or 1 ICU RN +/- 1 helper per 3 patients - all numbers in FTE)

MOC 1:2	No sick leave ICU RN	No sick leave RN/AHP/HCA	30% sick leave ICU RN	30% sick leave RN/AHP/HCA
CVICU 26	74.2	53	96.6	69
DCCM 24	68.9	47.7	89.7	62.1
PACU8 20	58.3	42.4	75.9	55.2
PACU4 12	31.8	26.5	41.4	34.5
TOTAL FTE required	233.2	169.6	303.6	220.8
Actual ICU RN FTE across 2 units not OH restricted	259.6	0	259.6	0
Deficit to run all 82 beds at MOC 1:2 or better	Surplus 26.4 ICU RN not that much in excess MOC effectively 1:2	Need to recruit/pay OT/redeploy 169.6 FTE	Deficit Need to recruit/train 44 FTE ICU RN to manage	Need to recruit/pay OT/redeploy 220.8 FTE

If ADHB had to rapidly expand to this number of beds, then recruiting and training on the job of 44 FTE ICU RN would most likely be feasible, provided that such an expansion occurred over 6-12 weeks. If the MOC was 1 ICU RN per 3 ICU patients with no 'helper' then it would be necessary to deploy 1 'proning team' of 6 staff at a staff cost of 41.4 FTE. Two turning teams of 4 staff would also be required at a staff cost of 55.2 FTE. This is because approximately 25% of patients need to be turned prone, the rest will just need to be turned regularly (+/- have sheets changed). So 96.9 FTE for turning/proning teams, with potentially another 220.8 FTE staff to become unskilled bed side helpers. This FTE expansion would represent a significant challenge.

Three times starting capacity (102 beds) – Additional clinical area fitted out for 20 ICU beds

Table 6: To run 102 beds with 'MOC min' (1:1:4) not worse than 1 ICU RN +/- 1 other staff per 4 patients (all numbers in FTE) and/or a minimum of 3 full time 'turning teams' of 4 persons and one 'proning team' of 6 persons

MOC minimum	No sick leave ICU RN	No sick leave other	30% sick leave ICU RN	30% sick leave other
CVICU 26	58.3	42.4	75.9	55.2
DCCM 24	58.3	42.4	75.9	55.2
PACU8 20	47.7	31.8	62.1	41.4
PACU4 12	31.8	21.2	41.4	27.6
EXTRA 20	47.7	31.8	62.1	41.4
TOTAL FTE required	243.8	169.6	317.4	220.8
Actual ICU RN FTE across 2 units not OH restricted	259.6	0	259.6	0
Deficit to run all 102 beds at MOC 1 ICU & 1 other per 4 patients	Surplus	Need to recruit/pay OT 169.6 FTE	Deficit 57.8 Need to recruit/train 57.8 FTE ICU RN to manage	Need to recruit/pay OT 220.8 FTE
	1 proning team 6 persons	31.8 FTE	1 proning team 6 persons	41.4 FTE
	3 turning teams of 4 persons	63.6 FTE	3 turning teams of 4 persons	82.8 FTE
	Each team has to turn	25 patients		

With 102 beds staffed on a further degraded MOC, the unskilled staff numbers required increase slightly but the skilled ICU nursing staff only increase a small amount.

Medical Staffing

For business as usual the CICM stipulates in IC – 1 https://www.cicm.org.au/Resources/Professional-Documents#Policies that there should be 1 SMO and 1 other doctor (usually an RMO) per 8-15 patients. Given the geographic locations of the additional possible intensive care areas and the patient numbers, this would mean that ideally there would be 2 intensivists and 2 RMOs on CVICU, DCCM and the two 20 bedded expansion areas (PACU8 and other) and one additional SMO and RMO for the PACU 4 area. It is unlikely that this staffing could be achieved in the setting of a pandemic surge with rapid escalation to 102 intensive care beds. If it were, it is unlikely that it could be sustained for anything other than a short period of time. In the extreme circumstances of a rapid pandemic surge, it is possible to imagine that a degraded medical model of care (MMOC) would be employed. In this degraded MMOC each additional clinical area (PACU 8, PACU 4 and other) might be supervised by one non intensivist SMO (probably an anaesthetist), with over sight provided by a 'shared roaming' supervising intensivist. It is also possible to imagine that some of the senior RMOs (fellows currently employed as MOSSs) might in these extreme circumstances, 'act up' as SMOs on either the CVICU or the DCCM, 'buddied up' with an SMO intensivist. The two intensive care areas would, under this model take the more complex patients (such as those requiring multiorgan

support, not just respiratory support). The additional need for a triage/coordination team of one CVICU and one DCCM SMO would mean that numbers might at worst look like this:

Table 7: Medical Staff

	SMO day	SMO night	RMO day	RMO night
Triage	**2**	**2**		
CVICU	**2**	**1**	**2**	**2**
DCCM	**2**	**1**	**2**	**2**
Supervising intensivist	**1***	**1***		
PACU4	**1**	**1**	**1**	**1**
PACU8	**1**	**1**	**2**	**2**
Other	**1**	**1**	**2**	**2**
Total	**10**	**8**	**9**	**9**

*The supervising intensivist could come from either unit and would provide oversight for the anaesthetist SMOs in PACU4/8 and other. Pragmatically this may be with help from one of the SMOs rostered in the CVICU or DCCM for that shift depending on the complexity of the patients actually being cared for in the intensive care areas. As per the recommendation of the hospital's clinical ethics advisory group, the triage intensivists would have no direct patient care duties. Current SMO head count for CVICU is 8 and DCCM is 12. There are also a total of 4 fellows across the 2 units currently. It can be seen that three SMO anaesthetists minimum will be needed per shift. This staffing requirement does not take into account additional SMO anaesthetist numbers that would be required for RRT calls / ward consultations / HDU patients that have been moved into other areas.

For the following table it is assumed that there is 30% sick leave, either for actual illness or self isolation requirements, and that SMOs and RMOs work 14 hour clinical shifts (12 hours on with up to 2 hours for medical handover and doffing of PPE), at 4 per week where possible.

Table 8: Medical Staff Clinical Shifts

	SMO			RMO		
	SMO day	**SMO night**	**Total**	**RMO day**	**RMO night**	**Total**
SMO intensivist	**7**	**5**	**12**	**4**	**4**	**8**
Shifts/week	**49**	**35**	**84**	**28**	**28**	**56**
Sick weighting (30% loss)			**120**			**80**
Actual head count (May 2020)			**24**			**20**
Shifts per head			**5**			**4**
SMO anaesthetist	**3**	**3**	**6**	**5**	**5**	**10**
Shifts/week	**21**	**21**	**42**	**35**	**35**	**70**
Sick weighting (30% loss)			**60**			**100**
Head count needed 4 shifts/week			**15**			**25**

It can be seen from Table 8 above that even with the minimum staffing laid out in Table 7, the SMO intensivists would need to work 5 shifts/ week, which is unlikely to be sustainable beyond a few weeks. This staffing model also leaves no time for nonclinical work, some of which will be essential, such as education/orientation of new staff. The current intensive care RMOs would be enough in number provided that they were allowed to work 56 hours a week on average. ADHB would have to find/deploy 15 SMO anaesthetists and 25 additional RMOs with some ICU experience in order to make this minimum staffing model possible. This would be in addition to finding staff for the RRT, HDU areas and the COVID intubation team, all of which are required for the minimum medical staffing model for the intensive care beds to be employed.

Table 9 below outlines the steps needed for medical, nursing and unskilled staff recruitment for ACH to get to that capacity.

Disposables

The rapid expansion in ICU beds in the UK and other jurisdictions has put considerable pressure on hospitals' supply chain for certain disposable equipment/supplies. In order to deliver intensive care a secure supply of drugs, oxygen, ventilator circuits and PPE will be required. Whilst oxygen supply and delivery infrastructure in Auckland City Hospital appears to be robust, the supply of PPE and drugs appears less secure. A shortage of haemofiltration disposables has also been encountered in some hospitals in the UK.

The required amount of PPE is likely to be 30-40 sets per patient per day in ICU initially. This may fall with savings from cohorting of patients (and poorer nurse:patient ratios) to approximately 15-20 sets/patient/day. Thus at 50 ICU patients the rate of PPE consumption may be approximately 1500-2000/day, and this may not increase by much as numbers expand to 100 patients.

Data is available on the current usage of sedatives and muscle relaxants, and the number of patient ventilator days, in both the CVICU and DCCM. In DCCM there are ~1650 patient ventilator days and in the CVICU ~ 2570. This equates to there being on average 5 patients receiving mechanical ventilation (and sedation) on the DCCM and 7 on the CVICU, or 12 in total. It appears from UK data (ICNARC https://www.icnarc.org/(X(1)A(fOTicSm4zAEkAAAAMDQxMTAxNWYtMDg3Mi00M2U3LTk4ZWQtODM4NWI4YjY4ODZibpjeDjL5I5Eo_kKsH30TVZJ9cgg1))/Our-Audit/Audits/Cmp/Reports) that ventilated COVID19 patients need a longer duration of mechanical ventilation (survivors median 15 days, non-survivors median 9 days) than patients currently admitted to the two ICUs. It is difficult to predict how this median increase in ventilator days per patient will affect drug usage during the period of mechanical ventilation. Whether a tracheostomy is performed earlier or later in these patients (which may significantly reduce the need for sedative drugs) will have a significant bearing. However, what is clear is that if an expansion of ventilated patients occurred from the base line number to ~50 (assuming that of the 102 ICU beds, half will be occupied by patients who are not mechanically ventilated via an ETT), then an increase in sedative and paralytic drug usage of at least 4-5 fold can be anticipated, and it may be considerably more.

Conclusion

Increasing adult ICU capacity in ADHB from 34 to 102 beds will necessitate significant investment in staff, equipment and infrastructure, not just ventilators. It also relies on a secure supply chain of certain essential consumables, including but not limited to intravenous drugs, PPE, enteric nutrition and oxygen. A provisional road map as to how to expand the staff and physical floor space is detailed below in table 9, but without security of the supply chain for consumables, the increase in capacity that is detailed may not be deliverable even with the expansion of staff and degraded MOC.

How do we get to 102 beds?

Table 9. *Currently in process

Phase/Time line	Beds	Action
BAU with 30% staff sick	Up to 28-30 beds across both units can be staffed	
BAU staff sickness all covered with overtime provided by existing staff pool	Up to 35 ICU beds across both units	Pay existing staff over time and recruit and train
Phase 1 MOC 1:1	Expand to use all 50 ICU beds as ICU beds	Aim to recruit / reallocate up to 60 FTE of RNs and begin training up to be competent ICU RN with buddying system of 1:1. Identify staff for reallocation and backfill expectations
Immediately upon exceeding BAU beds	RRT/HDU/COVID intubation team all need to be staffed by non ICU medical staff	
	Need to recruit and train in cohorts of 30 FTE.* Other positions may be covered by HCA/AHPs	Parallel recruitment of HCA/AHPs to assist with patient care 1 staff:1 patient - 167.5 FTE
6 weeks	First cohort of 30 FTE new ICU RN complete basic training. Commence on second cohort if available	
	Expand RMO numbers in ICU. Commence orientation /training on the job of anaesthetist SMOs to care for ICU patients. Open HDU areas outside of ICUs.	Staffed all 50 beds with better than 1 ICU RN per 2 patients with up to 30% sick leave, aim would be for 1 other staff member for all 'extra patients' – likely not achievable (need 167.5 FTE)
Phase 2 MOC 1:1 – min2	50 to 62 beds (ICU +PACU4) Identify and plan next expansion area beyond PACU	MOC now between 1 ICU RN /2 or 3 patients ?with each 1 ICU RN with a buddy RN/HCA/AHP
	MMOC now definitely degraded below minimum CICM	Proning team x1 Turning team x 1
	Anaesthetic SMOs now primary decision maker for some ICU patients, with single organ failure, cared for in expansion area(s) with intensivist oversight.	69 'other' FTE required for turning teams
Hopefully 4-6 weeks	Have now trained second cohort of 30 FTE new ICU RN Identify ward areas for HDU	
Phase 3 MOC min2	63 to 82 beds (PACU8)	MOC now 1 ICU RN / 3 patients ?with each 1 ICU RN with a buddy RN/HCA/AHP
	HDUs move to ward areas	Proning team x1 turning team x2
	To deliver this MOC need to have expanded ICU RN FTE by 22 (1 cohort). If more have been trained then minimum model of care will be better than 1 ICU RN / 3 patients	Assumes 20% sick leave or ICU RN FTE needs to be expanded by more Needs total of 220.8 other FTE + 96.6 'other' FTE for 1 proning team and 2 turning teams
Phase 4 MOC min	82 to 102 beds. (other) Needs identified and equipped physical space	MOC at worst now 1 ICU RN / 4 patients ?with each 1 ICU RN with a buddy HCA/AHP
	To deliver this MOC need to have expanded ICU RN FTE by 60 (2 cohorts of 30). If more have been trained then minimum model of care will be better than 1 ICU RN / 4 patients	Assumes 30% sick leave or ICU RN FTE needs to be expanded by more Another 27.6 'other' FTE for additional turning team
	Need to have minimum 15 anaesthetic SMOs and 25 RMOs with ICU experience	Proning team x1 turning team x3
		Continue to recruit more HCAs/AHP if no more RNs available