Optimal ICU Design-
‘How to build a new ICU-The Good, the bad and the ugly’

Conflicts

- None
- No funding from our commercial Partners-McGoughlin & Harvey; Philips; Acrylisize; Getinge; ASCOM; Brandon-Medical

King's Critical Care

10 years...in 10 minutes

5 Jul 2018
17:02

Tom Best, critical care consultant: 'It's a massive project, 10 years in the making'

Jessica Elgot

Professor Dunnett, London Olympics

Evidence Base

"Little as we know about the way in which we are affected by form, by colour, and light, we do know this, that they have an actual physical effect"
Florence Nightingale, 1859

Special Article

Guidelines for intensive care unit design*

Dan R. Thompson, MD, MA, FACP, FCCM (Co-Chair); D. Kirk Hamilton, FAIA, FACHA (Co-Chair); Charles D. Cadenhead, FAIA, FACHA, FCCM; Sandra M. Swoboda, RN, MS, FCCM; Stephanie M. Schwindel, MArch, LEED; Diana C. Anderson, MD, MArch; Elizabeth V. Schmitz, AIA; Arthur C. St. Andre, MD, FCCM; Donald C. Axon, FAIA, FACHA†; James W. Harrell, FAIA, FACHA, LEED AP; Maurene A. Harvey, RN, MPH, MCCM; April Howard, RN, CCRN, CCRC; David C. Kaufman, MD, FCCM; Cheryl Petersen, RN, MBA, CCRN

Objective: To develop a guideline to help guide healthcare professionals participate effectively in the design, construction, and occupancy of a new or renovated intensive care unit.

Crit Care Med 2012; 40:1586–1600

Evidence base

CHEST Postgraduate Education Corner

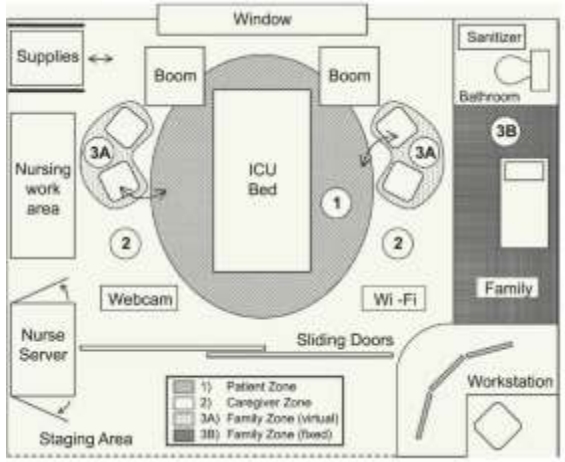
CONTEMPORARY REVIEWS IN CRITICAL CARE MEDICINE

Innovative Designs for the Smart ICU

Part 1: From Initial Thoughts to Occupancy

Neil A. Halpern, MD, FCCP

CHEST 2014; 145 (2): 399 – 403



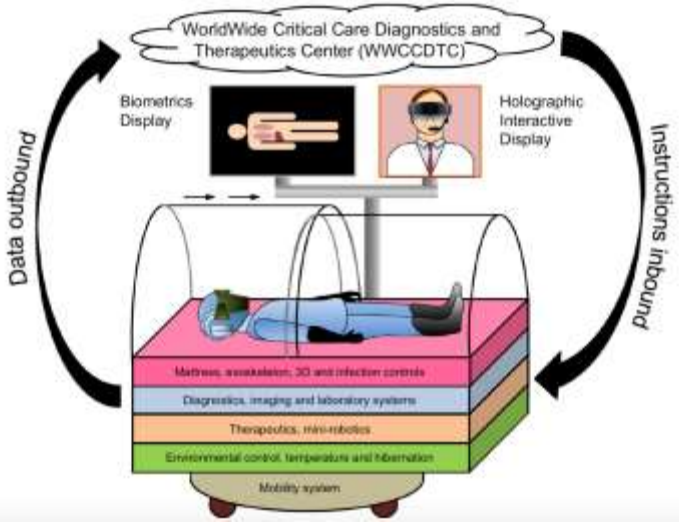
"The design of the room should focus upon functionality, ease of use, healing, safety, infection control, communications, and connectivity."

WHAT'S NEW IN INTENSIVE CARE

ICU design in 2050: looking into the crystal ball!

Neil A. Halpern[1,2,5*], Diana C. Anderson[3] and Jozef Kesecioglu[4]

Intensive Care Med (2017) 43:690–692



Intensive Care Med (2013) 39:1626–1634
DOI 10.1007/s00134-013-2966-0

ORIGINAL

Irene P. Jongerden
Arjen J. Slooter
Linda M. Peelen
Hester Wessels
Colette M. Ram
Jozef Kesecioglu
Margriet M. Schneider
Diederik van Dijk

Effect of intensive care environment on family and patient satisfaction: a before–after study

Table 3 Comparison of mean (SD) family and patient satisfaction scores, after patient discharge from the ward-like ICU and single-room ICU

	Family			Patients		
	Ward-like ICU	Single-room ICU	$p^{\dagger}$	Ward-like ICU	Single-room ICU	$p^{\dagger}$
Total satisfaction	69.5 (16.6)	74.1 (15.2)	0.02	63.6 (18.9)	69.6 (18.3)	0.02
Subscale "satisfaction with care"	65.1 (17.8)	70.8 (18.0)	0.007	63.6 (18.6)	70.3 (18.2)	0.01
Subscale "satisfaction with decision-making"	74.9 (17.4)	78.0 (14.4)	0.12	64.9 (20.4)	68.5 (20.8)	0.21

Family satisfaction: three items removed due to >60 % missing (items 5, 13, 14) and one item removed due to corrected item-total correlation <0.30 (item 31)

† *p*-Value based on *T* tests

Evidence base

Ferri et al. BMC Anesthesiology (2015) 15:57
DOI 10.1186/s12871-015-0038-4

BMC Anesthesiology

RESEARCH ARTICLE Open Access

Evidence-based design in an intensive care unit: End-user perceptions

Mauricio Ferri[1], David A Zygun[2], Alexandra Harrison[1] and Henry T Stelfox[1,3,4*]

Results: We conducted interviews with thirty-nine ICU end-users, twenty-four in the early phase and fifteen in the late phase. We identified four themes (eleven sub-themes): atmosphere (abundant natural light and low noise levels), physical spaces (single occupancy rooms, rooms clustered into clinical pods, medication rooms, and tradeoffs of larger spaces), family participation in care (family support areas and social networks), and equipment (usability, storage, and providers connectivity). Abundant natural light was the design feature most frequently associated with a pleasant atmosphere. Participants emphasized the tradeoffs of size and space, and reported that the benefits of additional space (e.g., fewer interruptions due to less noise) out-weighed the disadvantages (e.g., greater distances between patients, families and providers). End-users advised that local patient care policies (e.g., number of visitors allowed at a time) and staffing needed to be updated to reflect the characteristics of the new facility design.

Conclusions: End-users identified design elements for creating a pleasant atmosphere, attention to the tradeoffs of space and size, designing family support areas to encourage family participation in care, and updating patient care policies and staffing to reflect the new physical space as important aspects to consider when building intensive care units. Evidence-based design may optimize ICU structure for patients, patient families and providers.

Intensive Care Med (2013) 39:481–488
DOI 10.1007/s00134-012-2726-6

ORIGINAL

Irene J. Zaal
Carolina F. Spruyt
Linda M. Peelen
Maarten M. J. van Eijk
Rens Wientjes
Margriet M. E. Schneider
Jozef Kesecioglu
Arjen J. C. Slooter

Intensive care unit environment may affect the course of delirium

Table 2 Main outcomes and multivariate regression analysis

Delirious patients[a]	Old ICU ($n = 28$)	New ICU ($n = 34$)	p value
Crude number of days with delirium, median (IQR)	3 (2–5)	2 (1–3)	0.04
Adjusted difference in the number of days with delirium, (95 % CI)[b]	*Reference*	−0.4 (−0.7 to −0.1)	0.005
Mean DSI per day with delirium, mean (SD)	2.3 (0.7)	2.5 (0.8)	0.34
Adjusted difference in DSI, (95 % CI)[b]	*Reference*	0.3 (−0.2 to 0.7)	0.22
Days spent comatose, median (IQR)	4 (0–5)	1 (1–4)	0.33
Mortality, n (%)	1 (4 %)	3 (9 %)	0.72
All patients	**Old ICU ($n = 55$)**	**New ICU ($n = 75$)**	**p value**
Crude risk of delirium during ICU admission[a], n (%)	28 (51 %)	34 (45 %)	0.53
Adjusted odds ratio for delirium, OR (95 % CI)[a,b]	*Reference*	0.6 (0.3–1.6)	0.53
Mean RASS, mean (SD)	−1.1 (1.1)	−1.3 (1.4)	0.55
Days spent comatose, median (IQR)	0 (0–4)	0 (0–2)	0.94

CI confidence interval, *DSI* delirium severity index, *ICU* intensive care unit, *IQR* interquartile range, *OR* odds ratio, *RASS* Richmond agitation and sedation score, *SD* standard deviation

[a] Assessed by review of medical and nursing charts and the confusion assessment method for use in the intensive care unit (CAM-ICU)

[b] Models adjusted for age, gender, APACHE II, Charlson co-morbidity index, highest SOFA score, admission type and admitting discipline

King's Critical Care

Crit Care Med. 2014 Oct;42(10):2204-10. doi: 10.1097/CCM.0000000000000502.

ICU architectural design affects the delirium prevalence: a comparison between single-bed and multibed rooms*.

Caruso P[1], Guardian L, Tiengo T, Dos Santos LS, Junior PM.

After controlling for other variables, patients in multi-bed areas were four times more likely to be recorded as delirious than those in single rooms BUT very difficult to miss other important variables.

Darbyshire and Young *Critical Care* 2013, **17**:R187
http://ccforum.com/content/17/5/R187

CRITICAL CARE

RESEARCH Open Access

An investigation of sound levels on intensive care units with reference to the WHO guidelines

Julie L Darbyshire[1*†] and J Duncan Young[1,2†]

Results: Average sound levels always exceeded 45 dBA and for 50% of the time exceeded between 52 and 59 dBA in individual ICUs. There was diurnal variation with values decreasing after evening handovers to an overnight average minimum of 51 dBA at 4 AM. Peaks above 85 dBA occurred at all sites, up to 16 times per hour overnight and more frequently during the day. WHO guidelines on sound levels could be only achieved in a side room by switching all equipment off.

Crit Care Med. 2016 Jan;44(1):147-52. doi: 10.1097/CCM.0000000000001378.

Noise Levels in Surgical ICUs Are Consistently Above Recommended Standards.

Tainter CR[1], Levine AR, Quraishi SA, Butterly AD, Stahl DL, Eikermann M, Kaafarani HM, Lee J.

MEASUREMENTS AND MAIN RESULTS: The study included 539 participants with sound level recorded using an application downloaded to a personal mobile device from 39 ICUs. Maximum and mean sound levels were 78 dB (SD, 9) and 62 dB (SD, 8), respectively. Maximum sound levels were higher in ICUs with a sleep policy or protocol compared with those without maximum sound levels 81 dB (95% CI, 79-83) versus 77 dB (95% CI, 77-78), mean difference 4 dB (95% CI, 0-2), $p < 0.001$. There was no significant difference in sound levels regardless of single room occupancy, mechanical ventilation status, or illness severity. Clinical nursing staff in all 39 ICUs were able to record sleep assessment in 15-minute intervals. The median time awake and number of prolonged disruptions were 3 hours (interquartile range, 1-4) and three (interquartile range, 2-5), respectively.

Maybe too much to ask for evidence of benefit from building design?

Effect of intravenous haloperidol on the duration of delirium and coma in critically ill patients (Hope-ICU): a randomised, double-blind, placebo-controlled trial

Valerie J Page, E Wesley Ely, Simon Gates, Xiao Bei Zhao, Timothy Alce, Ayumi Shintani, Jim Jackson, Gavin D Perkins, Daniel F McAuley

Original Investigation

Increased Hospital-Based Physical Rehabilitation and Information Provision After Intensive Care Unit Discharge
The RECOVER Randomized Clinical Trial

Timothy S. Walsh, MD; Lisa G. Salisbury, PhD; Judith L. Merriweather, PhD; Julia A. Boyd, PhD; David M. Griffith, MD; Guro Huby, PhD; Susanne Kean, PhD; Simon J. Mackenzie, MBChB; Ashma Krishan, MSc; Stephanie C. Lewis, PhD; Gordon D. Murray, PhD; John F. Forbes, PhD; Joel Smith, PhD; Janice E. Rattray, PhD; Alastair M. Hull, MD; Pamela Ramsay, PhD; for the RECOVER Investigators

Intensive Care Med (2019) 45:1–12
https://doi.org/10.1007/s00134-018-5452-x

SYSTEMATIC REVIEW

The effectiveness of non-pharmacological interventions in reducing the incidence and duration of delirium in critically ill patients: a systematic review and meta-analysis

Leona Bannon[1*], Jennifer McGaughey[2], Rejina Verghis[1], Mike Clarke[3], Daniel F. McAuley[1] and Bronagh Blackwood[1]

JAMA | Original Investigation | CARING FOR THE CRITICALLY ILL PATIENT

Effect of a Nurse-Led Preventive Psychological Intervention on Symptoms of Posttraumatic Stress Disorder Among Critically Ill Patients
A Randomized Clinical Trial (POPPI)

Dorothy M. Wade, PhD; Paul R. Mouncey, MSc; Alvin Richards-Belle, BSc; Jerome Wulff, PhD; David A. Harrison, PhD; M. Zia Sadique, PhD; Richard D. Grieve, PhD; Lydia M. Emerson, MPH; Alexina J. Mason, PhD; David Aaronovitch, BA; Nicole Als, BA; Chris R. Brewin, PhD; Sheila E. Harvey, PhD; David C. J. Howell, PhD; Nicholas Hudson, BA; Monty G. Mythen, MD; Deborah Smyth, BSc; John Weinman, PhD; John Welch, MSc; Chris Whitman, BSc; Kathryn M. Rowan, PhD; for the POPPI Trial Investigators

ORIGINAL ARTICLE

Five-Year Mortality and Hospital Costs Associated with Surviving Intensive Care

Nazir I. Lone[1,2], Michael A. Gillies[2], Catriona Haddow[3], Richard Dobbie[3], Kathryn M. Rowan[4], Sarah H. Wild[1], Gordon D. Murray[1], and Timothy S. Walsh[2]

[1]Usher Institute of Population Health Sciences and Informatics, University of Edinburgh, Edinburgh, United Kingdom; [2]Department of Anaesthesia, Critical Care and Pain, University of Edinburgh, Royal Infirmary of Edinburgh, Edinburgh, United Kingdom; [3]Information Services Division, NHS Scotland, Edinburgh, United Kingdom; and [4]Intensive Care National Audit & Research Centre, London, United Kingdom

Intensive Care Med (2018) 44:395–396
https://doi.org/10.1007/s00134-018-5057-4

FROM THE INSIDE

Suspended in time and space

Stéphanie Nguyen[1], Virginie Souppart[2] and Nancy Kentish-Barnes[2*]

After a reflexive silence, Mr. P explains how 5 min in the ICU seems like 20, that time is not occupied and how his thoughts go round and round in his head. He mimics this with his hands, and says, “It’s not good”. His thoughts are trapped in a closed circuit, events lack meaning, his hands are not active, and he himself, as a Person, finds it hard to exist.

Guidelines/Standards

UK GPICS STANDARDS

1. Critical care facilities must comply with national standards
2. All new build units must comply with HBN 04-02.
3. Existing units that do not comply must have a time-line to establish when national standards will be met.

Related documents

- Bristol Royal Infirmary - Ward 600 plan.pdf (405.71 KB)
- FICM-Bristol-Royal-Infirmary.pdf (456.92 KB)
- FICM-Great-Western-Hospital-Swindon.pdf (454.56 KB)
- FICM-Plymouth-Hospitals-NHS-Trust.pdf (390.47 KB)
- FICM-QEH-Birmingham.pdf (387.43 KB)
- FICM-Royal-Cornwall-Hospital.pdf (449 KB)
- FICM-Royal-Hallamshire-Hospital-Sheffield.pdf (454.5 KB)
- FICM-Royal-Oldham-Hospital.pdf (387.01 KB)
- FICM-Salford-Royal-Hospital.pdf (387.19 KB)
- FICM-Sheffield-Teaching-Hospitals.pdf (388.34 KB)
- FICM-Wythenshaw-Hospital.pdf (451.19 KB)

What worked well in the new design

General Facilities

- Sharing facilities with other Critical Care units (e.g. general and neuro ICU) as this helps with cross cover staffing and additional beds when needed
- Increased storage space
- Open plan
- Waste points
- Single sex accommodation
- Natural light
- Electronic blink glass
- Pendant systems
- Ability to separate into different zones if necessary and for each zone to work independently

Beds

- Increased space around beds
- Single rooms now available
- Sink at access end of bed for hand washing
- Floor colour change around bed space for improved infection control practices
- Built in hoisting

Relatives' Facilities

- Improved facilities for relatives, including overnight accommodation

Staff Facilities

- Office space/meeting rooms/staff rooms

General Advice

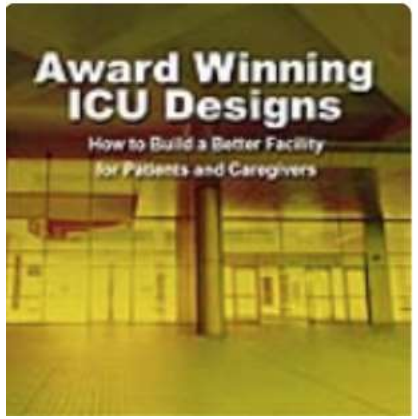
- Encourage clinical team to work with architects

What could be done differently

- Poor visibility in some areas due to existing/necessary structure e.g. supporting columns
- The unit is spread over a large area and can be difficult to cover for staff
- There is poor storage for patient property; we rely on using storage lockers
- Wider doorways into rooms should have been installed
- The unit has hot-desking rather than dedicated offices
- There is a lack of noise control on the unit
- Additional storage for larger devices and beds not in use would have been useful
- Consultant offices are not on the unit; it would have been more convenient if they were
- A lack of air conditioning in non-clinical areas reduces flexibility and occasionally staff morale
- Ensure size of rooms is appropriate Include as many electrical sockets are installed as possible
- Ensure the bed is positioned appropriately in relation to electrical sockets/gases
- Ensure the clean/drug rooms are positioned so that staff can still see patients
- Install an intercom system
- More glass walls instead of blinds to increase visibility
- Additional office and storage space

Guidelines/Awards

- Faculty Guidelines Institute



Crit Care Nurs Q
Vol. 37, No. 1, pp. 3–32

Two Decades (1993-2012) of Adult Intensive Care Unit Design

A Comparative Study of the Physical Design Features of the Best Practice Examples

Mahbub Rashid, PhD, RA

"When I woke, the first thing I remember was seeing the broken tile in the ceiling. I saw nothing else for a week."
JP (Patient from King's Pathfinder with permission)

What did our staff, patients and families want?

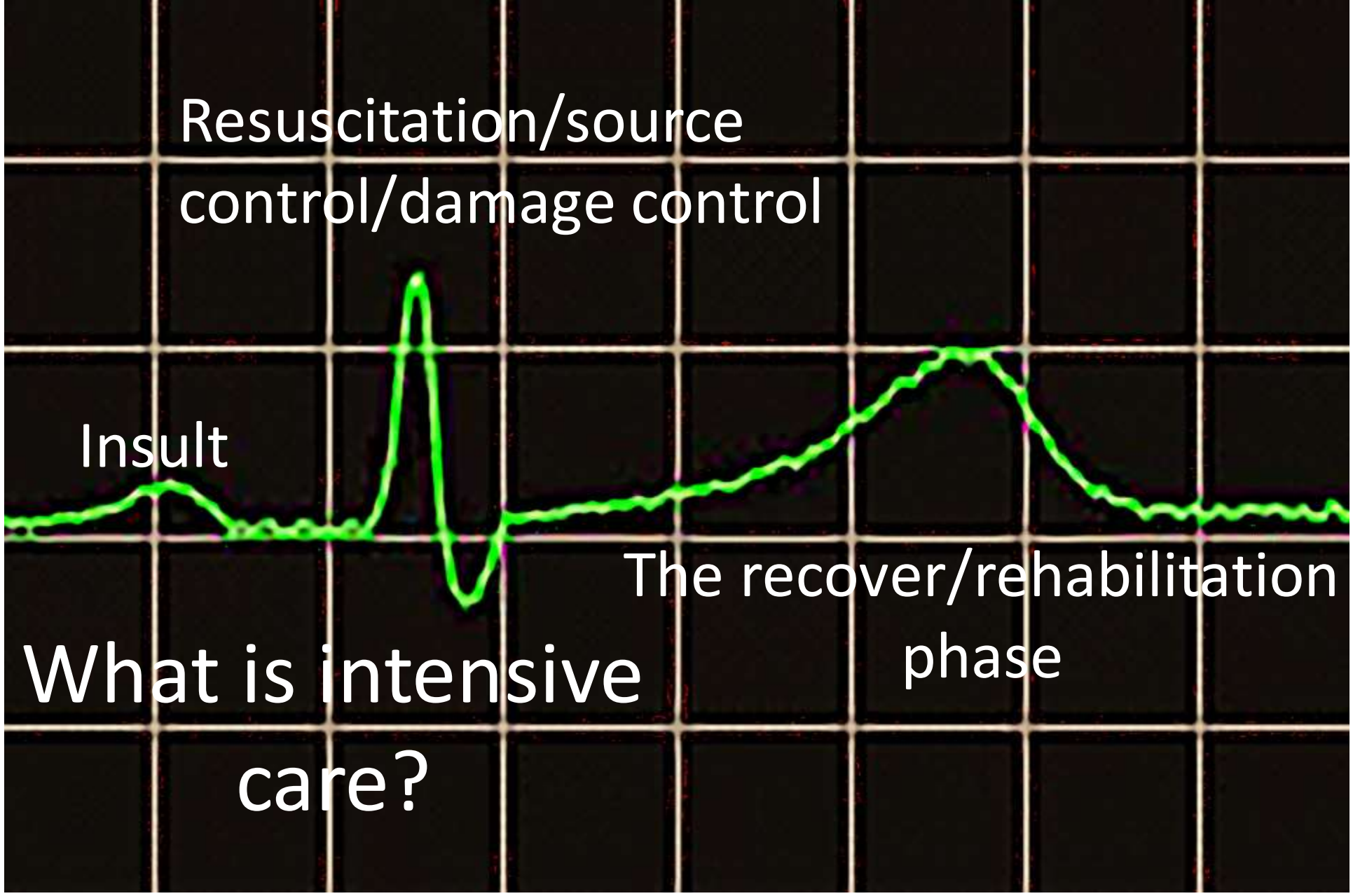
ICARUS Project, 2012

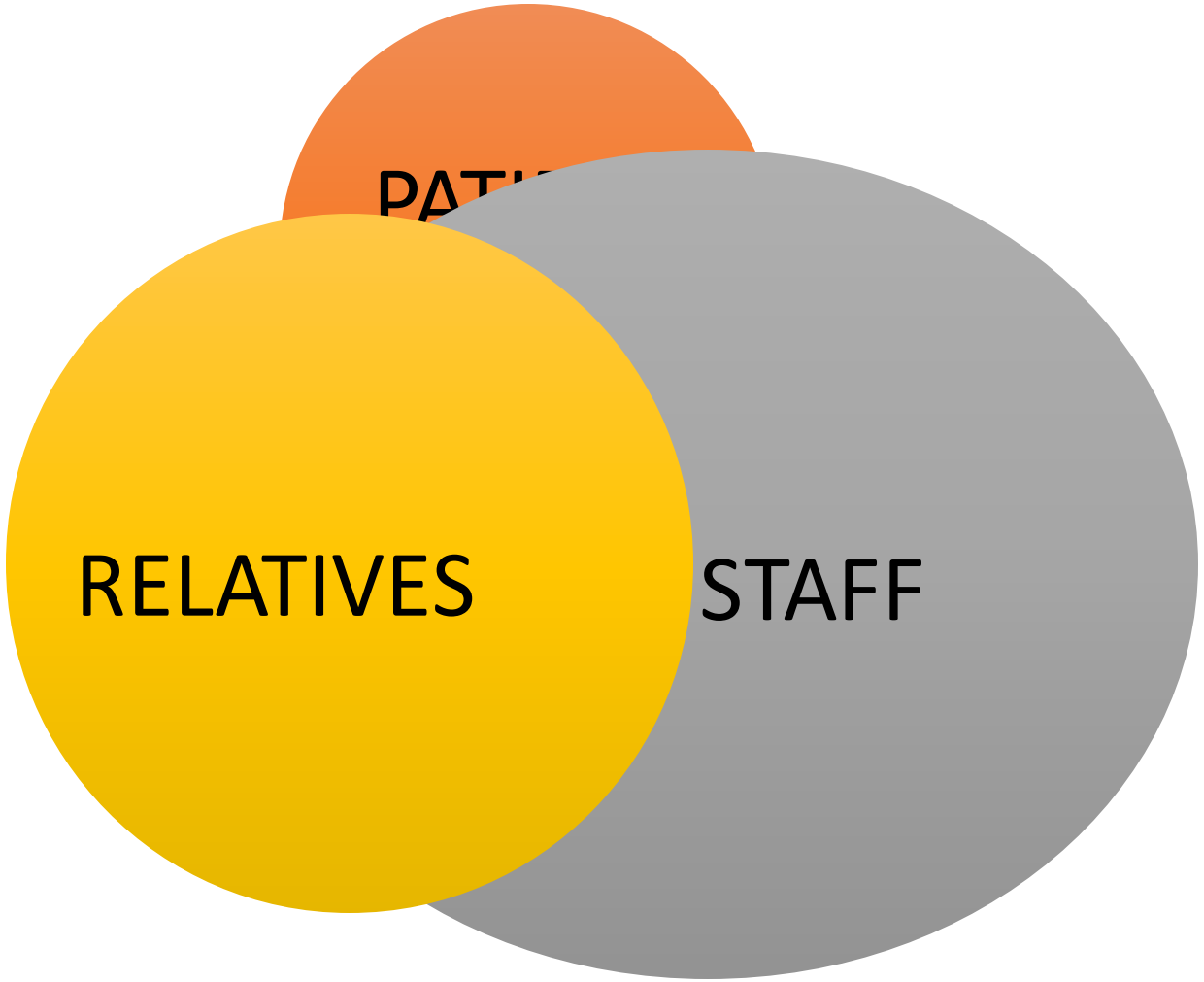
- NHS Digital funding
- Improvement science mixed methods baseline exercise to gauge opinions as to current delivery practice and what future practice should look like
- 800 health care professionals, patients and families
- Interviews, Round Table, Questionnaires, Non-participant workflow observation and systems testing. Crude peak decibel measurement. Adverse event capture.
- Thematic analysis and Delphi prioritization exercises to pick out design, informatics, workflow priorities. Kept the Medical, Nursing, Therapies/non-ICU users including Primary healthcare/Patients/Families separate
- Will be repeated after phase 1 of critical care centre

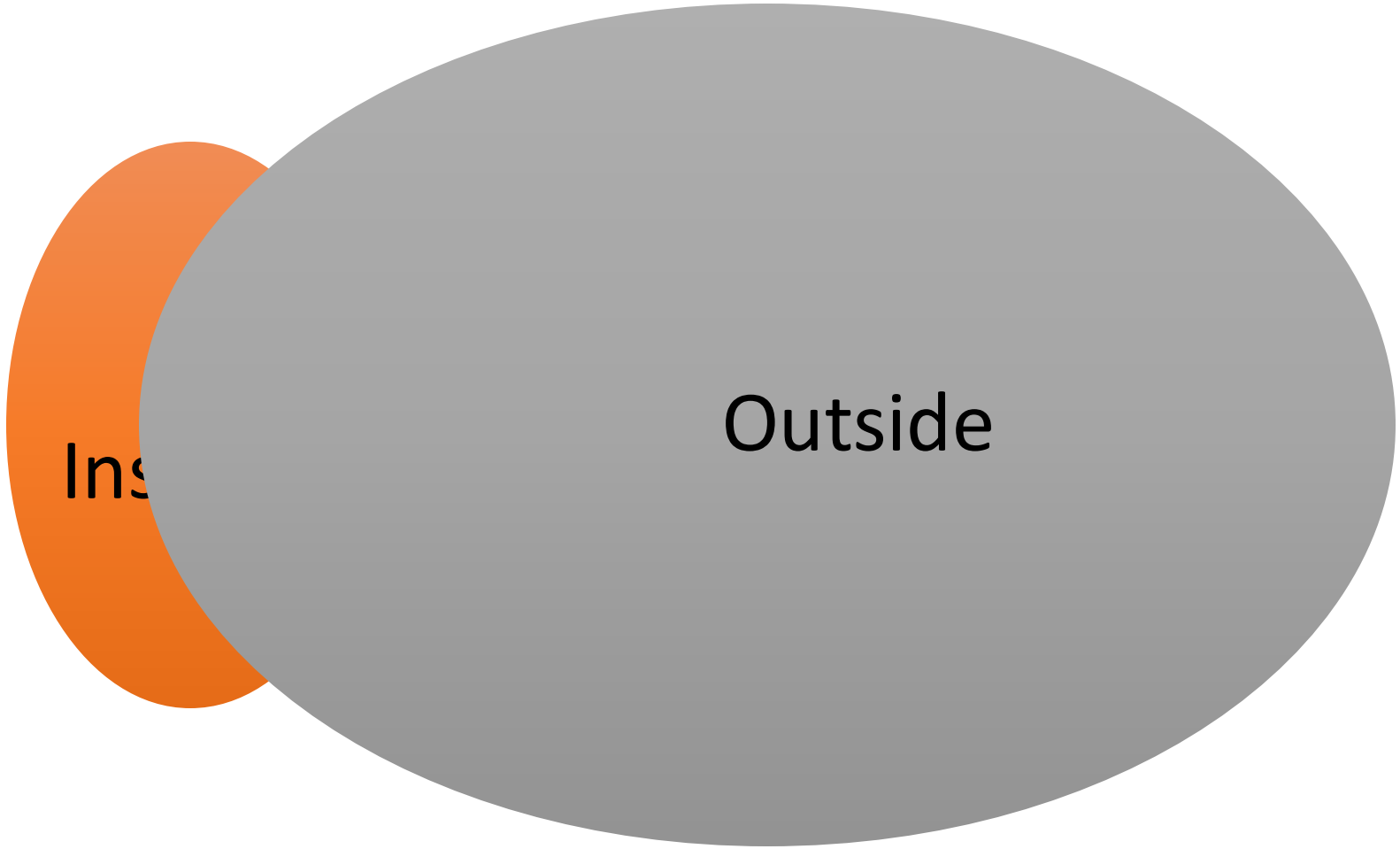
What is intensive care?

What do we do now? Good and bad.

What do we want from the new build?


Resuscitation/source control/damage control
Insult
The recover/rehabilitation phase
What is intensive care?


RELATIVES
STAFF

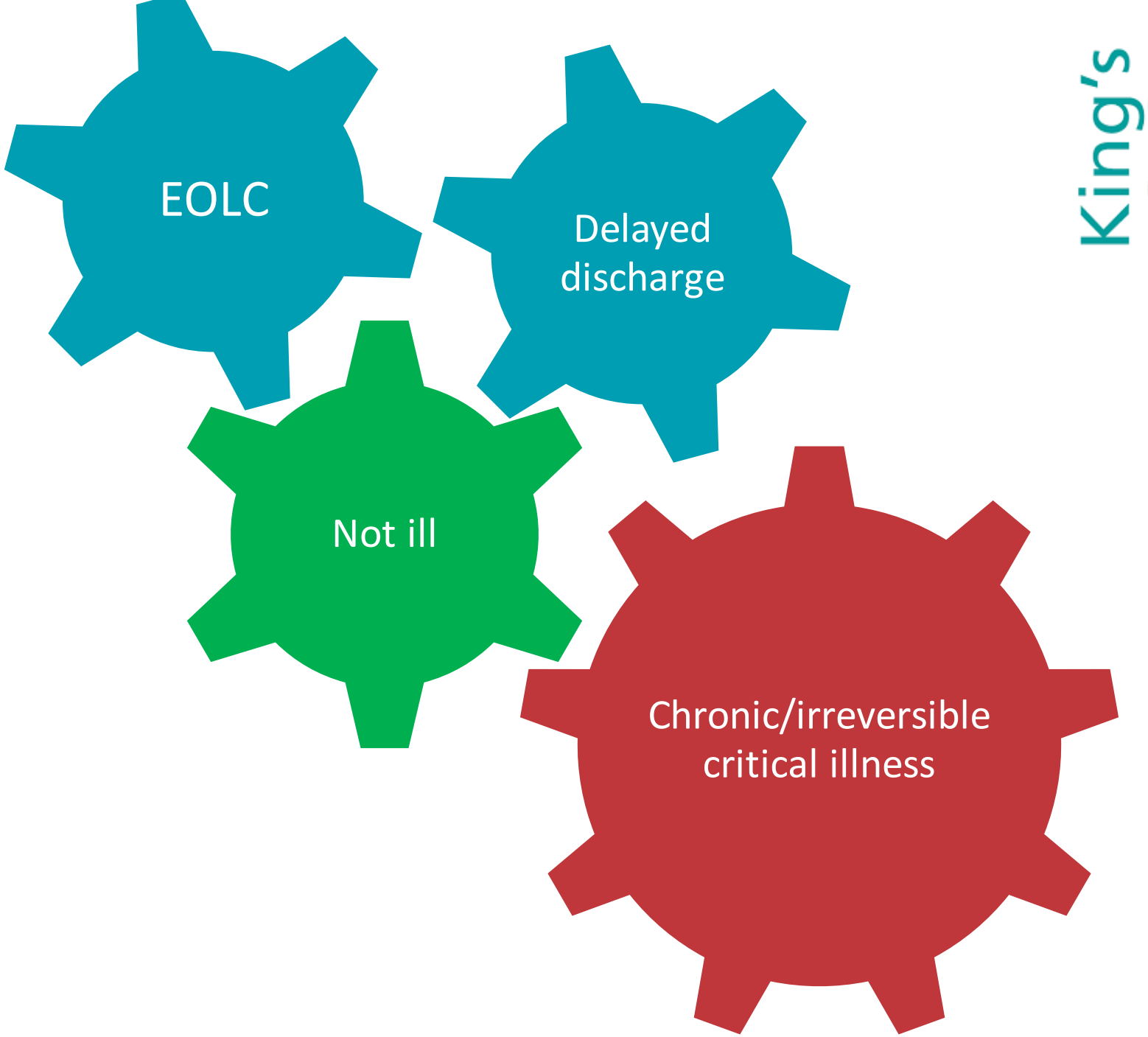

Ins
Outside

Before

ICU

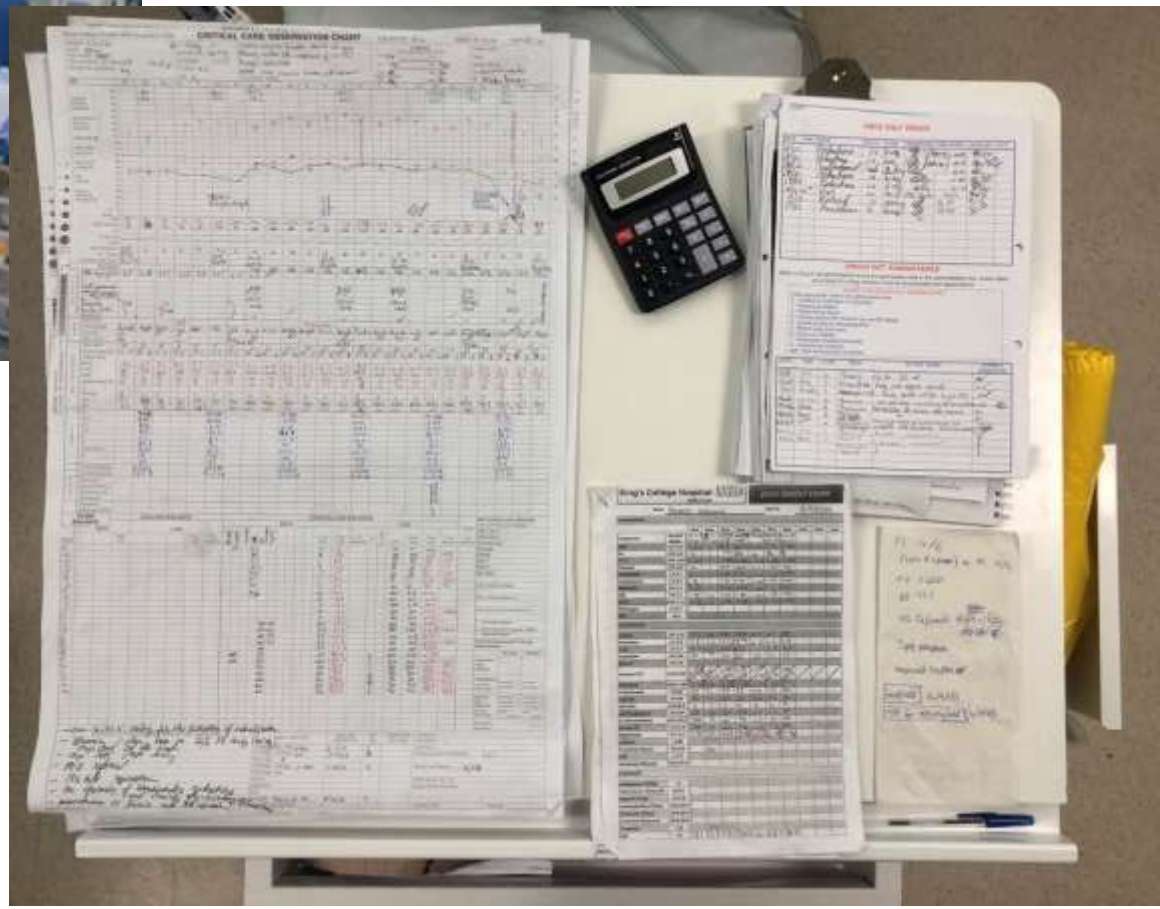
After

King's Critical Care



King's Critical Care

What do we do now? Good & bad


CRITICAL CARE OBSERVATION CHART

What do we want?

"I always wanted a happy nurse to be looking after me…if they were happy then I think that helped them cope with the stress of putting up with me!"
FG (Patient from King's Pathfinder with permission)

"The ability to say goodnight to my children over the internet would have changed my whole experience of intensive care following my accident…it would have reminded me of the person I had been and what I could be again"
(Patient from King's Pathfinder with permission)

"Time to Care": streamline workflow & resources/modern informatics/audiovisual comms nurse-nurse and nurse-sem room/reduce nurse journeys/reduce monotony & solitude

"Space to Care": dynamic bed spaces-more space/early mobilization/all levels-hybrid between technology and home-avoid isolation-right sound (NOT silence)/hybrid between open plan and side rooms (old ICU)/Skype & Facebook links-improve contact with real world cues

"Patient Safety" Safety briefing-briefing outputs/infection control/airway access/pharmacological intervention review

"Inter-professional communication" Safety briefing-improving life for longer stay patients-step down-interoperability 'work arounds'

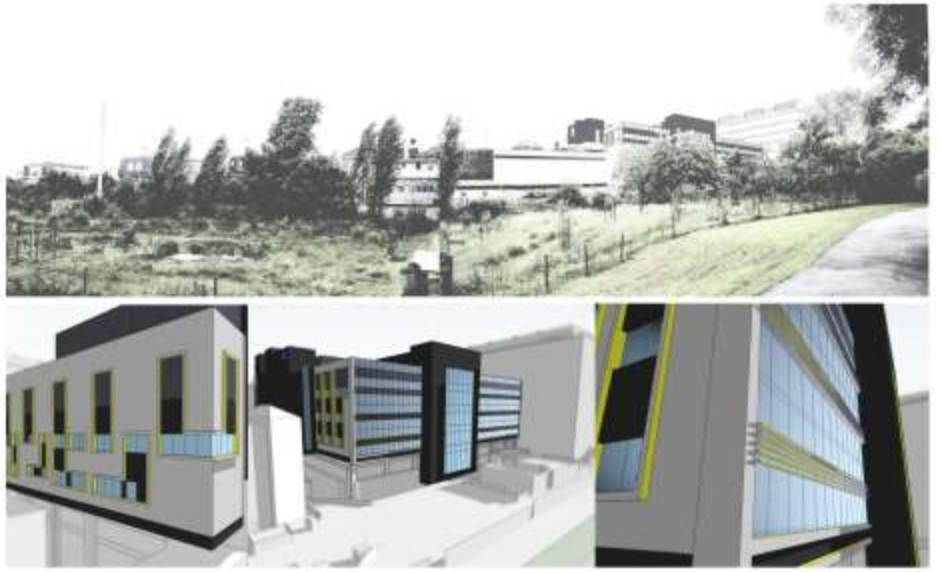
"Patient exists before, during and after intensive care" Flow analysis-PACE project ('Getting to know you')-Primary Healthcare comms via Local Care Record

"Research for patient benefit from the building" £100 million complex intervention...can it overcome the known dominance of frailty/comorbidities/health trajectory? What to measure? Effect of taking patients outside (Physiology/effect on relatives/staff/how to do it/dying outside). We want to focus on reducing solitude/monotony/lack of cues of life.

"Don't be afraid to be different" Orientation of ICU-Seminar room design-outside ICU beds-bespoke art-digital art-social media-entertainment systems

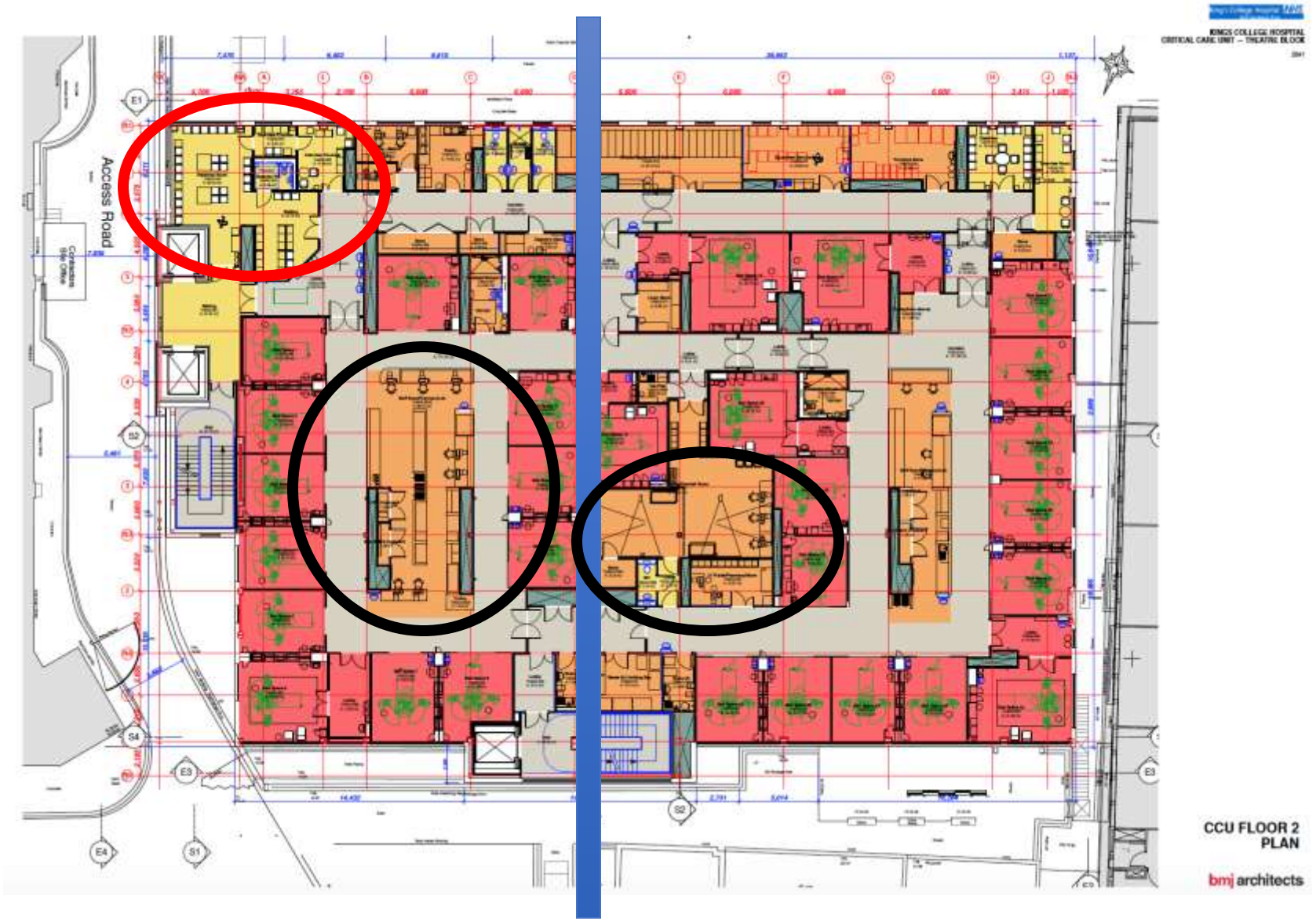
King's Critical Care

The Journey

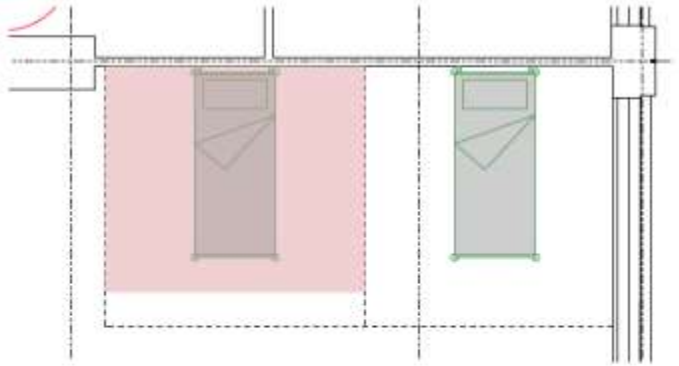


Where did we end up?

N


Access Road
KINGS COLLEGE HOSPITAL
CRITICAL CARE UNIT – THEATRE BLOCK
CCU FLOOR 2
PLAN
bmj architects

Park



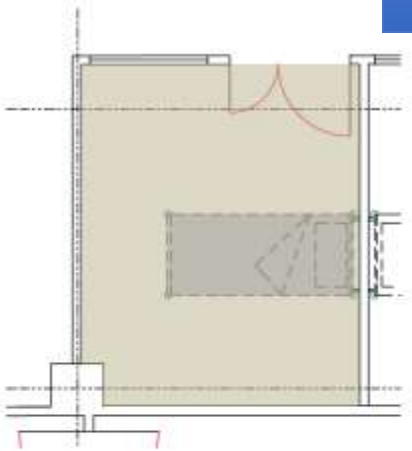
EXISTING SURGICAL CRITICAL CARE UNIT
BED SPACES

PROPOSED CRITICAL CARE UNIT
BED SPACES

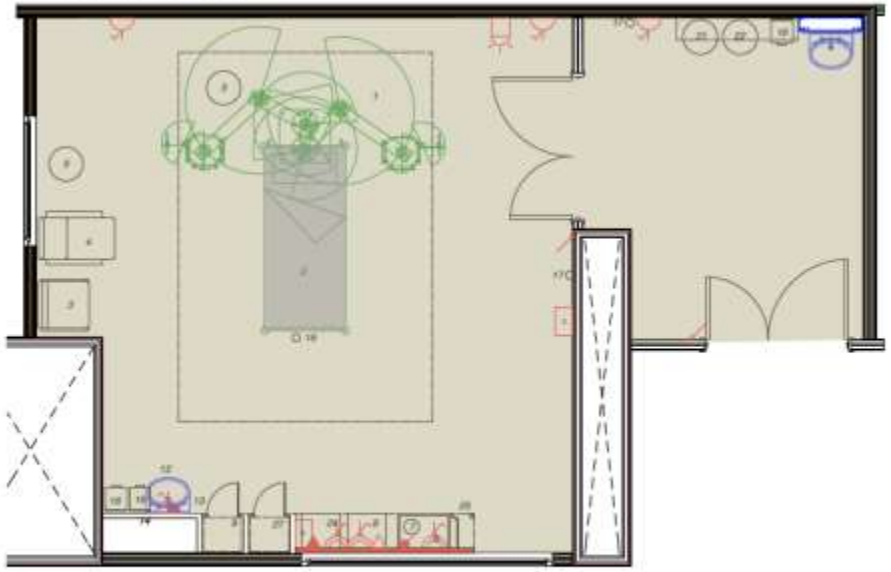
The layout is based on HBN 4 & 57 for Isolation Rooms and HBN 27 for bed spaces.

There is also a requirement for compliance with single sex legislation where relevant, paying very close attention to the requirements of Infection Control and a staged escape strategy.

The unit should be able to cope with endemic occurrences; therefore each bed space is capable of doubling-up in terms of services requirements.



EXISTING SURGICAL CRITICAL CARE UNIT
ISOLATION ROOM



PROPOSED CRITICAL CARE UNIT
ISOLATION ROOM

Practicalities...what we learnt

- Create a case...do you need it? Adverse incidents-define risk of not building it. Identify any/all sources of funding. Underline that critical care has everyone else's patients. Be certain about the arguments.
- Get it right from start-new build vs conversion; put it in the correct location; think about making it bigger than you think you will need.
- Know your project better than anyone else.
- If anyone says you do not need to *involve* doctors, nurses, patients, families in building an ICU...they are wrong...and don't stop once the building is finished. Doctors and nurses can't have everything they want....but learn what to compromise on and what to defend at all costs
- **Don't** always do what everyone else has done...but **do** go and look at lots of other ICUs and critical care services and *listen* to them- understand context dependent/resources dependent (severity, casemix, nursing ratio)
- Go and see what your builder and suppliers have done before
- Maximise commercial leverage and partnership.
- Specifically defend the project against final phase cuts affecting finishes-we did this with a fundraising campaign.

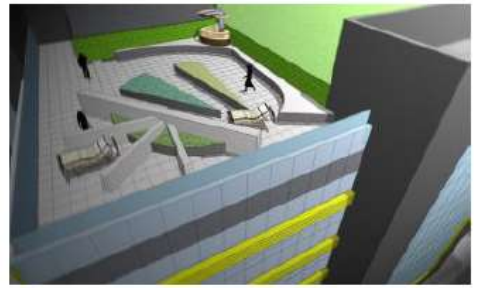
- Understand the tempo of the project. Momentum and deadlines.
- Don’t underestimate time scale – 10 years and remember effect of lead time eg bed numbers/technology/supportive therapies/operational strain
- Need to plan human resources in the correct time scale....if you double the number of ICU beds...you will need more nurses...remember turnover
- Need to expect building to fail 21st Century Building Management Systems when it is tested (pressure/infection control/fire/electrical)
- Details of room & other zones design matter- eg marginal gains on pendant flexibility; profile; use hoist to carry services to foot of bed (eg for ECMO).
- Do not overlap commissioning/testing with build...wait until the building is completed before you try and move in...whatever the pressures
- Test the new clinical and operational setting (systems/workflow)...although you will need some real time assessment. Note inertia and difficulty with change. Remember to test the oxygen...turn it on in all the beds...and check the rest of the institution
- Integrate research opportunities and improvement science....do not spend 100 million on a building and not research its benefits...it is a £100 million intervention. If it does not improve outcomes....that is worth knowing.

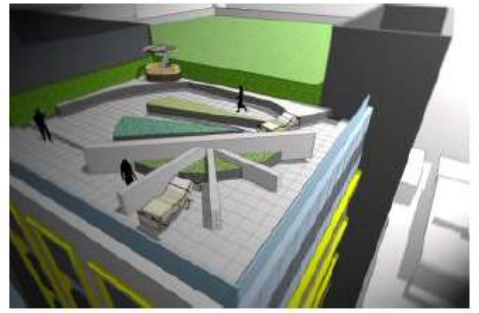
Summary of design features

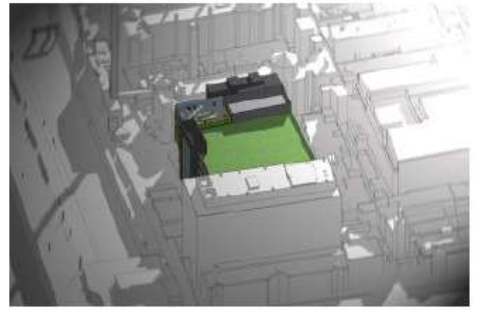
- Integration with a Helidec, imaging, existing ICUs, Emergency department: ‘building on a building’
- Integration and continuity with Ruskin Park; Natural light- optimized within limits of design
- Colour and themes - Spring, Autumn, Winter, Summer
- Hybrid between ‘side rooms’ and open plan-lines of sight/sound
- Maximum flexibility and space in each bed space – ‘ECMO & damage control to hotel room’
- Beds can rotate 360 degrees.....can have 2 pendants/1 pendant/no pendants
- Hybrid between ‘home’ and ‘high technology’
- Can double capacity to 120 beds in a major incident
- Design to handle open doors vs closed doors
- Design to attempt to minimise delirium-reflective surfaces/non-pharmacological
- Early mobilization (hoists) and patient-family communication (Skype)
- Interprofessional communication and reduce ‘nurse journeys’ (videoconferencing)
- Optimal use-touch screen observations chart can double as patient entertainment systems
- Bathrooms for sarcopenic/deconditioned patients
- Outside space – 4 to 5 beds- hybrid cover: power/data/medical gases


DELL


Comelit







Summary of design compromises

- Light wells
- Building columns-lines of sight disrupted
- Insufficient offices to create ‘a department’
- No family accommodation
- Reduced staff rest areas
- Windows on south side predominantly
- Changing rooms occupy prime locations on top floor


Harriet

Research

How do you show that the building is effective?

- Primary end point: Time alone/solitude; Sleep time/quality; Awareness of chronic health trajectory of patient by staff; communication-team working measures
- Secondary end points: patient-; family-; staff-; Long term outcomes (physical; neurocognitive; psychological)
- Specifically look at effect of external ICU-a complex intervention on patient, family and staff. What is effect on physiology? What is affect on sleep? Dying outside?

Summary

- Described the drivers behind the design of a large new critical care centre in the UK.
- Many examples of well considered ICU design and good descriptions of what to think about.
- Evidence base is more limited in relation to particular design features improving patient/family outcomes. There is literature emerging on elements of whole design: light, sound and delirium; sleep, alarming.
- The idea that emerged from our baseline exercise was to use the new ICU as a complex intervention to maximise ‘normality’ and minimize solitude and monotony for patients, including the use of ICU beds outside.
- Practical lessons, strategies and compromises.
- Importance of integrating research & formal measurement of benefit using improvement science and outlined what we have done and are trying to do.

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We want to save lives and return people to their lives