Overview of talk

• What does ‘big data’ mean?
• How can it be used in transfusion medicine?
• What are the challenges and the limitations?
What does ‘Big Data’ mean?

• Industry and academia are drowning in data
• There is no formal definition of “Big Data”
• Maybe: ‘The technological ability to store, aggregate, and process data’
• The key is to be able to process and analyse data so that it can be used for a useful purpose
Use of ‘Big Data’ in healthcare

• Can provide rich data which can be used to improve patient outcomes
• Facilitated by:
  ✓ Increasing uptake of Electronic Health Records (EHRs) by hospitals
  ✓ Data linkage between different IT systems
How can ‘Big Data’ be used to drive progress in transfusion medicine?

- Benchmarking: comparison of blood use by different clinical teams and by different hospitals
- Use of machine learning to develop algorithms for good practice within EHRs e.g. MSBOS
- Electronic clinical decision support
- Detection of transfusion-related complications e.g. TACO
High level efforts in the UK to improve transfusion practice in hospitals

- 2001/02: National Blood Transfusion Committee and National Comparative Audit of Blood transfusion programme established
- Choosing Wisely recommendations for transfusion (2017)
- Transfusion 2024
There has been considerable progress.....

- Reduction in red cell transfusions
- Reduction in wrong transfusions
Risk of harm or death from transfusion is very low

4248 reports submitted to SHOT in 2019

2.3 million blood components issued in the UK in 2019

Risk of death approximately 1 in 135,705 and of serious harm 1 in 17,884 components issued in the UK

The risks of transfusion-transmitted infection are much lower than all other transfusion-related complications

Note: This is a representative image and not accurate to scale
Reduction in ABO incompatible red cell transfusions
Reduction in **Red Cell** use in England 1999-2020
Still much to do.....

- National, regional and local audits consistently show inappropriate use of 15-20% red cells and 20-30% platelets/plasma
- Poor implementation of methods to avoid use of blood
- Safety of hospital transfusion still an issue
- Need to improve education and training
- Transfusion laboratories poorly staffed and resourced
- Poor IT for blood safety and for providing data on blood usage
Variation in red cell use by hospital

Blood Component Transfusions per 1,000 Bed Days by Hospital

<table>
<thead>
<tr>
<th>Hospital</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red Cells</td>
<td>42.42</td>
<td>40.40</td>
<td>49.50</td>
</tr>
<tr>
<td>Platelets</td>
<td>11.69</td>
<td>7.76</td>
<td>11.66</td>
</tr>
</tbody>
</table>

D’Souza et al (unpublished)
### Variation in red cell use by specialty

<table>
<thead>
<tr>
<th>Department</th>
<th>Mean Red Blood Cells</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burn</td>
<td>2.5</td>
</tr>
<tr>
<td>Cardiothoracic Surgery</td>
<td>1.9</td>
</tr>
<tr>
<td>Cardiology</td>
<td>0.5</td>
</tr>
<tr>
<td>Gastroenterology</td>
<td>1.2</td>
</tr>
<tr>
<td>General Surgery</td>
<td>0.3</td>
</tr>
<tr>
<td>Gynecology</td>
<td>0.5</td>
</tr>
<tr>
<td>Hematology/BMT*</td>
<td>1.8</td>
</tr>
<tr>
<td>Hepatology</td>
<td>1.3</td>
</tr>
<tr>
<td>Internal Medicine</td>
<td>0.3</td>
</tr>
<tr>
<td>Interventional Radiology</td>
<td>0.4</td>
</tr>
<tr>
<td>Medical ICU†</td>
<td>0.8</td>
</tr>
<tr>
<td>Nephrology</td>
<td>0.4</td>
</tr>
<tr>
<td>Neurology</td>
<td>0.1</td>
</tr>
<tr>
<td>Neurosurgery</td>
<td>0.2</td>
</tr>
<tr>
<td>Obstetrics</td>
<td>0.1</td>
</tr>
<tr>
<td>Oncology</td>
<td>0.5</td>
</tr>
<tr>
<td>Orthopedics</td>
<td>0.2</td>
</tr>
<tr>
<td>Otolaryngology</td>
<td>0.2</td>
</tr>
<tr>
<td>Plastic Surgery</td>
<td>0.2</td>
</tr>
<tr>
<td>Pulmonology</td>
<td>0.1</td>
</tr>
<tr>
<td>Surgical ICU†</td>
<td>2.2</td>
</tr>
<tr>
<td>Transplant Surgery</td>
<td>1.3</td>
</tr>
<tr>
<td>Trauma</td>
<td>0.9</td>
</tr>
<tr>
<td>Urology</td>
<td>0.3</td>
</tr>
<tr>
<td>Vascular Surgery</td>
<td>0.9</td>
</tr>
</tbody>
</table>

**Note:** The diagram illustrates the mean red blood cell usage across various specialties. The x-axis represents the mean red blood cell usage, ranging from 0 to 3.
Variation in compliance with Hb trigger by specialty

<table>
<thead>
<tr>
<th>Specialty</th>
<th>Clinical Haematology</th>
<th>General Surgery</th>
<th>General Medicine</th>
<th>Paediatrics</th>
<th>Gastroenterology</th>
<th>Geriatric Medicine</th>
<th>Trauma and Orthopaedics</th>
<th>Nephrology</th>
<th>Infectious Diseases</th>
<th>Obstetrics</th>
<th>Medical Oncology</th>
<th>Cardiothoracic Surgery</th>
<th>Cardiology</th>
<th>Neurosurgery</th>
<th>Urology</th>
<th>Plastic Surgery</th>
<th>Respiratory Medicine</th>
<th>Gynaecology</th>
<th>Clinical Oncology</th>
<th>Endocrinology</th>
<th>Palliative Medicine</th>
<th>Accident and Emergency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hb (g/L) threshold category</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt; 90</td>
<td>22.36%</td>
<td>33.17%</td>
<td>46.56%</td>
<td>16.39%</td>
<td>51.01%</td>
<td>52.56%</td>
<td>29.06%</td>
<td>53.26%</td>
<td>48.51%</td>
<td>26.92%</td>
<td>44.00%</td>
<td>31.25%</td>
<td>22.73%</td>
<td>22.73%</td>
<td>25.83%</td>
<td>12.82%</td>
<td>33.33%</td>
<td>25.57%</td>
<td>43.48%</td>
<td>38.89%</td>
<td>41.18%</td>
<td>45.45%</td>
</tr>
<tr>
<td>&gt; 80 – 90</td>
<td>53.79%</td>
<td>29.70%</td>
<td>28.83%</td>
<td>15.26%</td>
<td>20.31%</td>
<td>34.19%</td>
<td>34.04%</td>
<td>36.96%</td>
<td>38.27%</td>
<td>50.00%</td>
<td>26.00%</td>
<td>37.50%</td>
<td>45.45%</td>
<td>40.91%</td>
<td>41.48%</td>
<td>30.77%</td>
<td>57.58%</td>
<td>25.00%</td>
<td>30.43%</td>
<td>38.89%</td>
<td>29.41%</td>
<td>57.80%</td>
</tr>
<tr>
<td>70 – 80</td>
<td>18.63%</td>
<td>16.63%</td>
<td>7.98%</td>
<td>6.38%</td>
<td>15.23%</td>
<td>15.20%</td>
<td>32.01%</td>
<td>36.86%</td>
<td>38.27%</td>
<td>59.20%</td>
<td>26.00%</td>
<td>14.36%</td>
<td>11.36%</td>
<td>15.26%</td>
<td>17.07%</td>
<td>17.77%</td>
<td>14.28%</td>
<td>14.29%</td>
<td>17.39%</td>
<td>22.22%</td>
<td>11.76%</td>
<td>14.16%</td>
</tr>
<tr>
<td>70 – 80</td>
<td>8.91%</td>
<td>16.63%</td>
<td>10.00%</td>
<td>5.38%</td>
<td>7.29%</td>
<td>7.37%</td>
<td>15.26%</td>
<td>36.86%</td>
<td>6.17%</td>
<td>9.00%</td>
<td>8.00%</td>
<td>16.67%</td>
<td>15.91%</td>
<td>31.26%</td>
<td>14.63%</td>
<td>14.63%</td>
<td>32.14%</td>
<td>32.14%</td>
<td>6.70%</td>
<td>22.22%</td>
<td>17.80%</td>
<td>27.27%</td>
</tr>
<tr>
<td>&lt; 70</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

Staples S et al. Transfusion 2020:60:1658-65
Variation in red cell use by clinician

Patients transfused (%)  Mean units transfused

Hensley NB et al. Transfusion 2019:59:3058-64
Hospital transfusion process

- Assess clinical need
- Inform patient/consent
- Select product and quantity
- Order product
- Request form
- Blood sample
- Crossmatching
- Delivery
- Identity check
- Administration of product
- Recording
- Observation
- Respond to adverse event

→ bedside or ward PC

→ bedside

→ blood fridge

→ bedside

→ bedside
End-to-end electronic process for transfusion safety

- Assess clinical need
- Inform patient/consent
- Select product and quantity
- Order product
- Request form
- Blood sample
- Crossmatching
- Delivery
- Identity check
- Administration of product
- Recording
- Observation
- Respond to adverse event

Transfusion safety at the bedside

Bedside or ward PC

Bedside

Blood fridge

Bedside
Electronic transfusion process

Less paperwork
1 nurse
16 individual steps to carry out before safe to commence the transfusion


End-to-end electronic process for transfusion safety

1. Assess clinical need
2. Inform patient/consent
3. Select product and quantity
4. Order product
5. Request form
6. Blood sample
7. Crossmatching
8. Delivery
9. Identity check
10. Administration of product
11. Recording
12. Observation
13. Respond to adverse event

- Bedside or ward PC
- Blood fridge
- Bedside
- Bedside
- Bedside

Transfusion safety at blood fridges
Electronic blood ordering

‘Decision support’ for better practice

- Assess clinical need
- Inform patient/consent
- Select product and quantity
- Order product
- Request form
- Blood sample
- Crossmatching
- Delivery
- Identity check
- Administration of product
- Recording
- Observation
- Respond to adverse event

- bedside
- blood fridge
- bedside
- bedside
- bedside
- ward PC

- doctors
- nurses
- phlebotomist
- laboratory staff
- porters
- doctors / nurses / laboratory staff
Electronic blood ordering, decision support and data feedback to clinicians at the OUH has saved £500k from reduced blood use in the last 2 years.

1 Capture the diagnostic group
Electronic blood ordering, decision support and data feedback to clinicians at the OUH has saved £500k from reduced blood use in the last 2 years.

1. Capture the diagnostic group

2. Select a reason for transfusion
Electronic blood ordering, decision support and data feedback to clinicians at the OUH has saved £500k from reduced blood use in the last 2 years.
Electronic blood ordering, decision support and data feedback to clinicians at the OUH has saved £500k from reduced blood use in the last 2 years.

1. Capture the diagnostic group
2. Select a reason for transfusion
3. Automatic capture of the most recent relevant result
4. Alert if transfusion not justified
Electronic blood ordering, decision support and data feedback to clinicians at the OUH has saved £500k from reduced blood use in the last 2 years.

1. Capture the diagnostic group

2. Select a reason for transfusion

3. Automatic capture of the most recent relevant result

4. Alert if transfusion not justified

5. Reason for over-riding alert
   - Instruction from senior clinician
   - Recent point-of-care result (provide the result, date and time)
   - Disagree with recommendation (provide reasons)
   - Additional patient co-morbidity (provide details)
   - Other (provide details)
# Daily review of blood order alerts

<table>
<thead>
<tr>
<th>ID</th>
<th>ALERT_DTTM</th>
<th>Diagnostic_Group</th>
<th>Clinical_details</th>
<th>CRITERIA</th>
<th>Result</th>
<th>MRN</th>
<th>PATIENT_NAME</th>
<th>PRSNL_RAISING_ALERT</th>
<th>Position</th>
<th>WARD_AT_TRANS_FUSION</th>
<th>ORDER_STATUS</th>
<th>OVERRIDE_REASON</th>
<th>OVERRIDE_REASON_COMMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,430</td>
<td>09/04/2018 10:42</td>
<td>GI-Lower GI bleed</td>
<td>PR bleed. haemorrhoids. Multiple myeloma</td>
<td>Hb &lt;= 70g/l</td>
<td>hb=80</td>
<td></td>
<td></td>
<td></td>
<td>Specialist Registrar</td>
<td>J-ED</td>
<td>Completed</td>
<td>Instruction from senior clinician</td>
<td>VBG shows Hb 47</td>
</tr>
<tr>
<td>1,431</td>
<td>09/04/2018 16:28</td>
<td>Haem-AML</td>
<td>aml, low plt</td>
<td>PLT count &lt;= 20 with plt consumption</td>
<td>plt=31</td>
<td></td>
<td></td>
<td></td>
<td>House Officer Pre Reg</td>
<td>J-WD 6C SSW</td>
<td>Completed</td>
<td>Instruction from senior clinician</td>
<td></td>
</tr>
<tr>
<td>1,432</td>
<td>09/04/2018 14:23</td>
<td>Haem-AML</td>
<td>AML, post AraC. PV bleed, platelets 10 on POCH</td>
<td>Other provide specific clinical details</td>
<td>plt=16</td>
<td></td>
<td></td>
<td></td>
<td>Specialist Registrar</td>
<td>C-WD OnchTriage</td>
<td>Completed</td>
<td>Recent point of care test</td>
<td>Platelet 10 POCH, PV bleed</td>
</tr>
<tr>
<td>1,433</td>
<td>09/04/2018 15:49</td>
<td>Renal-CRF</td>
<td>upper GI bleed</td>
<td>Hb &lt;= 70g/l</td>
<td>hb=92</td>
<td></td>
<td></td>
<td></td>
<td>Senior House Officer</td>
<td>C-RDA Main RDU</td>
<td>Completed</td>
<td>Disagree - provide reason in textbox</td>
<td></td>
</tr>
<tr>
<td>1,434</td>
<td>09/04/2018 15:43</td>
<td>Renal-lymphoma</td>
<td>line thrombosis on fragmin, target plt &gt;30</td>
<td>Other provide specific clinical details</td>
<td>plt=29</td>
<td></td>
<td></td>
<td></td>
<td>Specialist Registrar</td>
<td>C-RDA DTU Chemo</td>
<td>Completed</td>
<td>Other details</td>
<td>prior thrombosis, target plt &gt;30</td>
</tr>
<tr>
<td>1,435</td>
<td>09/04/2018 15:49</td>
<td>Neuro-Intracranial bleeding</td>
<td>TBI - hb 67</td>
<td>Hb &lt;= 70g/l</td>
<td>hb=71</td>
<td></td>
<td></td>
<td></td>
<td>Specialist Registrar</td>
<td>J-WD Neuro ICU</td>
<td>Completed</td>
<td>Recent point of care test</td>
<td>67</td>
</tr>
<tr>
<td>1,436</td>
<td>09/04/2018 15:52</td>
<td>Haem-MDS</td>
<td>MDS</td>
<td>Other provide specific clinical details</td>
<td>plt=103</td>
<td></td>
<td></td>
<td></td>
<td>Staff Nurse</td>
<td>C-OP DTU</td>
<td>Completed</td>
<td>Instruction from senior clinician</td>
<td></td>
</tr>
<tr>
<td>1,437</td>
<td>09/04/2018 14:57</td>
<td>Ortho-Redo Hip</td>
<td>requested for possible intraoperative blood loss</td>
<td>Other provide specific clinical details</td>
<td>plt=88</td>
<td></td>
<td></td>
<td></td>
<td>Senior House Officer</td>
<td>NOC-Ward B</td>
<td>Ordered</td>
<td>Instruction from senior clinician</td>
<td></td>
</tr>
<tr>
<td>1,438</td>
<td>09/04/2018 18:56</td>
<td>Paed- top up transfusion</td>
<td>Blood loss during spinal surgery</td>
<td>Hb &lt;= 70g/l</td>
<td>hb=71</td>
<td></td>
<td></td>
<td></td>
<td>Senior House Officer</td>
<td>J-WD Melanies</td>
<td>Completed</td>
<td>Instruction from senior clinician</td>
<td></td>
</tr>
<tr>
<td>1,439</td>
<td>09/04/2018 11:06</td>
<td>Haem-MDS</td>
<td>Hb-79</td>
<td>Hb &lt;=80g/l in haematology inpatients</td>
<td>plt=79</td>
<td></td>
<td></td>
<td></td>
<td>Senior House Officer</td>
<td>C-WD Haem</td>
<td>Completed</td>
<td>Instruction from senior clinician</td>
<td>Hb-79</td>
</tr>
</tbody>
</table>
Electronic blood ordering, decision support and data feedback to clinicians at the OUH has saved £500k from reduced blood use in the last 2 years.

1. Capture the diagnostic group

2. Select a reason for transfusion

3. Automatic capture of the most recent relevant result

4. Alert if transfusion not justified

5. Data feedback to drive blood reduction
Compliance with agreed transfusion triggers in haematology improved from <50% to >90%

Decision support and feedback

Reduction of > £1million in annual blood budget in Oxford in 6 years
Randomising best practice alerts

Customising best practice alerts

Machine learning

- Machine learning is a component of artificial intelligence
- It involves the automated discovery of patterns within data
- The model ‘learns’ from examples rather than being programmed with rules or following a strict hypothesis

Shouval R et al BJHaem 2021; 31:262-70
Machine learning for predicting blood use

Feng Y et al Transfusion Medicine 2021; 31:262-70
### Machine learning for predicting blood use

<table>
<thead>
<tr>
<th>Factors</th>
<th>N</th>
<th>Min</th>
<th>Max</th>
<th>Mean</th>
<th>Std</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>130,996</td>
<td>0</td>
<td>109</td>
<td>51</td>
<td>17</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>129,895</td>
<td>3</td>
<td>180</td>
<td>66.6</td>
<td>14.5</td>
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<tr>
<td>Height (cm)</td>
<td>130,131</td>
<td>50</td>
<td>215</td>
<td>164.1</td>
<td>12.7</td>
</tr>
<tr>
<td>Sex</td>
<td>130,996</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>64,396 (49%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>66,600 (51%)</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Surgical grade</td>
<td>130,923</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>First-grade surgery</td>
<td>1,426 (1.1%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Secondary surgery</td>
<td>11,299 (8.6%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tertiary surgery</td>
<td>87,464 (66.8%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Four-stage surgery</td>
<td>30,734 (23.5%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Autologous blood storage (units)</td>
<td>4,452</td>
<td>0</td>
<td>4</td>
<td>0.07</td>
<td>0.36</td>
</tr>
<tr>
<td>RBC application total (units)</td>
<td>130,996</td>
<td>0</td>
<td>25</td>
<td>0.83</td>
<td>2.14</td>
</tr>
<tr>
<td>Blood transfusion volume (units)</td>
<td>130,996</td>
<td>0</td>
<td>10</td>
<td>0.82</td>
<td>1.54</td>
</tr>
<tr>
<td>BTV = 0 (unit)</td>
<td>90,387 (69%)</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>BTV = 1 (unit)</td>
<td>1,238 (1%)</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>BTV = 2 (unit)</td>
<td>11,862 (9%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BTV = 3 (unit)</td>
<td>12,06 (9%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BTV = 4 (unit)</td>
<td>8,953 (7%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 ≤ BTV ≤ 6 (units)</td>
<td>3,930 (3%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7 ≤ BTV ≤ 8 (units)</td>
<td>1,310 (1%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9 ≤ BTV ≤ 10 (units)</td>
<td>1,310 (1%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Abbreviations: BTV, blood transfusion volume; Max, maximum value; Min, minimum value; N, number; RBC, red blood cell; Std, standard deviation.*

Feng Y et al Transfusion Medicine 2021; 31:262-70
Machine learning for predicting blood use

Feng Y et al Transfusion Medicine 2021; 31:262-70
Machine learning for predicting blood use

Feng Y et al Transfusion Medicine 2021; 31:262-70
Big data: challenges & limitations

• Investment for hardware, set up software, train staff, and develop informatics services on both a local and national scale
• Information governance: concerns about patient confidentiality
• Common data standards and interconnectivity of IT systems
• Reliable and precise input e.g. accurate coding of clinical episodes
### Key actions for hospitals to reduce unnecessary transfusions

<table>
<thead>
<tr>
<th>Intervention category</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Education</td>
<td>Educational material, guidelines, departmental presentation, workshops, individual meetings, audit and feedback</td>
</tr>
<tr>
<td>Policy change</td>
<td>Protocol or algorithm, department policy, financial incentive</td>
</tr>
<tr>
<td>Decision support</td>
<td>Order form (computerised or paper), order sets, computerised physician order entry, reminders, checklists</td>
</tr>
<tr>
<td>Audit and feedback</td>
<td>Retrospective, prospective, audit approval</td>
</tr>
</tbody>
</table>

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**Reducing unnecessary red blood cell transfusion in hospitalised patients**

Nishila Mehta, Michael F Murphy, Lawrie Kaplan, Wendy Levinson

[the bmj](https://bmj.com) | [BMJ 2021:373:n830](https://doi.org/10.1136/bmj.n830)
Aim: support the needs of NHSBT for research to improve the supply of blood, blood products, stem cells and tissues and organs for transplantation

- £20 million over 5 years
- 5 Priority Areas:
  - Blood Donation;
  - Organ Donation and Transplantation;
  - Therapeutics;
  - Transfusion and Transplantation Transmitted Infections;
  - Data Driven Transfusion Practice

https://www.nihr.ac.uk/documents/nihr-blood-and-transplant-research-units-competition-brief/27100
Objectives of the Data Driven Transfusion Practice unit will be to conduct:

• Research that improves patient outcomes for those who receive blood products through learning from better connectivity of data between NHSBT and NHS Trusts

• Research to reduce inappropriate variation in clinical practice and to optimise supply and use of components

• Novel data linkage and to develop analytical methods to facilitate effective research and audit on an ongoing basis

https://www.nihr.ac.uk/documents/nihr-blood-and-transplant-research-units-competition-brief/27100
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