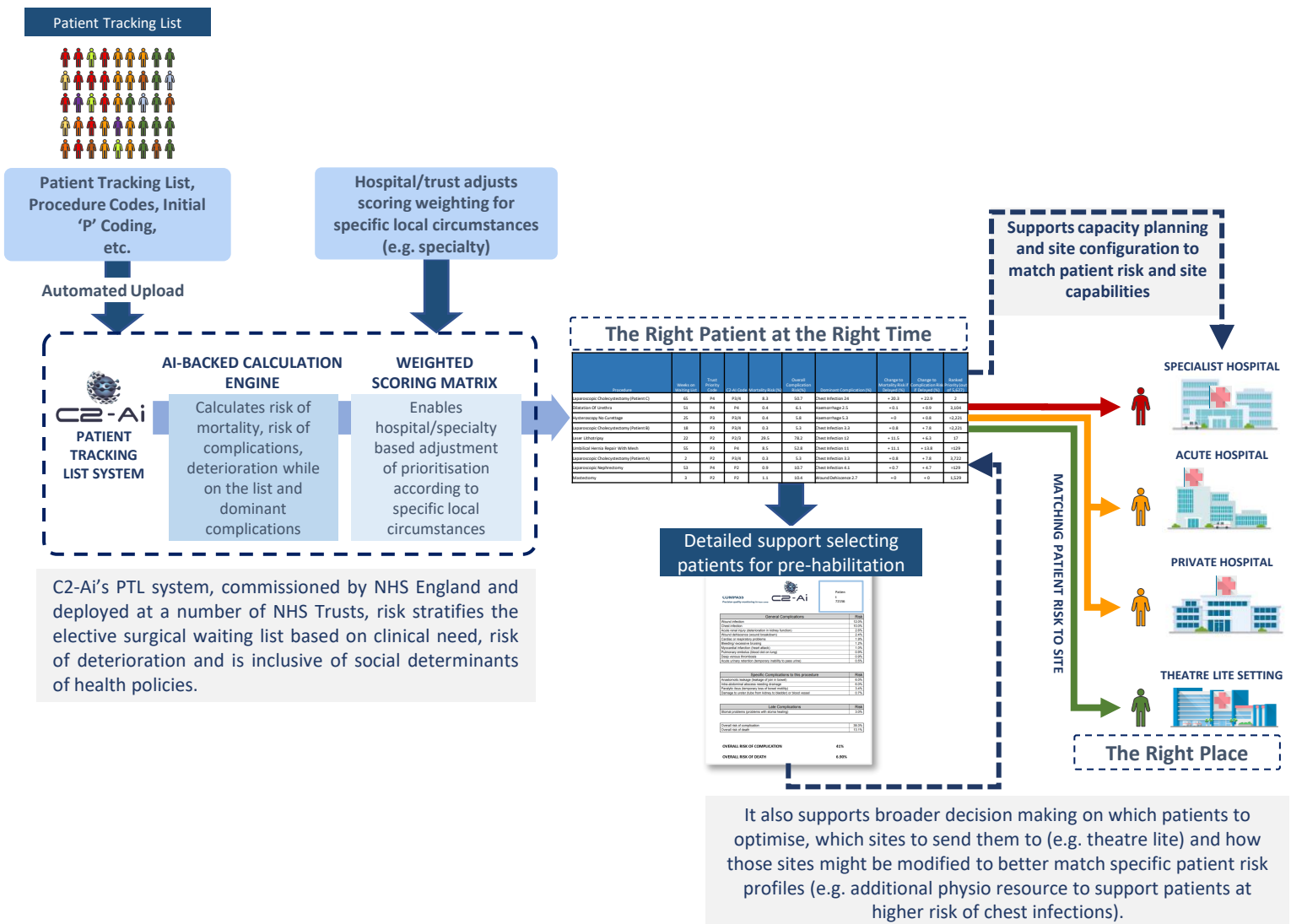


**“Unique software solutions for trillion USD problems”**



**Driven to enable every hospital to improve outcomes for patients - identifying and reducing clinical variation, avoidable harm and costs**

# SUMMARY - C2-Ai's PTL SYSTEM – “The right patient in the right place at the right time”



## BENEFITS

- 6 weeks** time saved per consultant/surgeon
- 50%** reduction in complications due to deterioration on wait list
- 50%** reduction in mortality due to deterioration on wait list
- 100 person years** reduction in admin overhead for surgeons per region – time that could be spent operating and clearing the backlog faster
- C2-Ai will make available population health information for use in research on Social Determinants of Health, and in support of EDI improvement

# C2-Ai's trusted systems are in use globally and in multiple NHS trusts

“C2-AI - saving lives all over the planet by predicting avoidable harm and mortality with world-leading AI...They are **globally unique, innovative, British award-winners**. I consider them to be essential for any nation which wants to take digital health seriously. **If their innovation was scaled across the NHS I estimate it would save 70,000 lives and £1bn.**”



Hassan Chaudhury, Digital Health Lead at Healthcare UK, DIT

Companies like Cambridge-based C2-AI, which last week won the COGX Health Innovation for Covid19 Award, **are leading the way in the UK's cutting edge, health tech sector**. C2-AI save lives by predicting avoidable harm and mortality so they free up capacity in intensive care units for COVID-19 patients.



Graham Stuart - House of Commons June 2020

## C2-AI team's experience includes as:

- inventor of the world's most widely pre-operative risk assessment system (POSSUM)
- the former Patient Safety and Audit lead in the UK
- advisor to the American Surgical Association on development of the NSQIP system
- advisor to the Veterans Administration in the US and governments globally
- the former Head of Patient Safety and Audit in the Department of Health
- lead on development of the first National Healthcare Standards

## Awards in last 12 months...



One of '10 Essential Digital Health ideas for a COVID-19 UK National Response'



Best Overall Innovation for Covid-19



One of Healthcare's Most Innovative Companies 2020



Medtech Company of the Year - Finalist



Best Medical App 2020



'Top 100 Digital Health Company' - in the highest 'Essential' category



2021 Award for Excellence in Innovation - UK



Patient Safety Finalist



Best Health Tech Solution of the Year



AI Company of the Year - Finalist



Most Innovative Solution for Covid-19



Best Covid-19 Health Innovation



Featured on BBC



Efficiency Saving of the Year



2021 AI in Healthcare Finalist

# Hospitals and regions must find effective ways to triage and prioritise patients on the Patient Tracking List based on clinical urgency

Patients must be treated in order of clinical priority - in line with NHS policies and patients' legal rights.

Organisations need to protect themselves from what is expected to be a significant number of legal challenges by implementing transparent processes with clear recording of how decisions are made and the reasons for them.

## Managing the backlog is not easy



Staff redeployment, pressures on HDU/ITU, staff sickness, infection management etc. have created a backlog.



Waiting longer increases clinical risk for some on the list



**100%** increase in mortality predicted due to deterioration on wait list\*



**40%** increase in complications predicted due to deterioration on wait list\*



**4bn** potential combinations of key physiological ranges and operative types to consider for each patient

## ...but current approach has some limitations

**15** minutes per patient for manual clinical validation – reviewing and prioritising every time the waiting list needs review

Prioritisation is difficult and subjective

Significant variation between specialties/trusts

Labour intensive and reduces time availability to actually treat patients

Hard to optimise sites regionally and direct of patients to appropriate sites (green/red, hot/cold)

## ...with direct impact on patient outcomes and risk

- **Patients not prioritised as effectively as possible**
- **Incremental delays due to burden of prioritisation**
- **Sub-optimal choices on pre-operative optimisation of patients**
- **Higher avoidable complications**
- **Higher avoidable mortality**
- **Reduced ICU capacity due to higher complication rates blocking beds**
- **Some patients will deteriorate so much the operation is no longer needed while others will not survive the wait**
- **Potential for civil/criminal challenge**

# C2-Ai uses existing proven systems together to deliver the evidence-based stratification and prioritisation support needed

C2-Ai's systems support the need to treat patients in order of clinical priority - in line NHS policies and patients' legal rights.

Combining C2-Ai validated, approved systems already in use by the NHS



## BENEFITS



**6 weeks** time saved per consultant/surgeon\*



**50%** reduction in complications due to deterioration on wait list



**50%** reduction in mortality due to deterioration on wait list



**100 person years** reduction in admin overhead for surgeons per region – time that could be spent operating and clearing the backlog faster

- Faster clearing of the backlog
- Lower patient harm and mortality (targeting 50% improvement)
- Better use of surgeon time
- More detailed view of clinical risk for each patient
- Better alignment of patient risk to sophistication of site (e.g. theatre-lite)
- Improved patient management post-operatively
- Optimise sites to match needs of Patient Tracking List
- Supports which patients to optimise prior to operation
- Reduces chances of legal issues/investigations etc.
- Supports transparent decision making
- C2-Ai will make available population health information for use in research on Social Determinants of Health, and in support of EDI improvement

\* Calculations of the impact of predicted delays on probability of deaths and complications for those susceptible to delay (C2-Ai analysis using referential dataset (heading for 200m patient records from 46 countries) and work with NHS Trusts)

# The choice of methodology used is important, with serious implications for organisations and individuals if it does not deliver

## OPERATIVE SEVERITY AND PHYSIOLOGICAL VARIABLES CREATE HUGE COMPLEXITY

MORTALITY RISK (%)

1.6%

Normal Physiology

x3

Abnormal BP

x10

Abnormal BP and Sodium



COMPLICATION RISK (%)

9.6%

Normal Physiology

x2

Abnormal BP

x4

Abnormal BP and Sodium

Assessing risk is difficult and time-consuming

A change of 2 physiological variables increases mortality risk by **10X** and morbidity risk by **4X**

C2-Ai systems consider 4 billion combinations of key physiological variables and operative risk

Procedure	Weeks on Waiting List	Trust Priority Code	C2-Ai Code	Mortality Risk (%)	Overall Complication Risk (%)	Dominant Complication (%)	Change to Mortality Risk if Delayed (%)	Change to Complication Risk if Delayed (%)	Ranked Priority (out of 5,627)
Laparoscopic Cholecystectomy (Patient C)	65	P4	P3/4	8.3	50.7	Chest Infection 24	+ 20.3	+ 22.9	2
Dilatation Of Urethra	51	P4	P4	0.4	6.1	Haemorrhage 2.5	+ 0.1	+ 0.9	3,104
Hysteroscopy No Curettage	25	P3	P3/4	0.4	5.8	Haemorrhage 5.3	+ 0	+ 0.8	=2,221
Laparoscopic Cholecystectomy (Patient B)	18	P3	P3/4	0.3	5.3	Chest Infection 3.3	+ 0.8	+ 7.8	=2,221
Laser Lithotripsy	22	P2	P2/3	29.5	78.2	Chest Infection 12	+ 11.5	+ 6.3	17
Umbilical Hernia Repair With Mesh	55	P3	P4	8.5	52.8	Chest Infection 11	+ 11.1	+ 13.8	=129
Laparoscopic Cholecystectomy (Patient A)	2	P2	P3/4	0.3	5.3	Chest Infection 3.3	+ 0.8	+ 7.8	3,722
Laparoscopic Nephrectomy	53	P4	P2	0.9	10.7	Chest Infection 4.1	+ 0.7	+ 4.7	=129
Mastectomy	3	P2	P2	1.1	10.4	Wound Dehiscence 2.7	+ 0	+ 0	1,529

Evidence-based triage calculation of individualised risk of mortality and complications – built into overall scoring and prioritisation matrix

COMPASS  
Precision quality monitoring in real time

C2-Ai

Patient 72156

General Complications	Risk
Wound infection	12.0%
Chest infection	10.0%
Acute renal injury (deterioration in kidney function)	2.6%
Wound dehiscence (wound breakdown)	2.4%
Cardiac or respiratory problems	1.9%
Bleeding/ excessive bruising	1.2%
Myocardial infarction (heart attack)	1.0%
Pulmonary embolus (blood clot on lung)	0.9%
Deep venous thrombosis	0.9%
Acute urinary retention (temporary inability to pass urine)	0.5%

Specific Complications to this procedure	Risk
Anastomotic leakage (leakage of join in bowel)	6.0%
Intra-abdominal abscess needing drainage	6.0%
Paralytic ileus (temporary loss of bowel motility)	3.4%
Damage to ureter (tube from kidney to bladder) or blood vessel	0.7%

Late Complications	Risk
Stomal problems (problems with stoma healing)	3.0%

Overall risk of complication	39.3%
Overall risk of death	13.1%

OVERALL RISK OF COMPLICATION 41%

OVERALL RISK OF DEATH 6.90%

Detailed mortality and risk information for each patient to support prioritisation and optimisation decisions

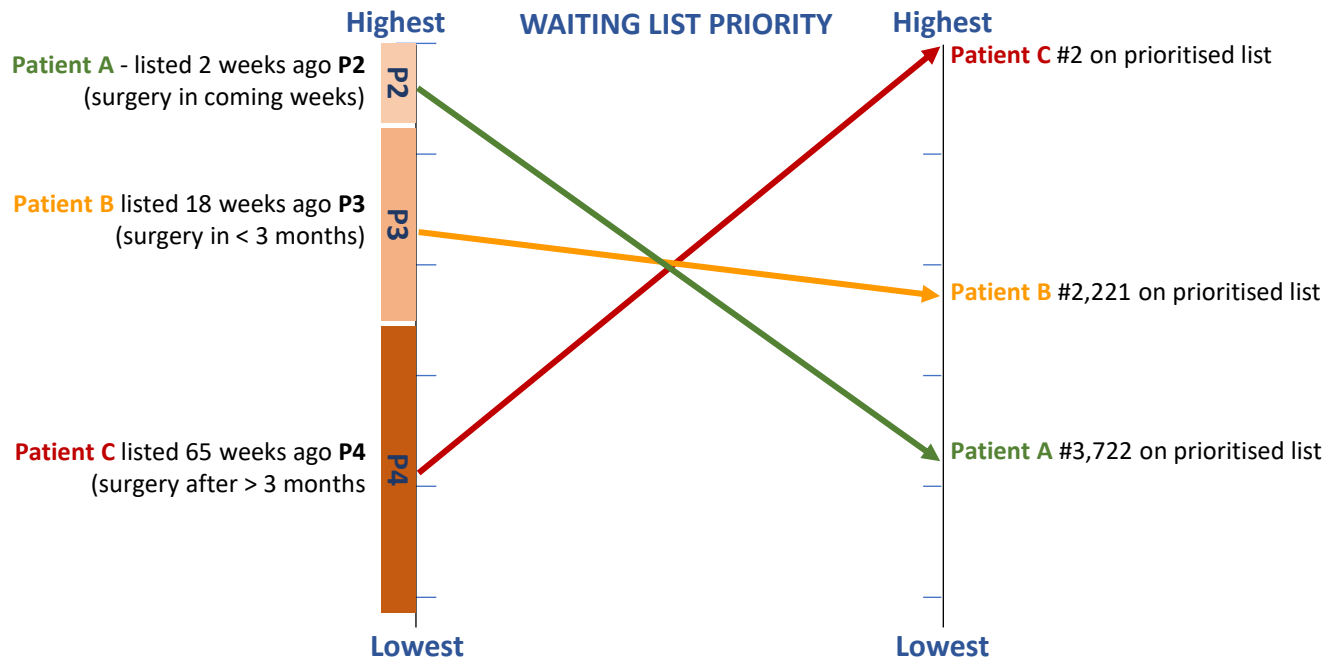
# Example – Real world prioritisation example – manual clinical validation compared to C2-Ai outputs

Patient A, B and C had all been listed for a Laparoscopic Cholecystectomy at one of our partner Trusts.

The additional insights provided through the current and predicted (in case of delay) risks for mortality and complications are factored into an evolved approach with an elective prioritisation score for each patient that then feeds into the prioritised waiting list.

## Today's Manual Clinical Prioritisation Approach

## Improved Clinical Prioritisation (C2-Ai)



The evolved approach take the priority P-code but also factors in:

- the impact of a delay on the patient's
  - risk of mortality (increase in risk)
  - risk of overall complications (increase in risk)
- length of time since being added to the waiting list

# Benefits of the C2-Ai approach (1 of 2)

## Enhanced decision making

### Evidence-based system supports informed decision making and confirmation of prioritisation

- Clears the backlog faster
- Eliminates variation
- Better patient outcomes - lower harm/mortality
- Reduces unnecessary time in clinicians' review of patients
- Prioritisation expedites surgery for those at elevated risk of emergency surgery or readmission

### More detailed view of clinical risk of each patient

- Flexible approach that can be tailored for local circumstances, preferences, priorities, and critically, the views of the treating clinicians – making their lives easier and decision making faster
- Easier to select and review patients quickly prioritises on clinical urgency, eliminates variation and avoids bias
- Consistent decision making compared to manual approaches
- Consistent with NHS policies and patients' legal rights
- Reduced risk of civil/criminal proceedings

## Improved effectiveness and efficiency

### Optimise facilities

- Apply risk criteria to selecting the right site for a patient (e.g. for theatre-lite settings)
- Identify which services need enhancing to best manage clinical risk outside of a hospital setting if delay likely to lead to deterioration
- Inform capacity planning decision making
- Evolve care at sites to increase range of potential cases (e.g. increasing physio capability to allow those at higher risk of chest infections to be managed at the site (<2.5% to <5%))

### Optimise staffing

- Improved allocation of theatre and anaesthetist workforce
- Provides visibility of mix of patient morbidity risks across the aggregated waiting list

### Improves utilisation of beds - hastening clearing the backlog

- Reduced avoidable complications reduces post-operative length of stay - freeing capacity for other patients



# Benefits of the C2-Ai approach (2 of 2)

## Improved patient outcomes

### Pre-habilitation - optimise patients before operation

- Patient level risk of mortality and complications linked to key physiological variables
- Supports decision making on patients that will do better having their condition optimised before their operation

### Optimisation of care after operation

- Most probable post-operative complications are identified to help manage resources and care planning

### Support for improvements around Social Determinants of Health and EDI

- C2-Ai will make available population health information for use in research on Social Determinants of Health, and in support of EDI improvement

## Tried, tested and trusted solution

### Reduces development risk compared to 'home-made' solutions

- Tried, tested, approved, validated, referenced approach - eliminates development risk
- Solutions built locally liable to risk of development failure and/or inability to withstand scrutiny on decision making logic
- Built with full compliance to ISO9001, 27001, 13485 and around MHRA compliant/approved elements
- Sophisticated information governance approach that is fully compliant with NHS Digital's requirements and across huge datasets

# Illustrative scope of work – automated upload, dashboard and monthly updates



## Triage of the full patient treatment list as follows:

1. Generation of a first triage report in editable Excel format for ease of use/customisation. This will classify patients into 5 groups, comprising:
  - a. investigations/diagnostic interventions
  - b. procedures where mortality and morbidity risk predictions are generated
  - c. procedures where additional detailed risk predictions for complications are applicable (approx. 90% of all activity)
  - d. duplicate patients
  - e. patients listed but with no intended procedure indicated (for further coding)

Within groups (a)-(c), COMPASS List Triage will specify:

- Date first listed
- Current length of time on the waiting list
- Intended procedure & code
- Current priority P code
- Overall risk of death
- Overall risk of complication

In addition, for all patients in group (c), the system will list:

- Selected list of predicted complications
- Change in mortality and complication risks if surgery delayed
- Change in complication profile if surgery delayed

## Systems and ongoing support:

C2-Ai has already built a live, secure, remotely hosted system (by trust and centrally) for authorised staff to access and interrogate individual patient listings, including summary patient records and score sheets.

Supplementary to this, a “points matrix” has been developed (and will be available soon) which will be built into the live system for each Trust to can apply to its finished list. This enables adjustment of prioritisation according to specific local circumstances (for example greater weight being accorded to surgeon assessment in a given specialty, and/or procedure-specific priorities).

Furthermore, dashboard visualisation of matrix level scoring of patients will be included to support area-wide decision-making about most appropriate treatment site and planning capacity/potential ICU requirements accordingly.

### **Finally, for ongoing maintenance of the PTL to ensure currency:**

- a. an upload function allows trusts to submit regular data updates, and automate their integration into the overall system
- b. refreshes will be delivered on a monthly basis**, with outputs as above.

# Data Requirements



Data requirements have been templated as part of the various trials and implementations, but in summary comprise:

- co-morbidities for patients on the waiting list;
- patient age;
- hospital number;
- NHS number (to enable tracking of patients across and between facilities);
- OPCS code of the intended procedure (including text).

The full PTL is required, as this is important to be able to accurately identify patients with long waiting times, patients listed for multiple procedures (duplicate and genuine), and patients not listed appropriately or with incomplete records.

Where patients have no listed OPCS procedure code, Trusts are requested to engage their internal coding department to perform a rapid, one-off coding exercise. From field experience this is not onerous, but where Trusts are unable to carry out this exercise for themselves, C2-Ai will be happy to conduct the additional work, but separate charges will apply.

# Our systems are hugely popular with clinical staff

Essential for implementing solutions that are durable and deliver real cost reduction



"The problem with [HSMR systems] is that they tell you there might be a problem, but not where or why. CRAB® tells you exactly what and where the problem is, and even which patients are involved. Then you can do something about it."

**Dr. Aresh Anwar,**  
Medical Director  
Royal Perth Hospital, Australia



"We are thrilled to receive this award, which reflects a great deal of hard work and support from within and [...] the support of C2-Ai who enabled us to benchmark our Trust's Acute Kidney Injury rates against national levels - and then measure the significant impact of our AKI Programme, which coincided with a significant and sustained fall in AKI rates our Trust, especially across surgical wards".

**Dr Jonathan Murray,** Renal Consultant at South Tees  
Hospitals NHS Foundation Trust, UK

"CRAB just makes sense. It presents data in a way that is easy to understand and interpret. It has been immensely useful for me both personally in my appraisal and in my role as a Clinical Director. It helps me to pick up early warning of problems with intelligence that can be believed and acted upon"

**Jeremy Cundall,**  
Executive Medical Director - Consultant Colorectal and  
General Surgeon, CDDFT



"CRAB® is 100% better than any solution available to us at the moment. It has turned out to be a very useful tool in analysing and understanding our case-mix and where our complications are occurring."

**Per Svedmark MD, PhD, Senior Consultant,**  
Stockholm Spine Centre, Sweden



"Accurate benchmarking of outcomes was a real challenge [...] however our work with [C2-Ai] has provided invaluable quality assurance. The risk adjusted reporting has provided confidence that our outcomes are better than comparable organisations and the level of detail enables us to focus on improvements in specific areas. It was particularly useful during our regulatory inspection and follow up meetings with the CQC to show how this strengthens our clinical governance..."

**Dr Jenny Davidson,**  
Director of Governance,  
King Edward VII's Hospital

"CRAB has allowed real time review of data, which has raised awareness and led to change in both clinical practice and hospital culture. I think it will become an essential part of the appraisal and governance structures of secondary care."

**David Williams**  
Consultant Surgeon  
Northern Devon Hospital Trust, UK



"CRAB® predictions have proved accurate in my primary external research validation of the system. I currently don't know of any other electronic system in use that can deliver this kind of overall and detailed qualitative feedback to the department and the individual surgeon. It has been a great benefit for our clinic and helped develop our work on patient safety."

**Wilhelmina Ekström, MD, PhD, Senior  
Consultant, Karolinska University Hospital,**  
Sweden

"It took 2 years and a very costly investigation to deal with a competence issue in our organisation some time ago. We set CRAB® the blind challenge of seeing if they could have found the problem in our historical data. They did so in 20 minutes. Needless to say, we have invested in the system"



**Dr. Michael Roberts,**  
Chief Medical Officer,  
Northland District Health Board,  
New Zealand

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Companies like Cambridge-based C2-AI, which last week won the COGX Health Innovation for Covid19 Award, are leading the way in the UK's cutting edge, health tech sector. C2-AI save lives by predicting avoidable harm and mortality, so they free up capacity in intensive care units for COVID-19 patients.

Government minister Graham Stuart  
House of Commons,  
UK Parliament June 2020

"C2-Ai have the most robust software approach to comparing safety and quality across hospitals, systems and physicians that I have ever seen. The algorithms are backed up by years of published international research. I believe their approach could be most useful as a solution for providers across any network".

James Bonnette, MD (USA)  
Executive Vice President  
The Advisory Board/Optum

"It is strikingly clear to me that you know more about how to fix this hospital than I do"

Chief Medical Officer, Nashville based US health system

"CRAB® can identify outcomes that are better than expected, as well as those that are worse, and thus can be used as an improvement tool as well as to assure clinicians and others of the standard of care being provided, and to measure productivity"

Professor the Lord Darzi, PC, KBE, FRS, FMEDSCI, HONFRENG, Currently Director of the Institute of Global Health Innovation at Imperial College London, Chair of Surgery at Imperial College London, the Royal Marsden Hospital and the Institute of Cancer Research

"I've been trialling the new C2-Ai App for AKI & Hospital-Acquired Pneumonia, both of which are phenomenal and work incredibly fast...delighted and excited as to how this tool can help us identify these patients early and put in place simple measures, which all have a significant impact".

Sunjay Kanwar, Consultant General Surgeon,  
St Helen's & Knowsley Teaching Hospitals NHS Trust,

We have the necessary approvals and meet relevant standards



One of only a handful of companies approved for full access to NHS historic datasets and NHS internal network



Approved for use with standards in place where needed (UK, EU and US)





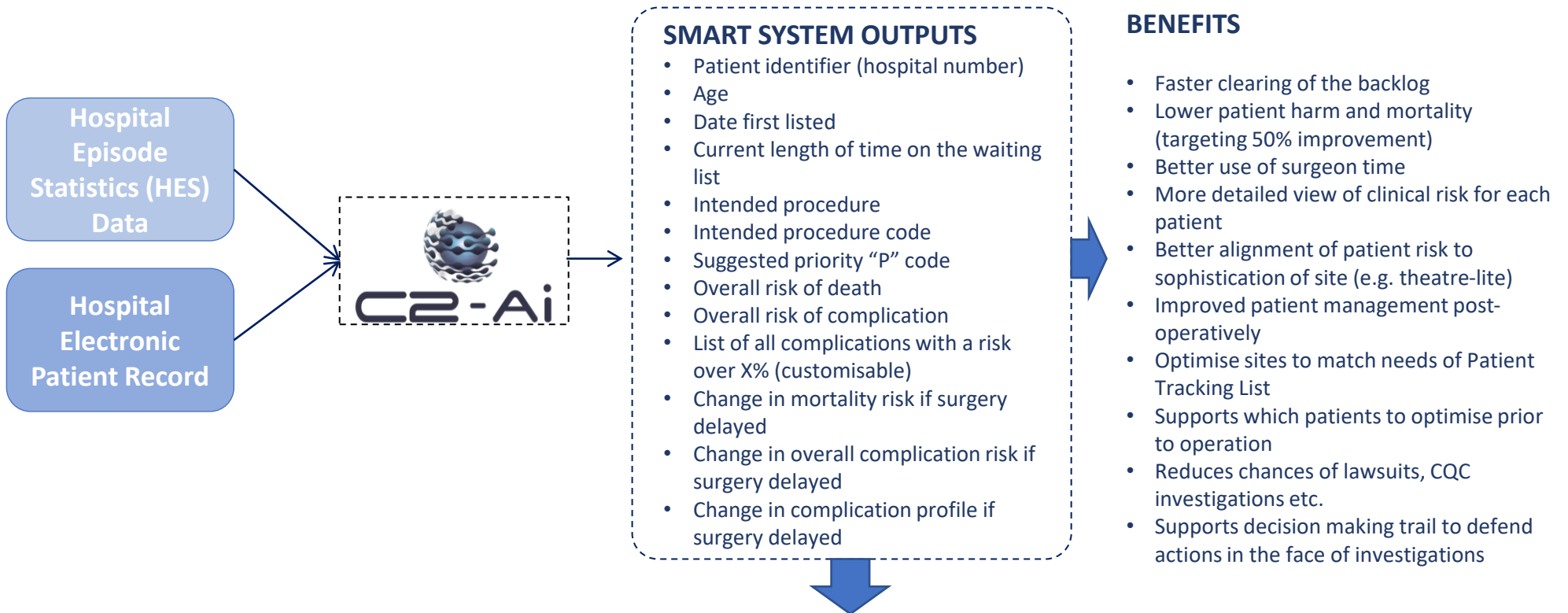
## CONTACT

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**US HQ** - St Petersburg, Florida

**International HQ** - Cambridge, UK

# C2-Ai's approach is in use in the NHS



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