Background

- **NEUROCRITICAL CARE** deals with complex neurosurgical, neurological and medical problems in critically ill patients who suffered from brain injuries.
- The continuous, simultaneous evaluation of cerebral function and vital signs (**MULTIMODAL MONITORING**) has become standard of care.
- NeuroICUs have become data rich environments that would benefit from advanced informatics (e.g. automated event detection, clinical decision support).
- However, multiple barriers still exist to the integrated use of data in a scalable or adaptable way.
- The main barrier is the **LACK OF MEDICAL DEVICE CONNECTIVITY**, due to the heterogeneous nature of device interfaces.

Objective

To review the characteristics of the device interfaces that have been examined by Moberg Research Inc. for the development of our platform for neurocritical care data integration.

Methods

Benchmark for the evaluation of devices interfaces:
- Adherence to manufacturer’s protocol specification documents
- Acceptance rate of standards (communication/nomenclature)
- Overall quality of protocol implementations

Results

<table>
<thead>
<tr>
<th>Adherence to Specifications</th>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lacked protocol specification documents?</td>
<td>8</td>
<td>100</td>
</tr>
<tr>
<td>Deviated from the specifications?</td>
<td>18</td>
<td>32</td>
</tr>
<tr>
<td>Exhibited a behavior different from what expected based on specifications?</td>
<td>32</td>
<td>5</td>
</tr>
<tr>
<td>Exhibited undocumented behaviors?</td>
<td>11</td>
<td>0</td>
</tr>
<tr>
<td>Exhibited error conditions not mentioned in specifications?</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>Lacked protocol version field in the output?</td>
<td>0</td>
<td>100</td>
</tr>
</tbody>
</table>

Acceptance Rate of Standards

- Based on existing communication standards?
  - 4
- Based on an existing standard nomenclature?
  - 4

Quality of Protocol

- Included identification of the source device and/or data types?
  - 71
- Specified units for the transmitted data?
  - 96
- Provided checksums or parity?
  - 46

Discussion

Issues with Adherence to specifications:
- Historically medical device outputs have been used for research and not clinically.
  - Often an after-thought, with little documentation and support.
- Overall lack of adherence to manufacturer’s protocol specifications, including undocumented behaviors.
  - E.g. variability over time of nominal data frequency.
- Lack of protocol version field.
  - Risk of data misinterpretation if subtle changes to the output format are not detected by packet parsing.

Issues with Acceptance rate of standards:
- Only 1 out of 24 devices used standard nomenclature and communication (IEEE 11073), with some deviations to accommodate neurocritical care needs.
  - Technological overhead for institutions that want to use integrated data for advanced applications (e.g. clinical decision support tools).

Issues with Quality of protocol:
- Prevalence of transmission error detection schemes and source/data type identification is not optimal yet.
  - Possible data misinterpretation, leading to delayed or incorrect patient treatment.

Conclusion

To our knowledge, this is the first survey of medical device connectivity in neurocritical care, aimed at raising awareness about the current barriers to a connected health system.
- It is our recommendation that medical device manufacturers provide a well-designed, documented communication protocol for their devices so as to reduce the identified barriers.
- As a result of this effort, a Working Group has been formed to accelerate the development of a connected neurocritical care environment (**www.SmartNeuroICU.org**).

Acknowledgement

The authors would like to thank Mr. Gary Trapuzzano (Moberg Research, Inc.) for his kind guidance and feedback.

This work is supported by the US Army Medical Research and Materiel Command under Contract No.W81XWH-09-C-0055. The views, opinions and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy or decision unless so designated by other documentation.