TREAT®

Implementering af innovativ AI-løsning med antibiotikabeslutningsstøtte i klinisk praksis

Who are we?

- Our dynamic team is focused on development and implementation of specialized healthcare IT solutions (SaMD)

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Chief Executive Officer (CEO)

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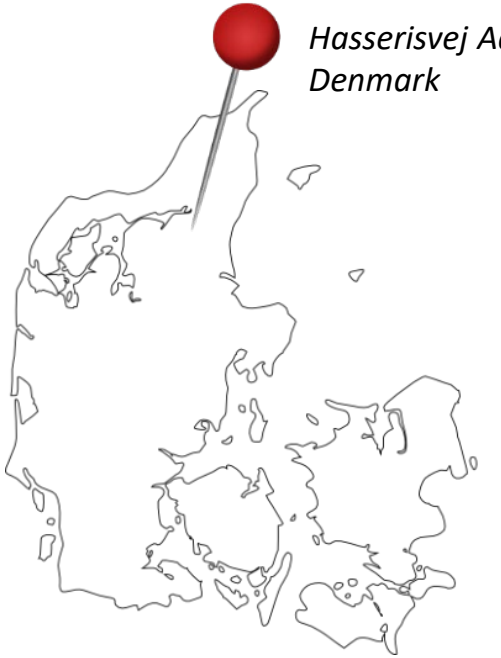
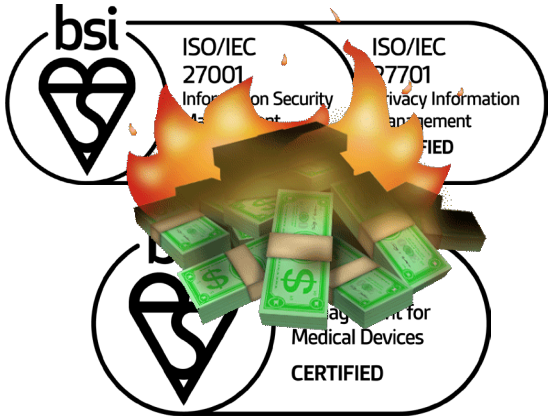


Hasserisvej Aalborg, Denmark

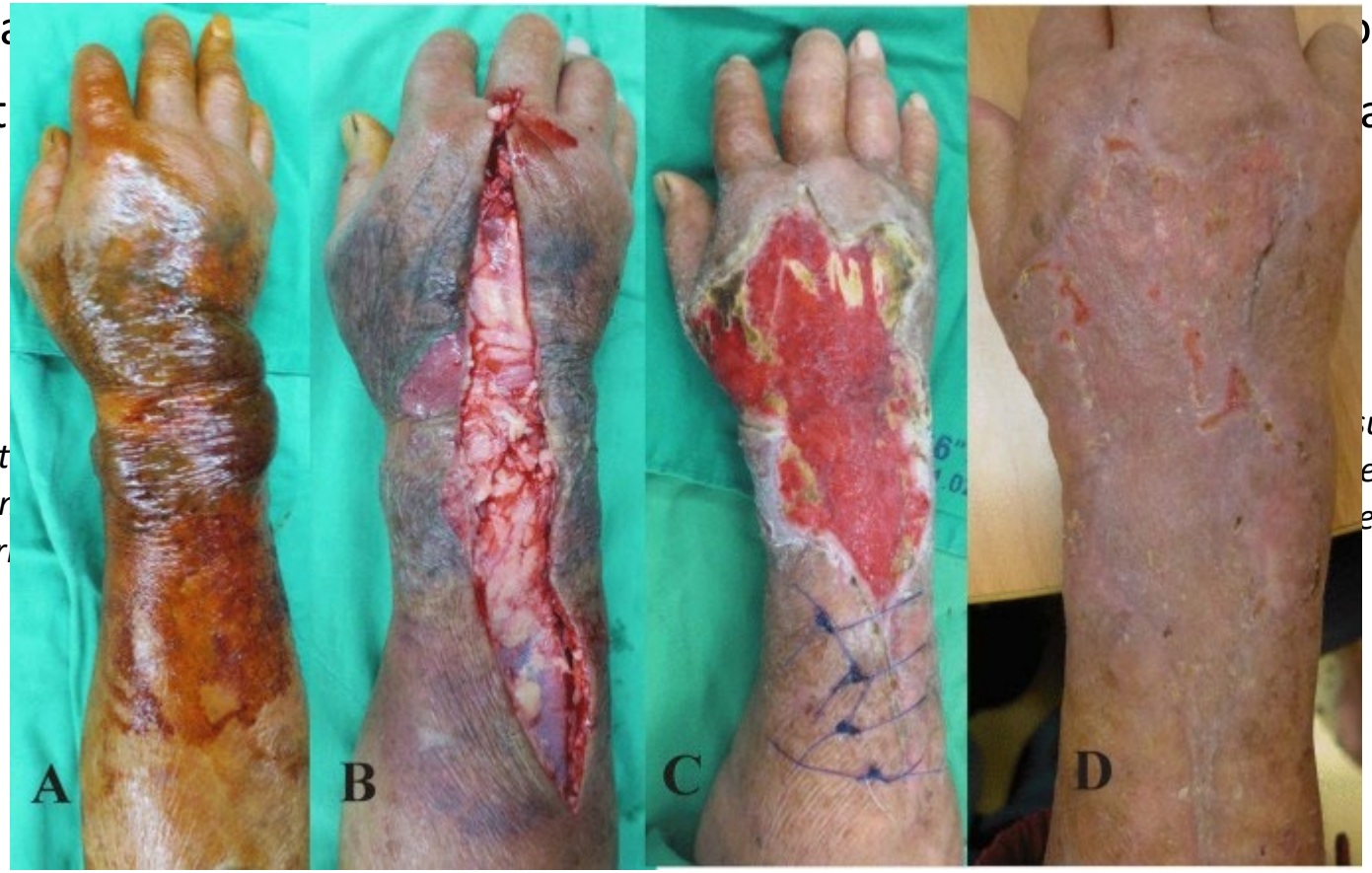


Treat Systems is a dynamic and innovative Danish SME focused on developing certified healthcare software solutions including decision support, machine learning (ML) and artificial intelligence (AI).

The Challenge of the “Super bugs”

- The microbiological battle toughens

- Antimicrobial resistance is one of the world’s most pressing public health threats and will in 2050 kill more people than cancer
- Excessive or ina oblem
- Antimicrobial t ailable



Minimizing
antimicrobials as t
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infection.

[AMR-Review Report, May 2016]

TREAT SYSTEMS

Two Available Software Products

– Highly configurable modules can be combined in numerous ways

An **Antimicrobial stewardship** tool helping clinicians to select the most rational antimicrobial therapy at point of care

A **Diagnostic stewardship** tool for the microbiological laboratories that Identifies populations for whom rapid diagnostics are cost-effective

CE

**Solutions are software as a medical device and comes in native languages and can be used as stand alone or OEM solution*

TREAT SYSTEMS

Core functions and modules

- Integration of personalized, locally calibrated decision support and antimicrobial stewardship in real-time.

Pilot in Region South

Pilot in Region North

TREAT-Worklist

Live dashboard with alerts and an overview containing all infection-relevant information for the stewardship team

(Users: Stewardship Team)

TREAT-AbxAdvisor

Supports the implementation of rational antibiotic use through decision support

(Users: Clinicians prescribing antibiotics)

TREAT-Essential

TREAT-Antibiogram

Easy search in the institutional antibiogram for specific drug-bug combinations

(Users: Microbiologist)

TREAT-InspectionTool

Reviewtool for past and current patient-specific infection episodes

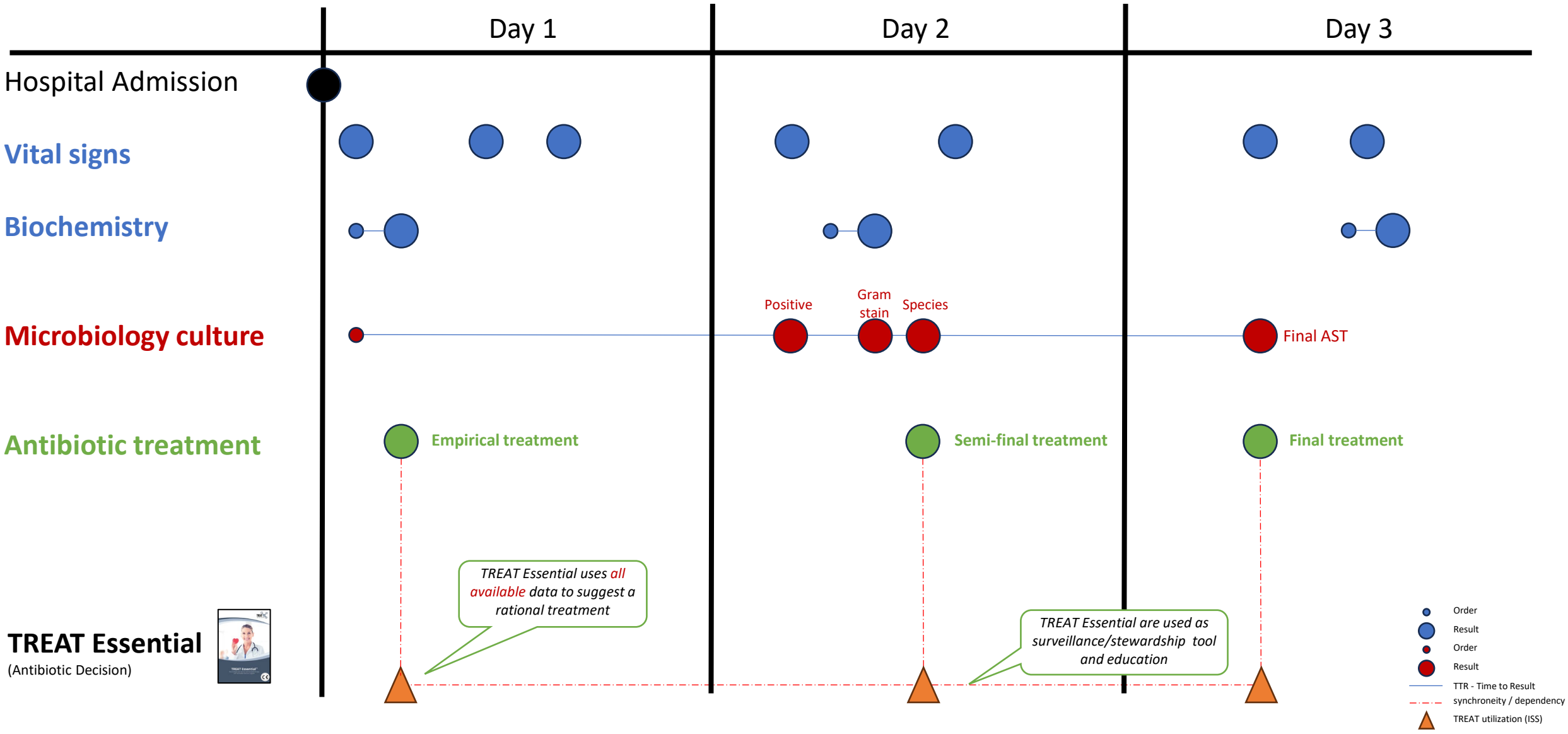
(Users: Clinicians prescribing antibiotics/Stewardship Team)

TREAT-ReportingTool

Provides easy access to clinical performance and KPIs for the antimicrobial stewardship team and hospital management.

(Users: Stewardship team and hospital management)

How TREAT Systems integrates into the clinical workflow



TREAT Essential
(Antibiotic Decision)

ISS: Infection Severity Score; PON: Point-of-Need; MDx: molecular diagnostics; Biochemistry: e.g. CRP, Albumin, Lactate, etc.; Vital signs: e.g. Heartbeat, Temperature, etc., AST: Antibiotic Sensitivity Testing

Integration and data requirements

- Database structure suitable for collection and processing of BIG data

Laboratory information

(Middleware and LIS)

- Biochemistry
- Microbiology

Clinical health data

(Electronic health record)

- Treatments (Abx/J01…)
- Vital parameters
- Allergy
- Background information
- Clinical Notes
- Patient demographics

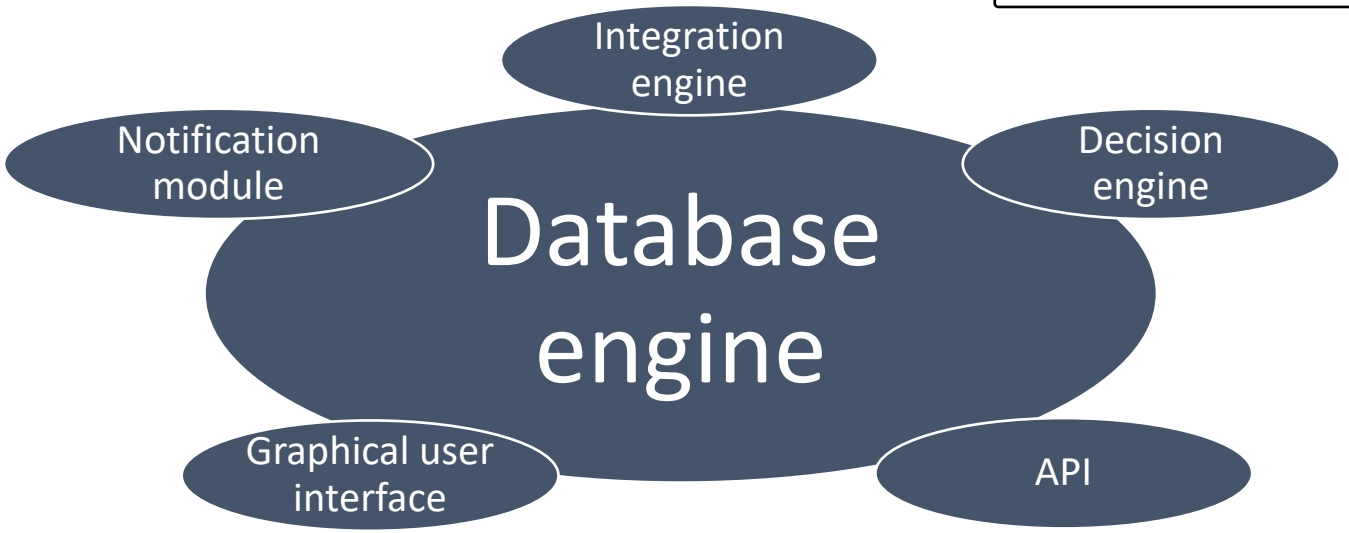
HL7® FHIR®

LOINC® From Regenstrief

SNOMED CT The global language of

ICD-10 www.cms.gov/ICD10

medcom



TREAT-Essential is a web-based on prem solution; the graphical user interface can easily be accessed at any computer on the hospital network. Individual elements of the TREAT-Essential solution are also available as APIs, facilitating deep integration within existing clinical modules.

Technology used

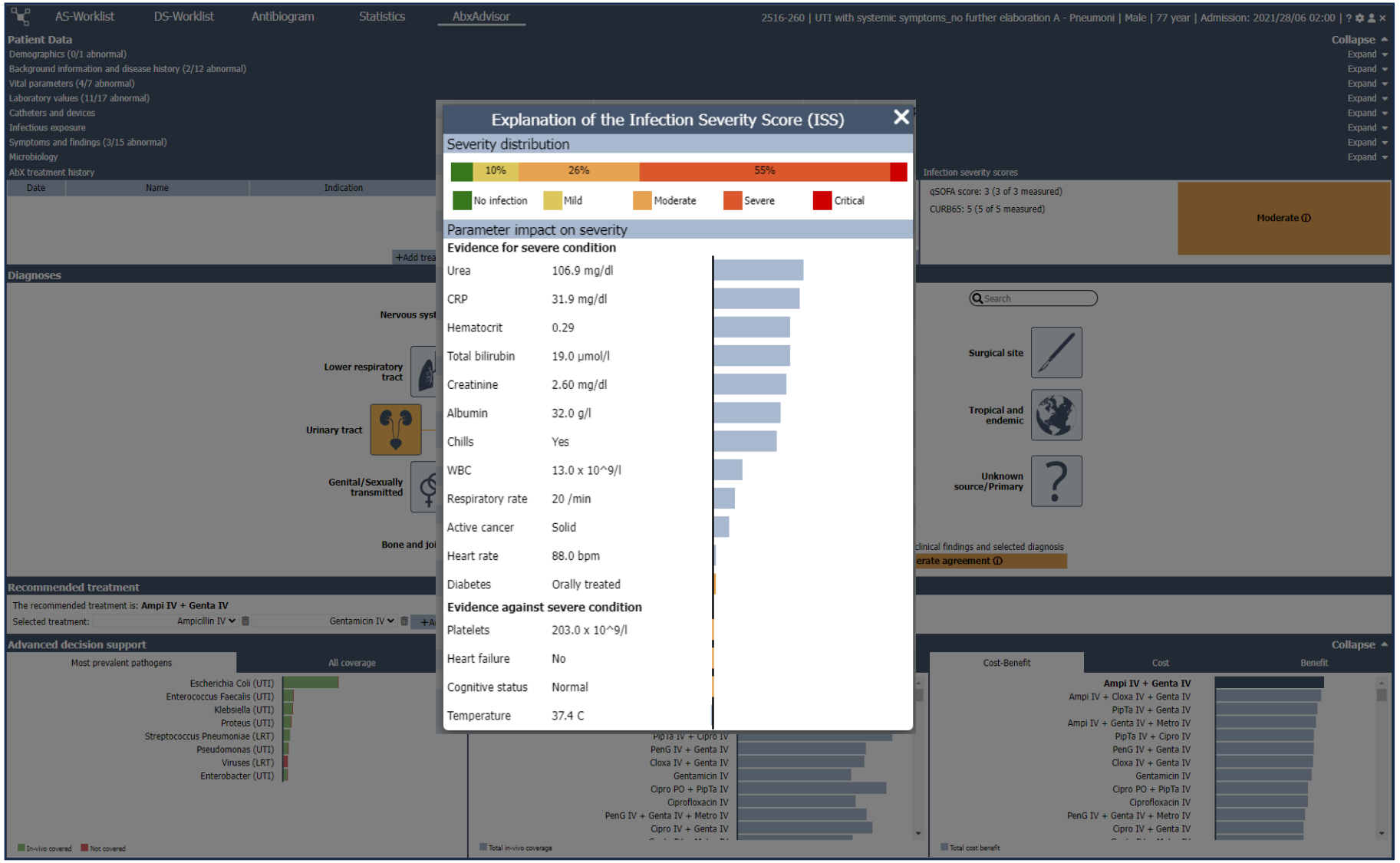
TREAT-Essential is a web-based solution coded in Angular, .Net Core and C# development language. Front end: HTML, TypeScript compiled to JavaScript and SCSS compiled to CSS.

TREAT SYSTEMS

An example of the TREAT-AbxAdvisor

- Decision support on pathogen distribution, local susceptibilities and the rational antibiotic treatment

- Generates personalized antimicrobial advice bedside calibrated to local resistance levels and guidelines even before microbiological results are available.
- The solution provides overview of infection relevant information
- The solution automatically calculates the severity of the infection
- It only requires the diagnosis to be input by the clinician, along with some intelligent follow up questions about symptoms and findings and background information.
- If the doctor wants explainability of the advice the “Advanced decision support” can be expanded



Suggested pilot installation at the emergency ward

- Improves empirical coverage and reduces consumption of broad-spectrum antimicrobials

The overall implementation and pilot project:

Retrospective trial → Implementation, Calibration, Installation/test (4 months) → Pilot (6 months) → Evaluation (2 months) → Production

A successful pilot was ensured:

Customer satisfactory
- Intuitive and useful software

Reduce Abx
- 10% reduction in the number of broad-spectrum prescriptions, defined on the Watch list of the WHO AWARE program.

Clinical performance
- 10% increase in patients receiving covering empirical antibiotic treatment for pathogens identified via blood cultures

Guideline compliance
- 30% increase in empirical antibiotic treatments prescribed according to the hospital's antibiotic guidelines

Decreased costs
- 10% decrease in direct cost associated with antibiotic treatment

Results from Region north

What did we achieve?

User experience - Interview

- Summary of users' experiences with TREAT-Essential, along with the constructive suggestions provided to further improve the system.

Positive feedback

- A great initiative and highly relevant for reducing the use of broad-spectrum antibiotics.
- It's smart to have all infection-relevant information on one page, with clear indicators of values outside the normal range.
- It's fascinating to observe how bacterial distribution changes across different diagnoses.
- Interesting to see how treatments cover various bacteria.
- I find TREAT easy to use, and it doesn’t take much time—it's nice to receive automatic notifications, even though the pop-up appears a bit too often.
- The system works exceptionally well—I have experienced no technical issues.
- A helpful support tool that provides clear explanations of the effects of different treatments.

Negative feedback

- Some of TREAT's recommendations seem odd and do not always align with our guidelines e.g. for pneumonia.
- In the initial weeks, the system was very slow to open, but this has improved over time.
- I rely solely on the hospital's guidelines and do not wish to use TREAT.
- I feel somewhat uncertain about whether I should follow TREAT's recommendations.
- I am unable to log into the system at all.
- An annoying pop-up keeps appearing repeatedly.

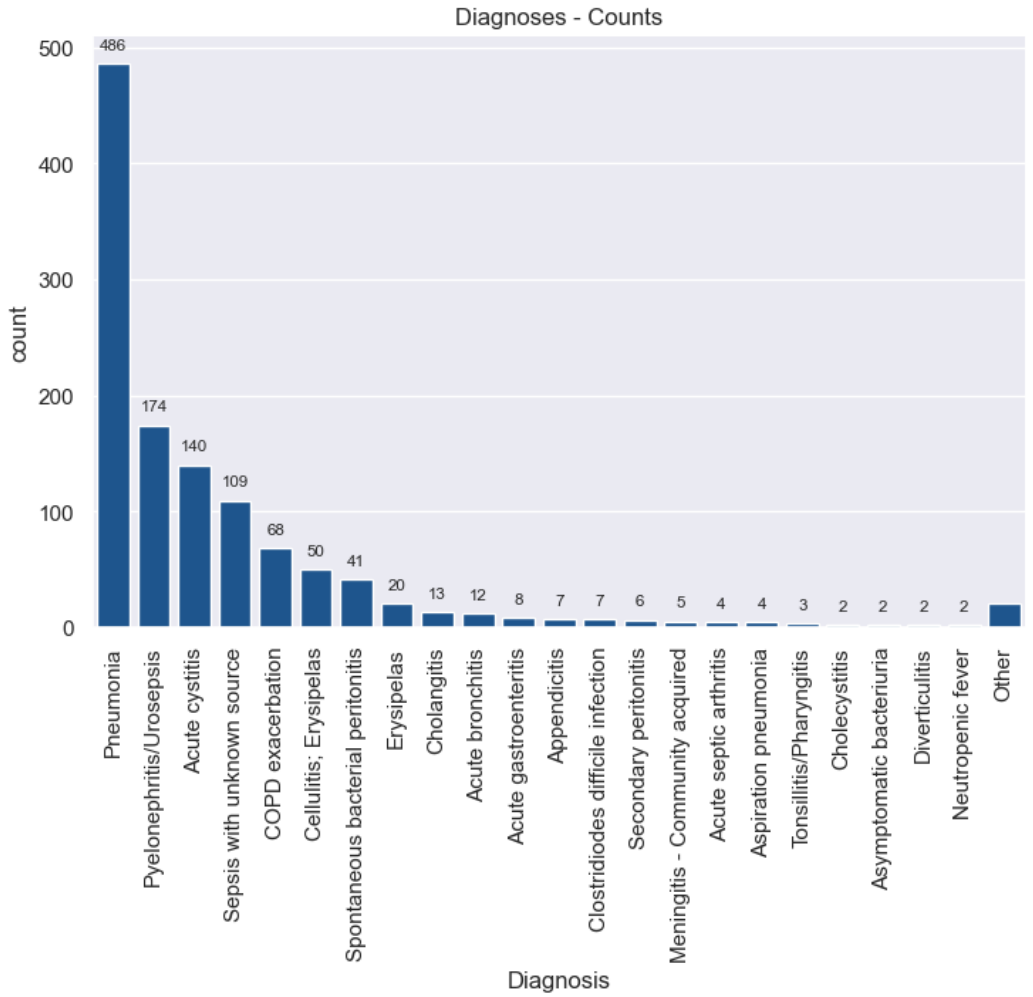
Suggestions for improvement

- It would be beneficial if TREAT could automatically retrieve vital parameters, eliminating the need for manual entry.
- It would be convenient if TREAT could automatically fetch CAVE (allergy information).
- A "confirmation" feature when treatment is approved would be useful, allowing users to write comments and provide feedback to the system.
- A diagnosis option labeled "Unknown/Unclear Focus" is missing and would be helpful.

Cohort description

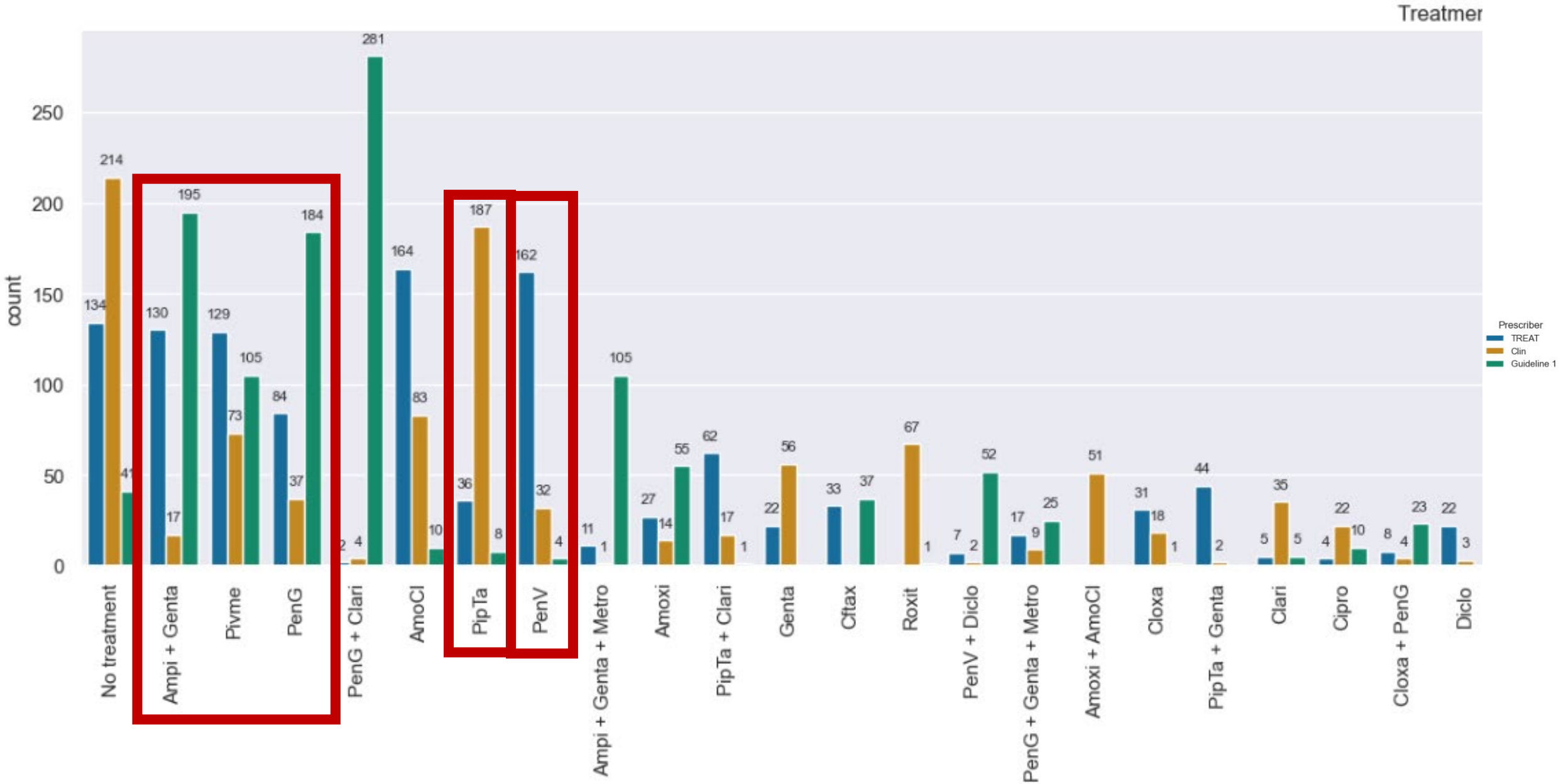
- In total, 1,185 patients were included in the analysis, having been assigned a TREAT diagnosis and possessing sufficient data to calculate antibiotic recommendations.

	Overall
N Patients, (%)	1185 (100.0%)
Age, mean (range)	71 (18-104)
Sex (female), n (%)	530 (44.7%)
Place of acquisition, n (%)	
Community	1170 (98.7%)
Nursing home	4 (0.3%)
Hospital	10 (0.8%)
Vitals/Lab data	
CRP	111.0 (45.5-196.0)
Creatinine	1.0 (0.7-1.3)
Albumin	33.0 (30.0-37.0)
Total Bilirubin	0.6 (0.5-1.0)
Urea	40.2 (27.6-61.4)
WBC	12.3 (9.0-16.1)
Platelets	238.0 (188.0-310.0)
Neutrophils	9.7 (6.8-13.3)
Lactate	1.2 (0.8-1.9)
Temperature	37.7 (37.0-38.3)
Respiratory rate	20.0 (18.0-25.0)
SaO2	0.9 (0.9-1.0)
HR	101.0 (99.0-110.0)
SBP	117.0 (111.5-149.0)
DBP	75.5 (73.0-90.0
Microbiology samples, n unique patients (%)	
Blood culture	1170 (98.7%)
Urine culture	875 (73.8%)
ENT culture	528 (44.6%)
LRT culture	383 (32.3%)
Skin and soft tissue culture	186 (15.7%)
CSF culture	74 (6.2%)
Treatment, n (%)	
Antimicrobial therapy	971 (81.9%)
Monotherapy	687 (70.8%)
Combination therapy	284 (29.2%)
Outcome, n (%)	
Significant MDI	195 (16.5%)
Bacteremia	146 (12.3%)
Local only	49 (4.1%)
Positive BC	151 (12.7%)
Positive Local	303 (25.6%)
30-day mortality	124 (10.5%)



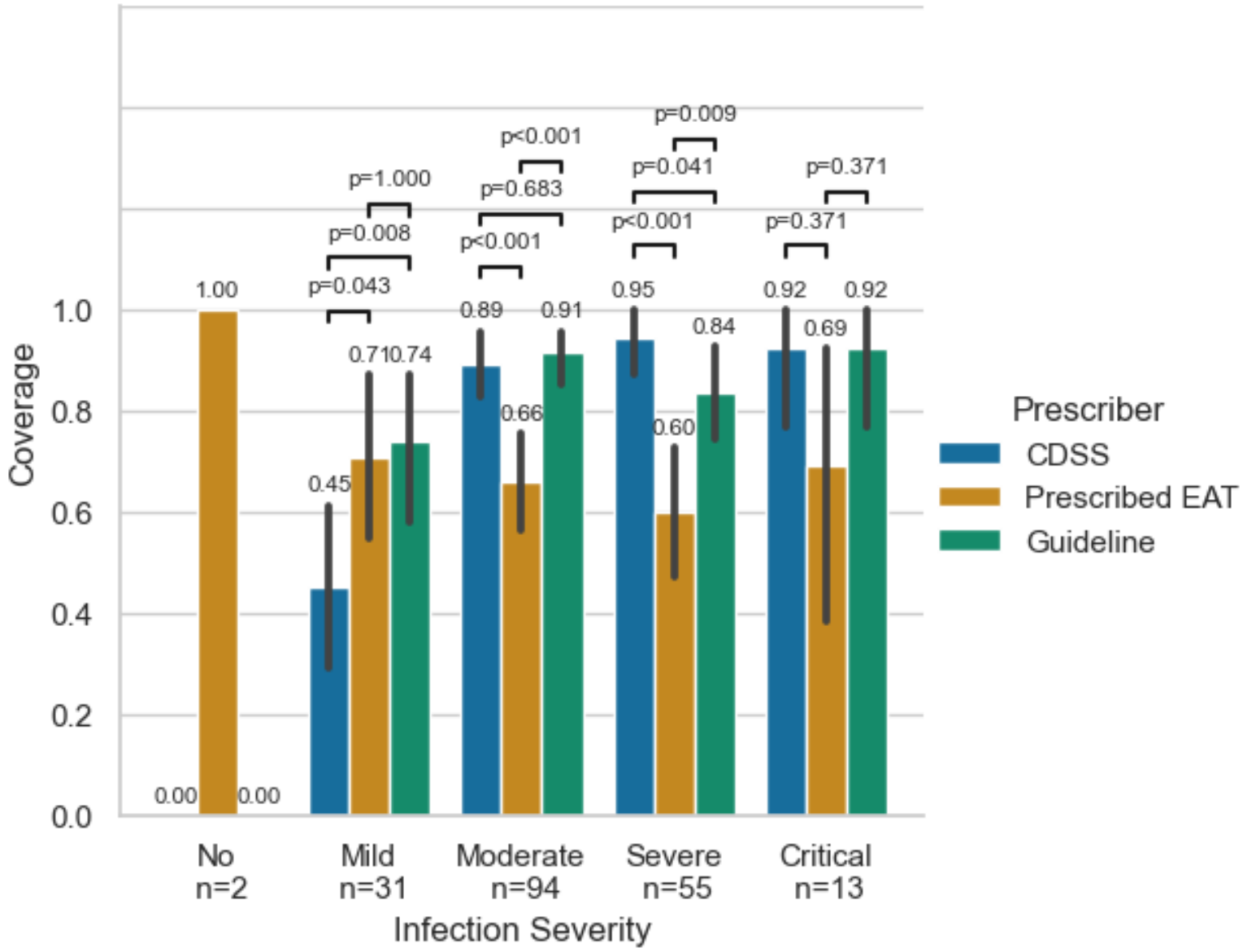
Treatments

- Treatment distribution for patients with suspected infection



Empirical Coverage of Patients with Significant Microbiology

- TREAT vs. clinicians vs. guidelines, categorized based on whether patients have bacteremia.



Summary of Pilot testing

- Clinical results

Empiric coverage
+12.3% more patients recieved appropriate empiric therapy
(+14.4% in prior 10,000-patient trials)

Reduced broad-spectrum use
-20.7% overall, incl. -59% for WHO ”Watch-drugs”
(-38.1% in earlier trials)

Guidelinecompliance
Potential increase of +31.4% if TREAT suggestions are followed (baseline 18.1%)

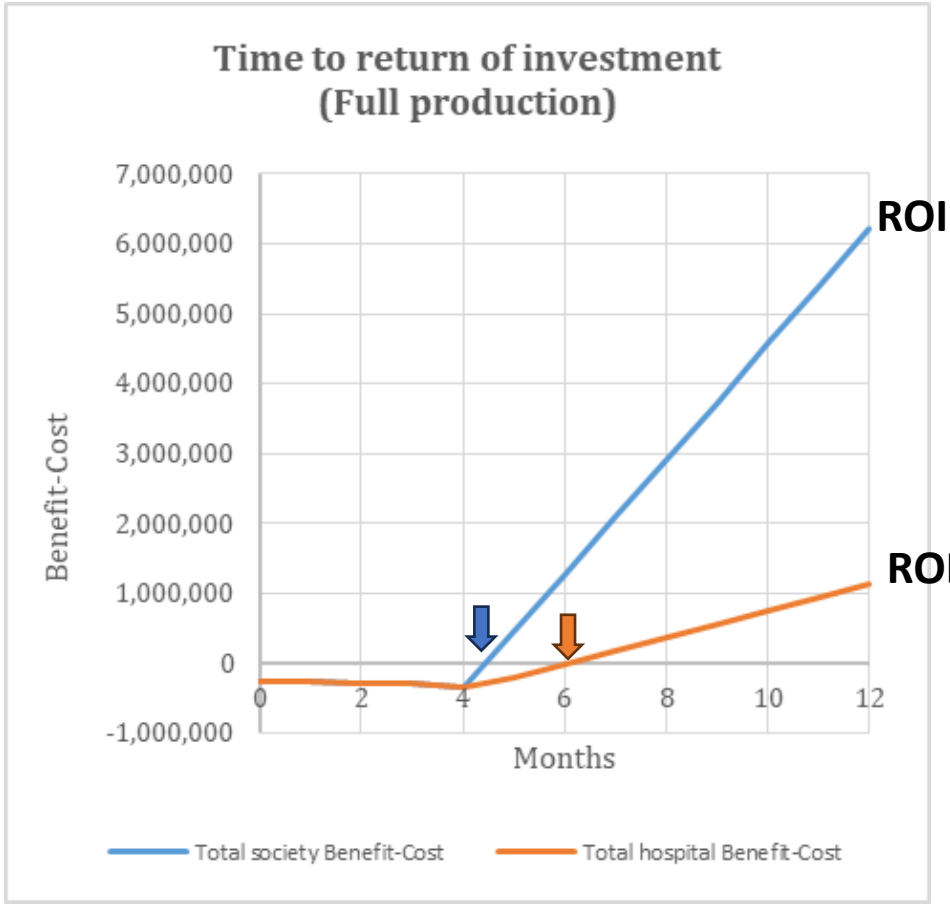
Lessons from the users:

- Overall positive feedback minor technical issues; high engagement from clinicians
- For the full benefit we need full integration with excisting systems
- Good ideas for future development

Return on investment for Region North Danmark (1000 beds)

- TREAT-Essential is highly cost-effective for both the hospital and for the society

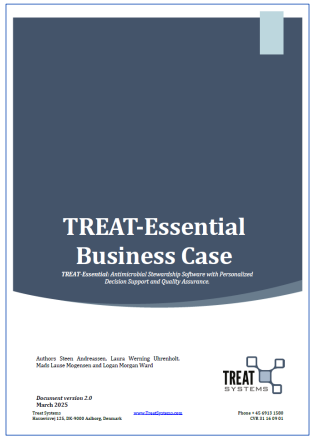
- **Costs:** Servers, Project Management, Calibration, Integration/IT Infrastructure, Training, Software License, Support and Maintenance
  Benefits: Shorter hospital stay, Fewer readmissions, Medication savings and Years of life saved



ROI society: 1392%

ROI hospital: 318%

Details can be found here:



Estimates are based only on patients with bacteremia (i.e. 10% of patients suspected of having infections). Savings are expected to be much higher due to fewer ICU admissions, time saved by the stewardship team during rounds, the impact of better infection triage and home care, less promotion of future multidrug-resistant pathogens, and training of junior doctors not included in the business case.

Core functions and modules

- Integration of personalized, locally calibrated decision support and antimicrobial stewardship in real-time.

TREAT-Essential

TREAT-Worklist

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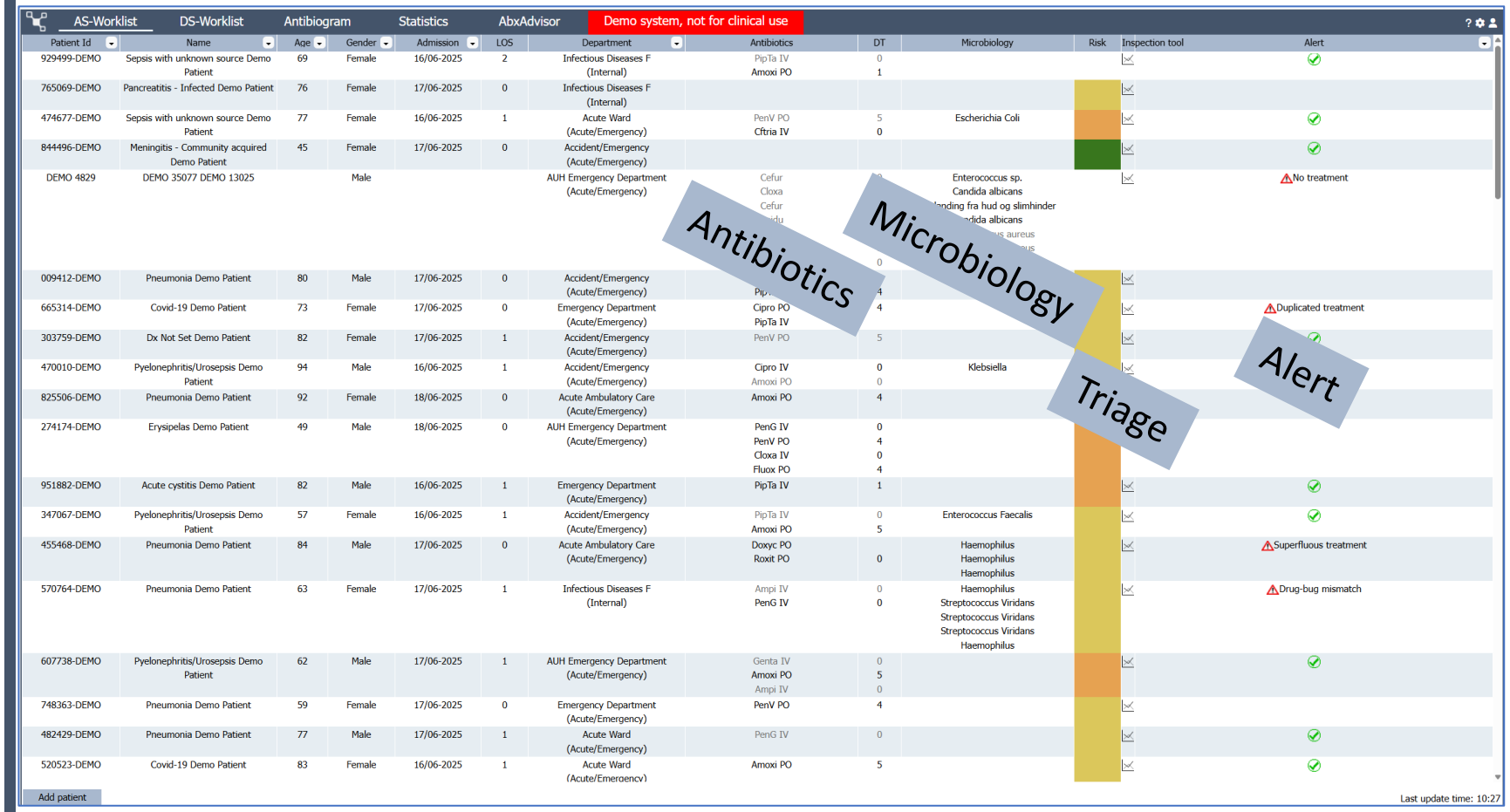
(Users: Stewardship team and hospital managment)

TREAT-Worklist

- Binds all infection–relevant information together for the specialist

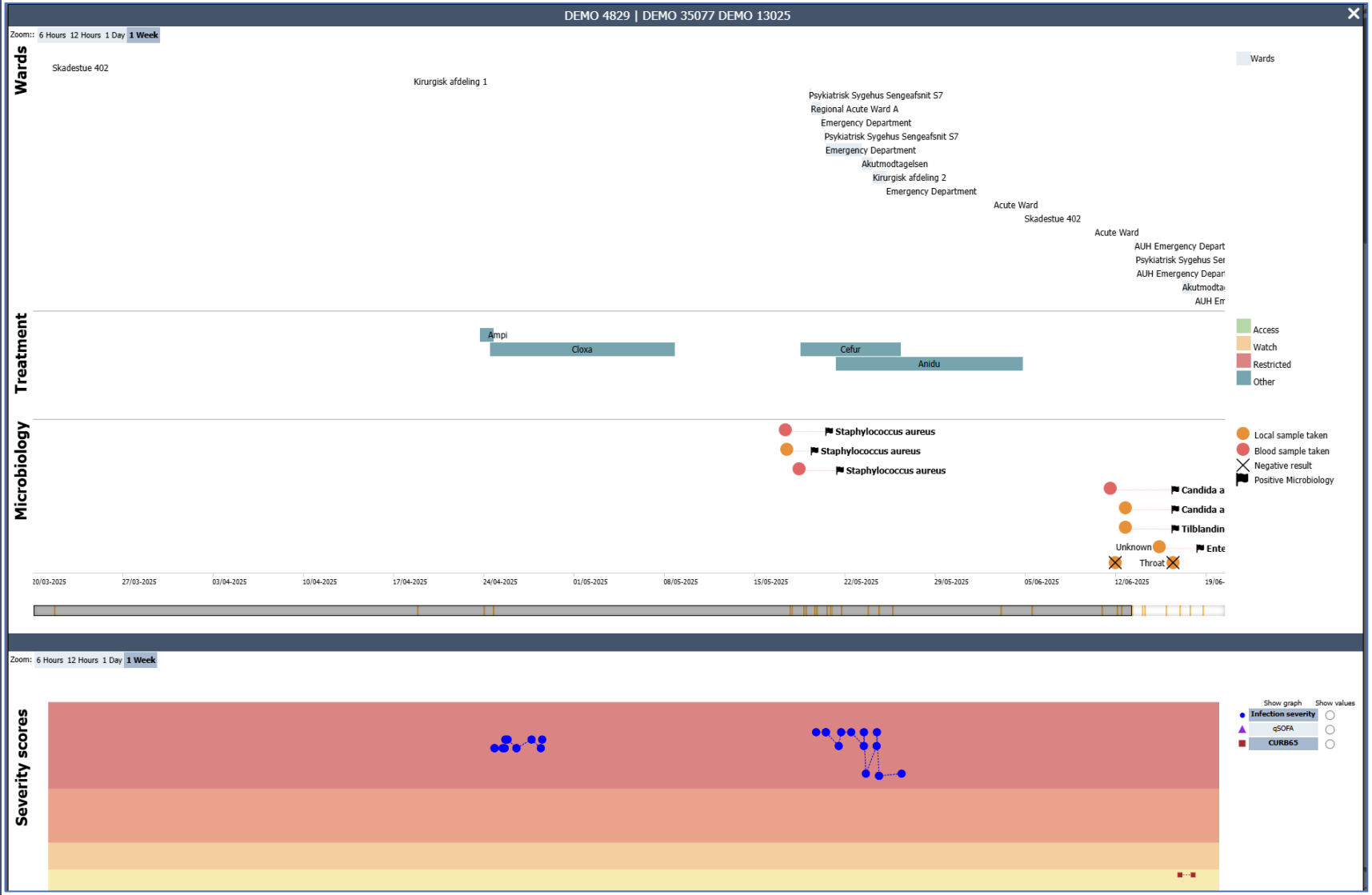
- The Worklist acts as a dashboard for the experts at the hospital, giving an overview of all patients receiving antibiotics treatment, as well as those for whom antibiotics should be considered.
- It provides an opportunity to review guideline compliance, usage of restricted antibiotics and to monitor high–risk patients.
- The Worklist puts the hospital's stewardship team in full control.



TREAT-InspectionTool

- Supports reviewing of the temporal course of an infectious episode

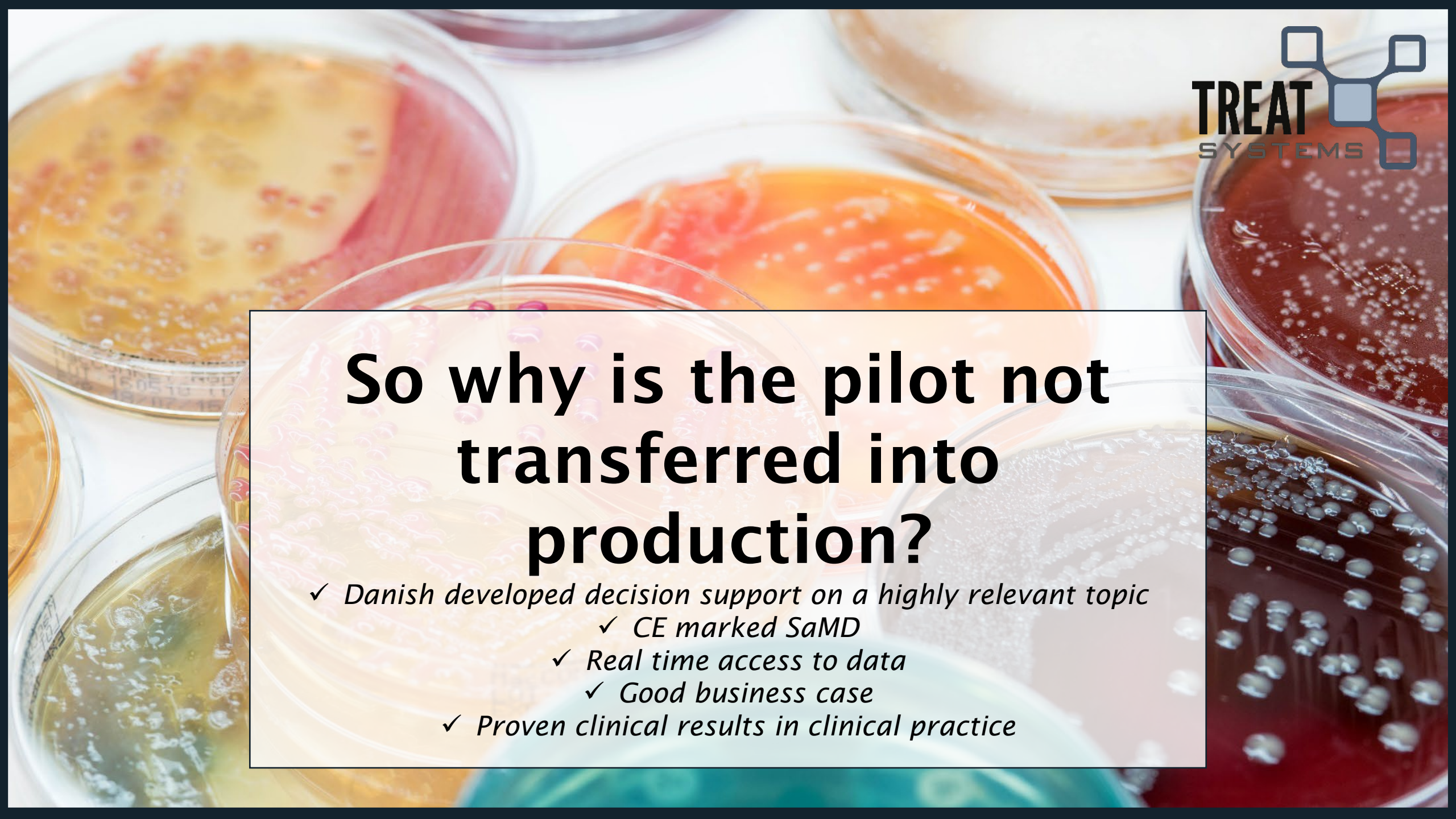
- With Treat-Essential's Inspection Tool, the specialist team and clinicians prescribing antibiotics can review specific infectious episodes in detail.
- The episode history includes a complete overview of antibiotics treatments, microbiology, vital parameters, biochemistry, hematology, blood gases and liver function indicators.



TREAT-Antibiogram

- Real time antimicrobial resistance surveilance

- Microbiologist and infectious disease specialist can review and monitor antimicrobial resistance rates in real time for specific departments, time period, age groups etc.
- Using the institutional antibiogram as a starting point, TREAT-Essential adjusts for whether a patient's infection is community– or hospital–acquired, and whether they have recently received antimicrobial treatment.
- This innovative approach also allows the likelihood of susceptibility to antibiotics not included in standard susceptibility test panels to be estimated.

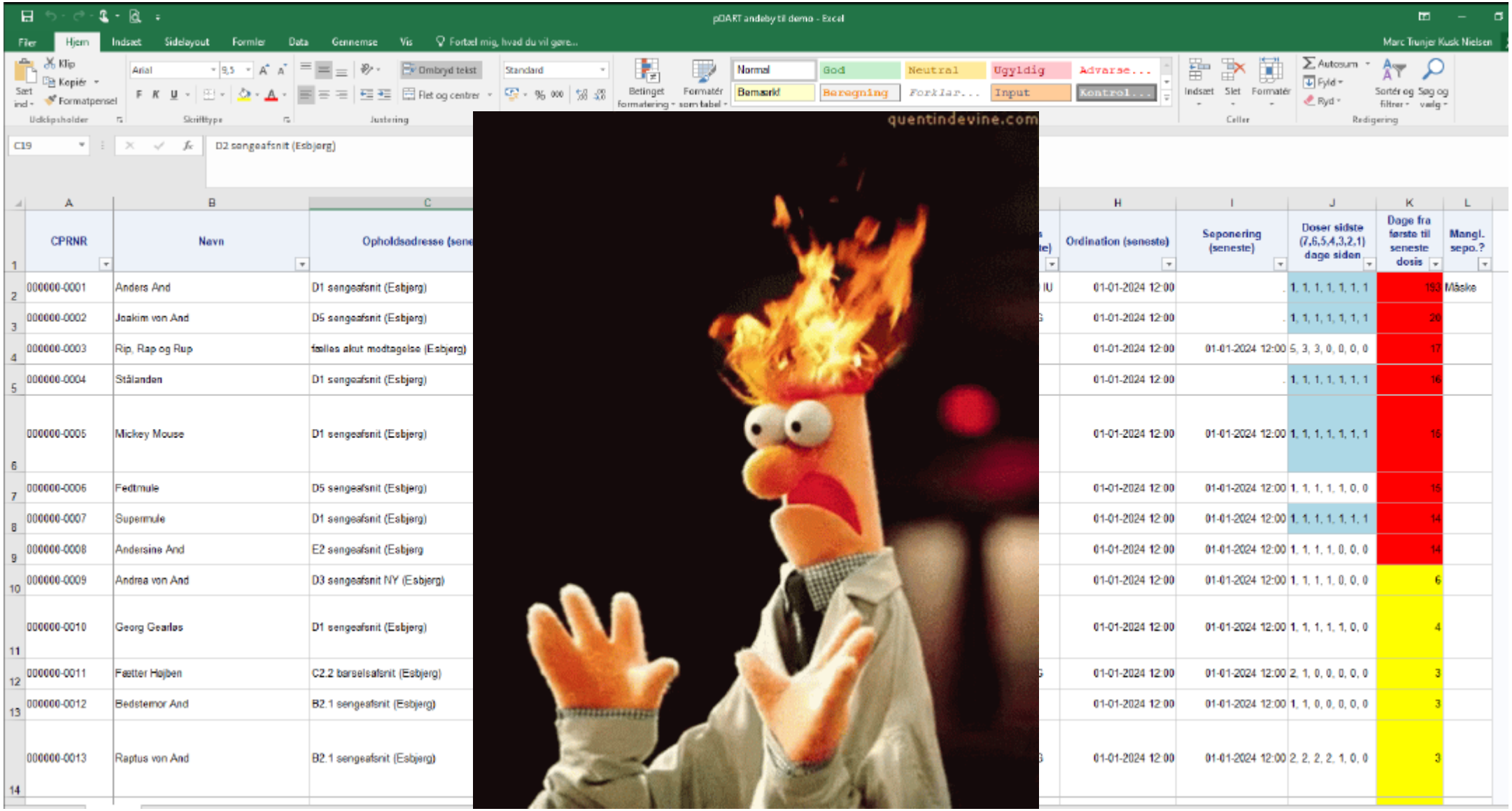


So why is the pilot not transferred into production?

- ✓ *Danish developed decision support on a highly relevant topic*
- ✓ *CE marked SaMD*
- ✓ *Real time access to data*
- ✓ *Good business case*
- ✓ *Proven clinical results in clinical practice*

The region would rather like to have their own Excel sheet

- showing medication



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6	000000-0005	Mickey Mouse	D1 sengeafsnit (Esbjerg)	01-01-2024 12:00	01-01-2024 12:00	1, 1, 1, 1, 1, 1, 1	16	
7	000000-0006	Fedtmule	D5 sengeafsnit (Esbjerg)	01-01-2024 12:00	01-01-2024 12:00	1, 1, 1, 1, 1, 0, 0	15	
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11	000000-0010	Georg Gearløs	D1 sengeafsnit (Esbjerg)	01-01-2024 12:00	01-01-2024 12:00	1, 1, 1, 1, 1, 0, 0	4	
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Open For Discussion

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Overview of research contribution

JOURNAL ARTICLES

1. Tim Alex Lindskou, Logan Morgan Ward, Morten Breinholt Søvsø, Mads Lause Mogensen, Erika Frischknecht Christensen (2023) Prehospital Early Warning Scores to Predict Mortality in Patients Using Ambulances. JAMA Network Open; 6(8):e2328128 http://dx.doi.org/10.1001/jamanetworkopen.2023.28128
2. John Karlsson Valik, Logan Ward, Hideyuki Tanushi, Anders F Johansson, Anna Färnert, Mads Lause Mogensen, Brian W Pickering, Vitaly Herasevich, Hercules Dalianis, Aron Henriksson, Pontus Nauclér (2023) Predicting sepsis onset using a machine learned causal probabilistic network algorithm based on electronic health records data. Scientific Reports; 13(1). http://dx.doi.org/10.1038/s41598-023-38858-4
3. Kris Kristensen, Logan Morgan Ward, Mads Lause Mogensen, Simon Lebech Cichosz (2022) Using Image Processing and Automated Classification Models to Classify Microscopic Gram Stain Images. Computer Methods and Programs in Biomedicine; 3(11):100091 http://dx.doi.org/10.1016/j.cmpbup.2022.100091
4. Catia Cilloniz, Logan Ward, Mads Lause Mogensen, Juan M. Pericas, Raúl Méndez, Albert Gabarrús, Miquel Ferrer, Carolina Garcia-Vidal, Rosario Menendez, Antoni Torres (2022) Machine-Learning Model for Prediction of Mortality Among Patients with Community-acquired pneumonia: Development and validation study. Chest 163(1) http://dx.doi.org/10.1016/j.chest.2022.07.005
5. Steen Andreassen, Jens Kjølseth Møller, Noa Eliakum-Raz, Gorm Lisby, Logan Ward (2021) A comparison of predictors for mortality and bacteraemia in patients suspected of infection. BMC Infectious Diseases 21(1) https://bmcinfectdis.biomedcentral.com/articles/10.1186/s12879-021-06547-0
6. John Karlsson Valik, Lisa Mellhammar, Jonas Sundén-Cullberg, Logan Ward, Christian Unge, Hercules Dalianis, Aron Henriksson, Kristoffer Strålin, Adam Linder, Pontus Nauclér (2021) Peripheral oxygen saturation facilitates assessment of respiratory dysfunction in the Sequential Organ Failure Assessment Score with implications for the Sepsis-3 criteria. Critical Care Medicine 50(3):p e272-e283 http://dx.doi.org/10.1097/CCM.0000000000005318
7. John Karlsson Valik, Logan Ward, Hideyuki Tanushi, Kajsa Müllersdorf, Anders Ternhag, Ewa Aufwerber, Anna Färnert, Anders F Johannson, Mads Lause Mogensen, Brian Pickering, Hercules Dalianis, Aron Henriksson, Vitaly Herasevich, Pontus Nauclér (2020) Validation of automated sepsis surveillance based on the Sepsis-3 clinical criteria against physician record review in a general hospital population: observational study using electronic health records data. BMJ Quality & Safety; 29:735-745. http://dx.doi.org/10.1136/bmjqs-2019-010123
8. Logan Ward, Steen Andreassen, Jesper Johnsen Astrup, Zakia Rahmani, Michela Fantini, Vittorio Sambri (2019) Clinical- vs. model-based selection of patients suspected of sepsis for direct-from-blood rapid diagnostics in the emergency department: a retrospective study. European Journal of Clinical Microbiology and Infectious Diseases, Vol 38(8), 1515-1522 https://doi.org/10.1007/s10096-019-03581-4
9. Logan Ward, Mical Paul, Steen Andreassen (2017) Automatic learning of mortality in a CPN model of the Systemic Inflammatory Response Syndrome. Mathematical Biosciences, Vol 284, 12-20 https://doi.org/10.1016/j.mbs.2016.11.004
10. Bente Arboe, Rasmus Rude Laub, Gitte Kronborg, Jenny Dahl Knudsen (2014) Evaluation of the decision support system for antimicrobial treatment, TREAT, in an acute medical ward of a university hospital, International Journal of Infectious https://doi.org/10.1016/j.ijid.2014.08.019
11. Kristian Kofoed, Alina Zalounina, Ove Andersen, Gorm Lisby, Mical Paul, Leonard Leibovici, Steen Andreassen (2009) Performance of the TREAT decision support system in an environment with a low prevalence of resistant pathogens Journal of Antimicrobial Chemotherapy, Volume 63, Issue 2, February 2009, Pages 400–404, https://doi.org/10.1093/jac/dkn504
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13. Mahbub Ul Alam, Aron Henriksson, John Karlsson Valik, Logan Ward, Pontus Naucler, Hercules Dalianis (2020) Deep Learning from Heterogeneous Sequences of Sparse Medical Data for Early Prediction of Sepsis. 13th International Conference on Health Informatics http://dx.doi.org/10.5220/0008911400450055
14. Logan Ward, Jens K Møller, Noa Eliakim-Raz, Steen Andreassen (2018) Prediction of Bacteraemia and of 30-day Mortality Among Patients with Suspected Infection using a CPN Model of Systemic Inflammation. 10th IFAC Symposium on Biological and Medical Systems, Sao Paolo, Brazil https://doi.org/10.1016/j.ifacol.2018.11.657
15. Logan Ward and Steen Andreassen (2015) A Bayesian Approach to Model Development: Automatic Learning for Tuning Predictive Performance. 9th IFAC Symposium on Biological and Medical Systems, Berlin Germany https://doi.org/10.1016/j.ifacol.2015.10.187
16. Logan Ward, Mads Lause Mogensen, Mical Paul, Leonard Leibovici, Steen Andreassen (2014) A Bayesian Approach to Model Development: Design of Continuous Distributions for Infection Variables. 19th World Congress, IFAC, Cape Town, South Africa https://doi.org/10.3182/20140824-6-ZA-1003.02235

OTHER SCIENTIFIC CONTRIBUTION

1. Logan Ward, Mads Lause Mogensen, Dafna Yahav, Mical Paul, Leonard Leibovici (2023) A simplified model-based decision support system for empirical antimicrobial therapy. 33rd European Congress for Clinical Microbiology and Infectious Diseases (online publication only)
2. Logan Morgan Ward, Mads Lause Mogensen, Anders L Madsen, Tim Alex Lindskou, Erika Frischknecht Christensen (2022) AmPHI-TIPS: risk stratification for pre-hospital patients. 32nd European Congress for Clinical Microbiology and Infectious Diseases
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4. Mads Lause Mogensen, Logan Ward, John Karlsson Valik, Steen Andreassen, Aron Henriksson, Hercules Dalianis, Pontus Nauclér (2019) Validation of a causal probabilistic network model for prediction of bacteraemia and mortality among patients with blood cultures drawn in the emergency department. 29th European Congress for Clinical Microbiology and Infectious Diseases, Amsterdam, Netherlands
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