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Diagnosing Urinary Tract Infections using laser-patterned paper-based tests

Collin Sones, Peijun He, Ioannis Katis, Anto John, Benjamin Mills, Rob Eason

Optoelectronics Research Centre, University of Southampton, UK

Bill Keevil and Catherine Bryant, Jessica Teeling

Centre for Biological Sciences, University of Southampton

Bhaskar Somani

Department of Urology, University Hospital Southampton NHS Trust

Nitin Mahobia

Department of Infection, University Hospital Southampton NHS Trust

Motivation….

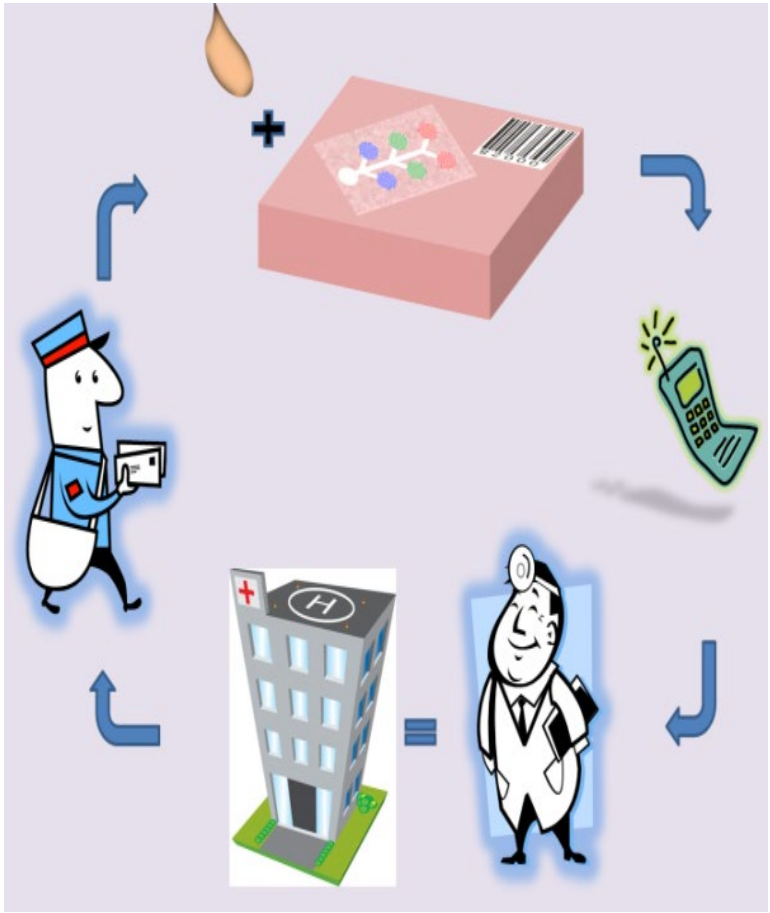
Enable detection bacterial (E-coli) infection (UTIs) at an early-stage

- **Home-testing for infections** – low-cost, patient-friendly testing, rapid, if possible, deliverable, readable using mobile-phones
- **As they wait** to be seen by their GP or clinician post an operative surgery

Reduce the burden of the testing

  - Free up the 'Clinician/GP time'

Tackle anti-microbial resistance



Current Bacterial Testing Pathway

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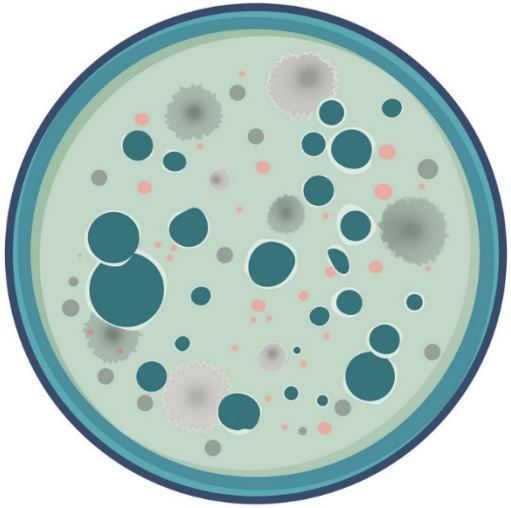
- Conventional or routinely adopted approach
  - Agar-plate based bacterial culture in pathological labs
  - Results visualized by highly trained experts after a day
- Identification is then followed by susceptibility testing
    - Via measurement of Disc Diffusion zone diameter
- Turnaround time of 2-5 days



Paper-based fluidics –ASSURED criteria

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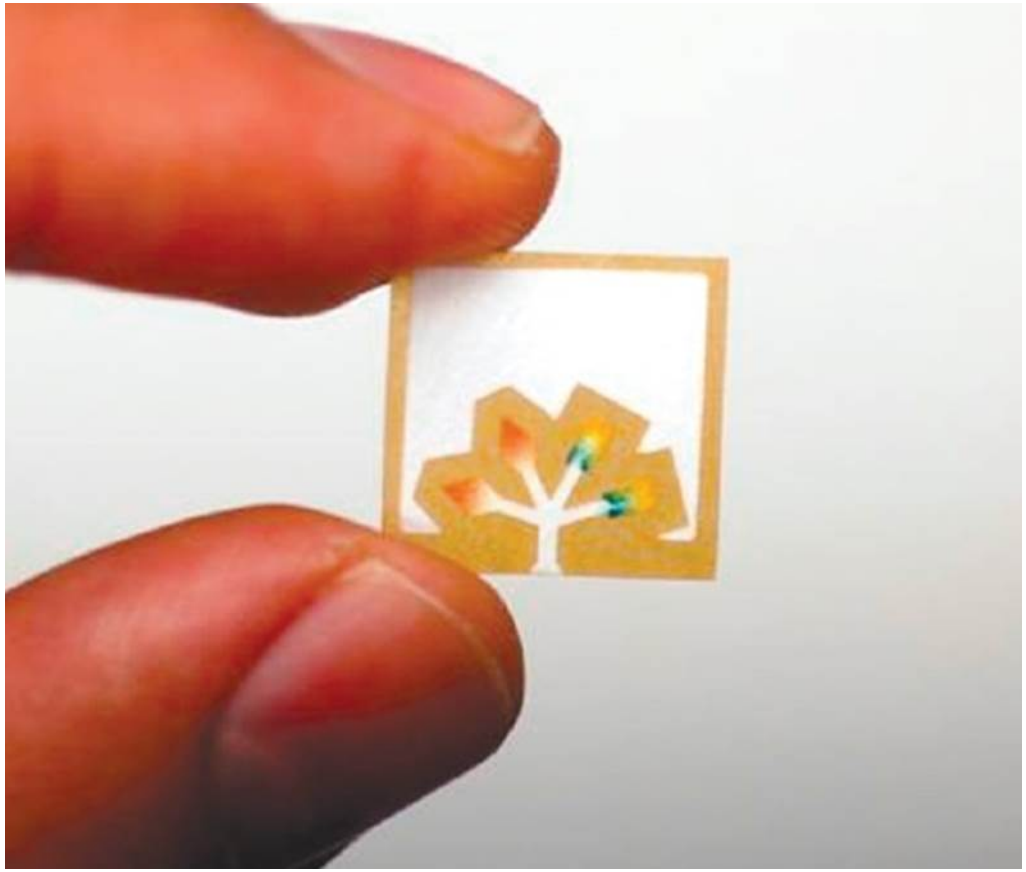
Such microfluidic lab-on-chip type devices consist of



Interconnected hydrophilic fluid-flow channels

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Hydrophobic barrier walls that extend throughout the paper

Requirements –

- Pattern paper to form the fluidic patterns
- Deposit biological materials for implementing the assay/test

LDW patterning approach

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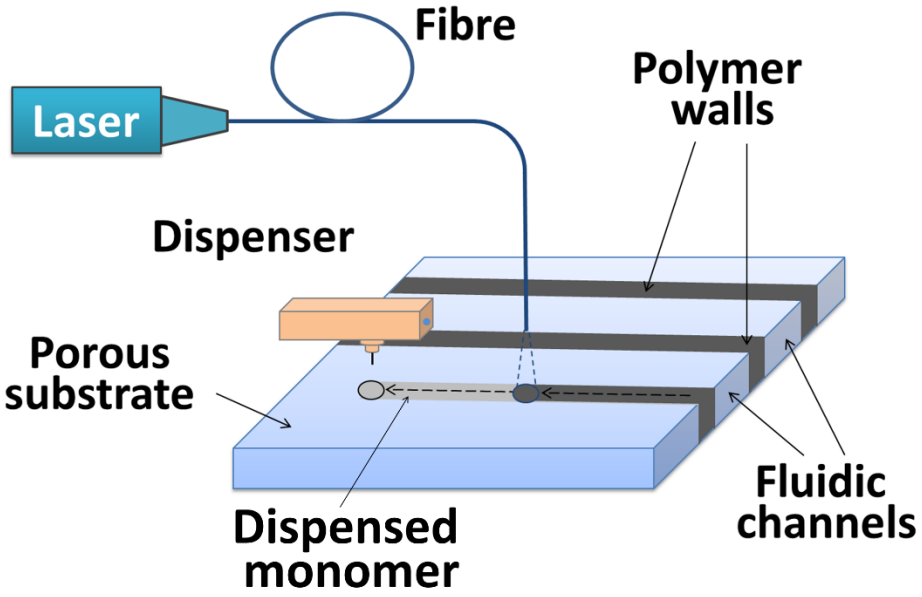
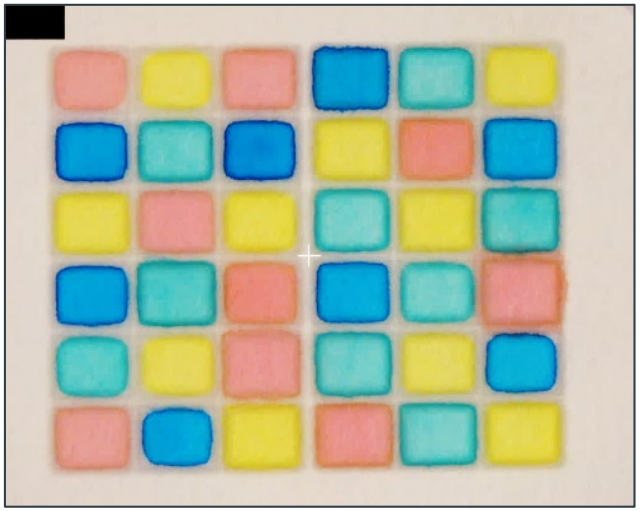
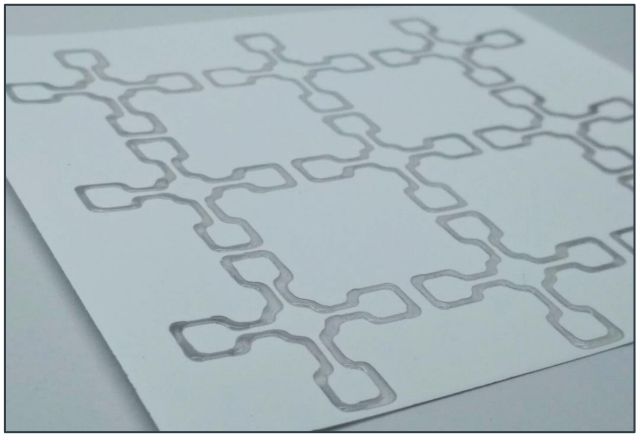
Technique that allows creation of μ-fluidic devices in porous materials

1. A local-deposition assisted laser-direct write procedure
2. Relies on the concept of light-induced polymerisation







Lasers used
Few mW of 405 nm c. w. lasers

Polymers used
Desolite 3471-3-14

Porous materials patterned
Cellulose, Nitrocellulose membranes, glass-fibre filters, and fabrics

Integrated paper device -

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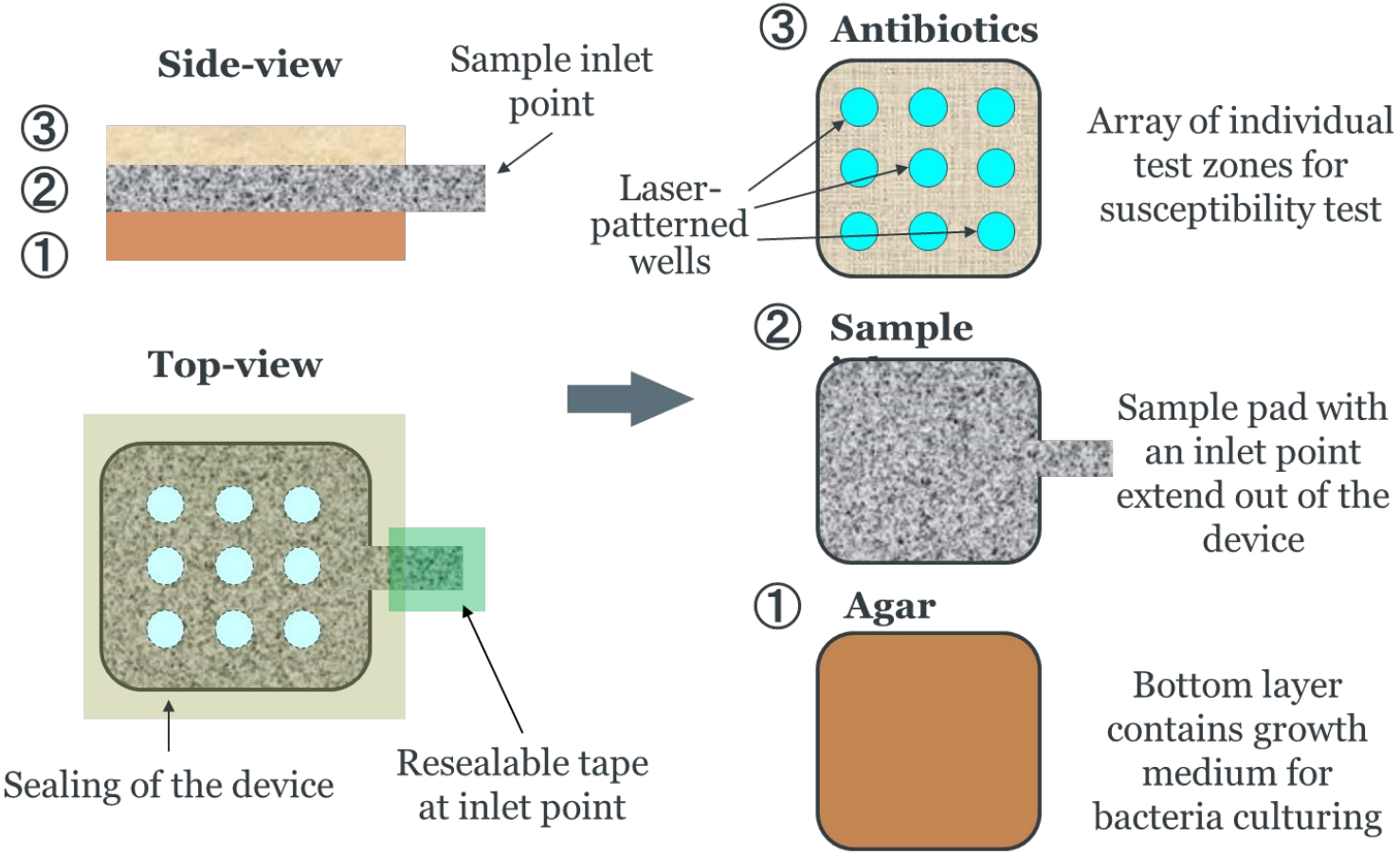
for Antimicrobial resistance testing



Turnaround time for both identification and resistance testing of 12-15 hours

Integrated paper device -

for Antimicrobial resistance testing

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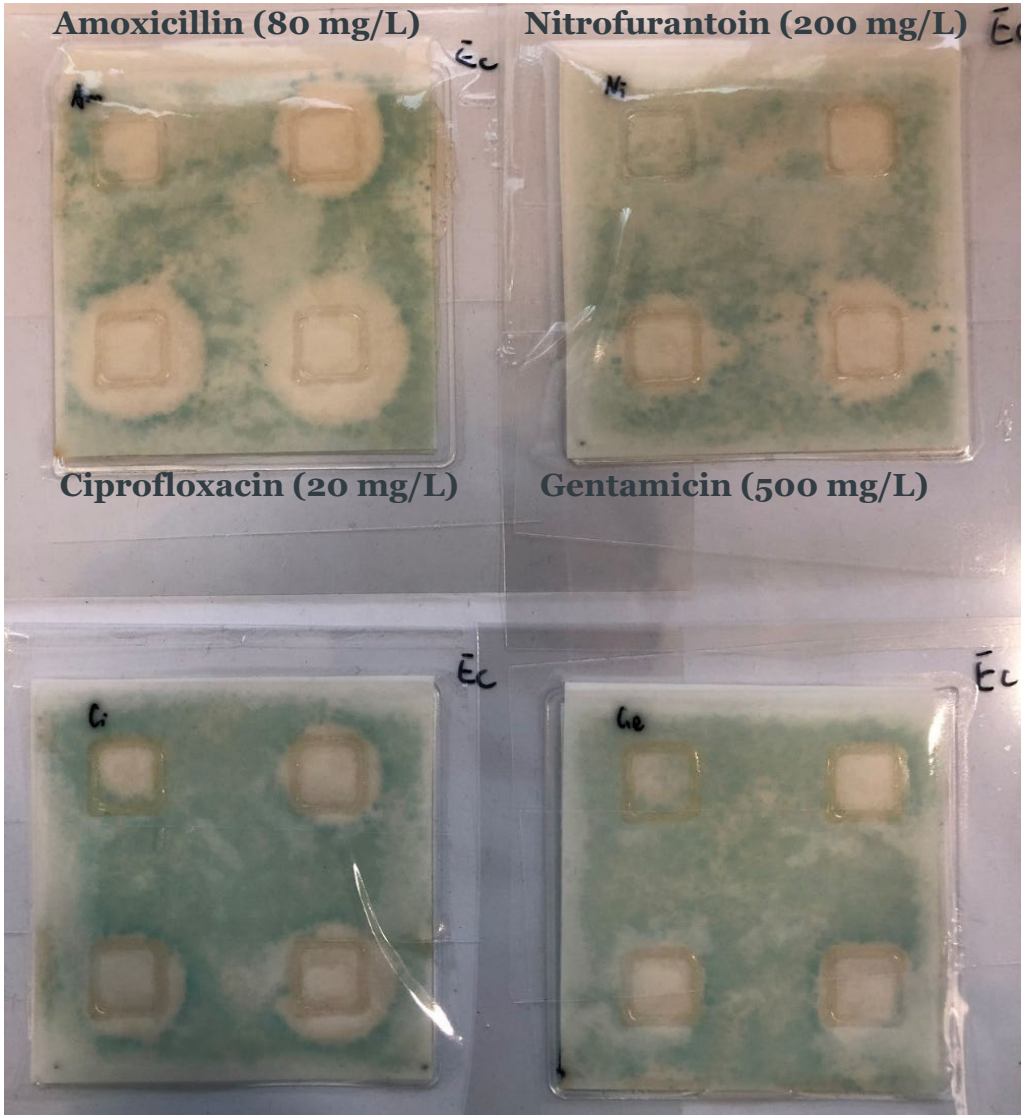
Top



Volume of antibiotic in each well

5	15
25	35µl

Agar: **CHROMagar E-coli**; CHROMagar, Microbiology, France

E.coli: **Clinical Strain BM02**

Amoxicillin (**A8523**), Ciprofloxacin (**11850**), Gentamicin (**G1397**) and Nitrofurantoin (**N7878**) from Sigma Aldrich, UK.

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Normalization of paper device to conventional disk diffusion test

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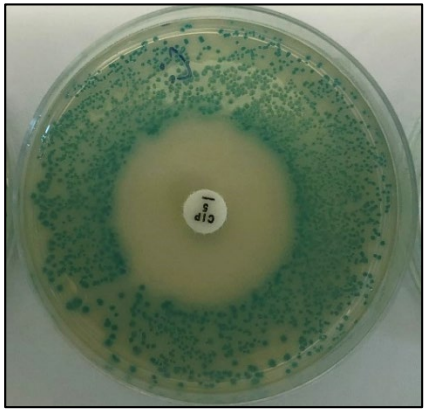
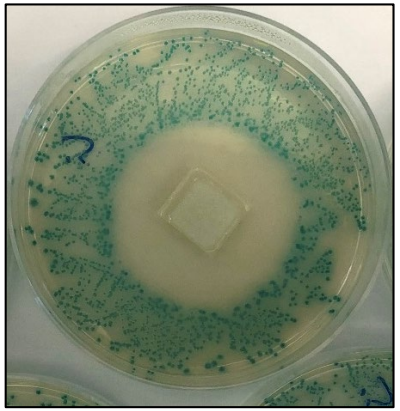
Disc on Agar

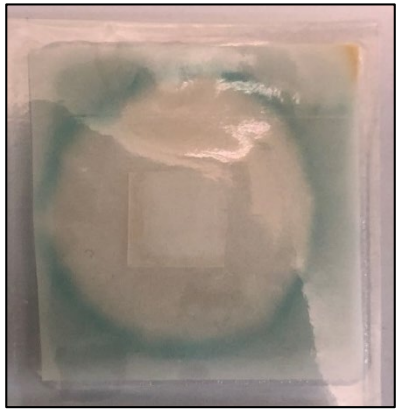


Disc on paper device

Paper disc on Agar



Paper disc on paper device



Ciprofloxacin	Avg. Dia. (mm) n=5
Disc (CT0425B, ThermoFisher) on Agar plate	28.3
Disc (CT0425B, ThermoFisher) on paper device	25.3
Paper square on Agar plate	28.8
Paper square on Agar-impregnated paper	25.4

* EUCAS Zone diameter breakpoint (mm): S>26 R<24

Conclusion:

- Our current strain is sensitive to ciprofloxacin
- Antibiotic susceptibility testing on paper-based devices produce results similar to conventional agar plate testing

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Normalization of paper device to conventional disk diffusion test

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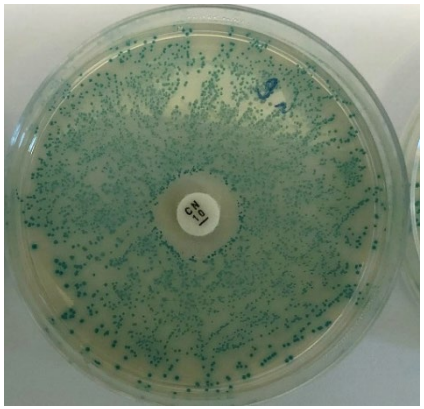
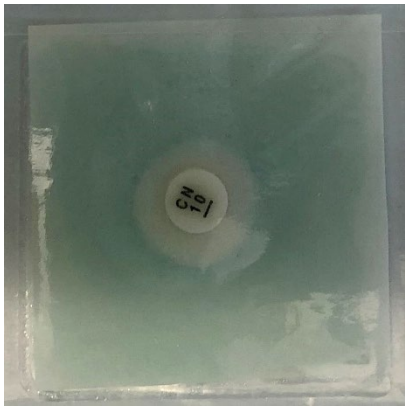
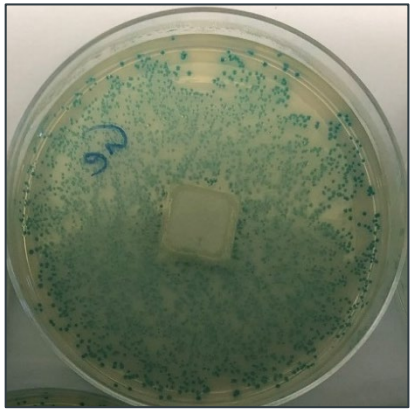
Disc on Agar



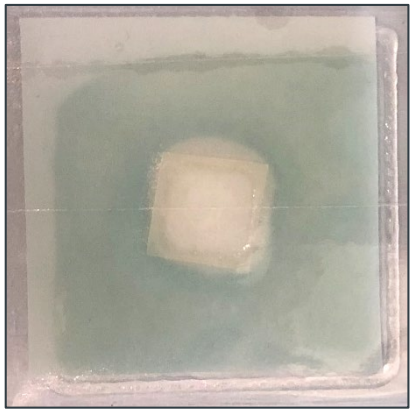
Disc on paper device



Paper disc on Agar



Paper disc on paper device



Gentamicin	Avg. Dia. (mm) n=5
Disc (CT0024B, ThermoFisher) on Agar plate	11.3
Disc (CT0024B, ThermoFisher) on paper device	11.7
Paper square on Agar plate	11
Paper square on Agar-impregnated paper	11

* EUCAS Zone diameter breakpoint (mm): S>17 R<14

Conclusion:

- Our current strain is resistant to Gentamicin
- Antibiotic susceptibility testing on paper-based devices produce results similar to conventional agar plate testing

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AI-assisted paper device -

for Antimicrobial resistance testing

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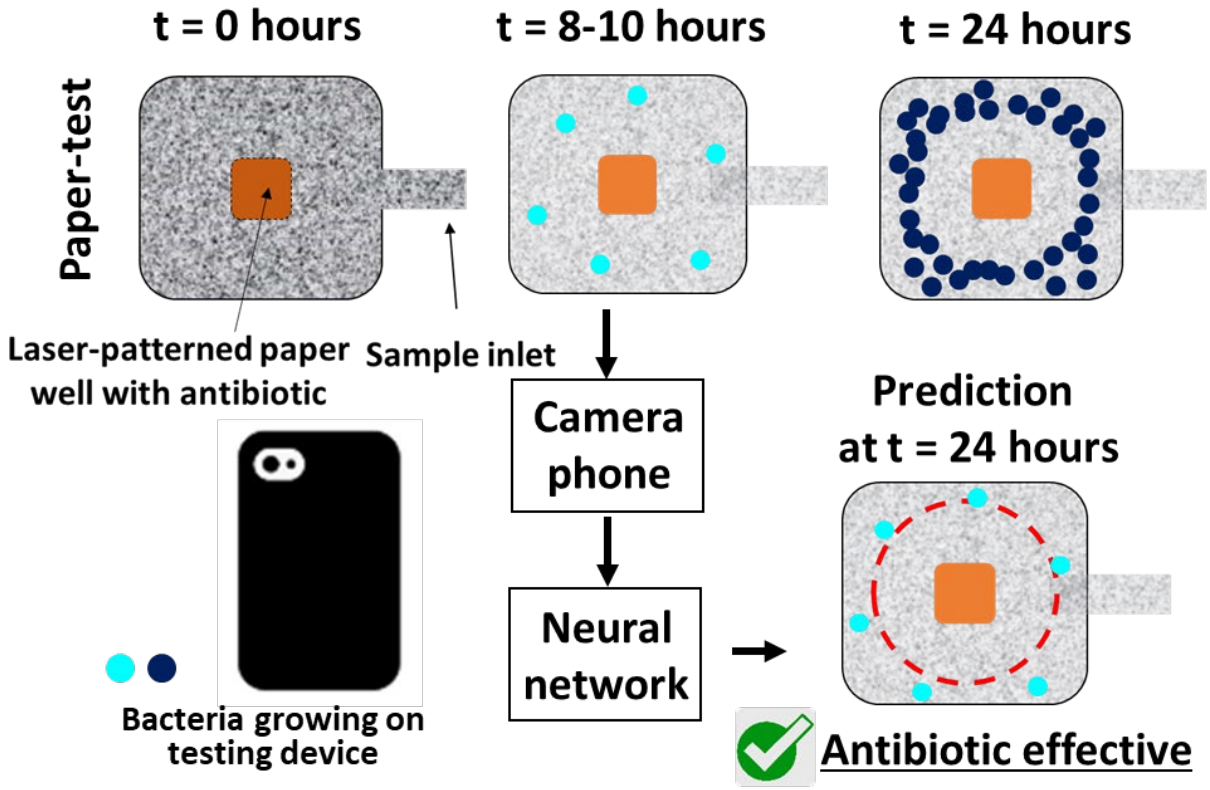

Paper-based device

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Neural network

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Early diagnosis and treatment

Paper-based bacterial testing, in combination with the predictive capabilities of neural networks (a machine learning technique), offer the potential for considerable reductions in this testing timescale.

We anticipate a reduction from 2-5 days to 8-10 hours and are confident that our unique bacterial testing pathway will facilitate early diagnosis and treatment necessary for effective disease-management and improved patient-outcomes

Thank you!

Bill Keevil and Catherine Bryant, Jessica Teeling

Centre for Biological Sciences, Faculty of Natural and Environmental Sciences, *University of Southampton*

Bhaskar Somani

Department of Urology, University Hospital Southampton NHS Trust

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NAMRIP Pump Priming Award
Fellowship - Institute for Life Sciences and the Faculty of Medicine

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