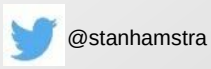
# Realizing the Promise of Big Data:
## *Learning Analytics in Competency-Based Medical Education*

Stanley J. Hamstra, Ph.D.
VP, Milestones Research and Evaluation



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# Disclosures

- Paid employee of ACGME
- Adjunct Professor at Northwestern University, Chicago *(unpaid)*
- Adjunct Professor at University of Ottawa, Canada *(unpaid)*



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# Outline

1) A Review of Milestones
2) Learning Analytics
3) Future Directions



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# Outline

1) **A Review of Milestones**
    1) **Purpose**
2) Learning Analytics
3) Future Directions



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Milestones can help us with…

# PROFESSIONAL ACCOUNTABILITY



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The NEW ENGLAND JOURNAL of MEDICINE

SPECIAL REPORT

# The Next GME Accreditation System — Rationale and Benefits

Thomas J. Nasca, M.D., M.A.C.P., Ingrid Philibert, Ph.D., M.B.A., Timothy Brigham, Ph.D., M.Div., and Timothy C. Flynn, M.D.

In 1999, the Accreditation Council for Graduate Medical Education (ACGME) introduced the six domains of clinical competency to the profession,[1] and in 2009, it began a multiyear process of restructuring its accreditation system to be based on educational outcomes in these competencies. The result of this effort is the Next Accreditation System (NAS), scheduled for phased implementation beginning in July 2013. The aims of the NAS are threefold: to enhance the ability of the peer-review system to prepare physicians for practice in the 21st century, to accelerate the ACGME's movement toward accreditation on the basis of educational outcomes, and to reduce the burden associated with the current structure

## LIMITATIONS OF THE CURRENT SYSTEM

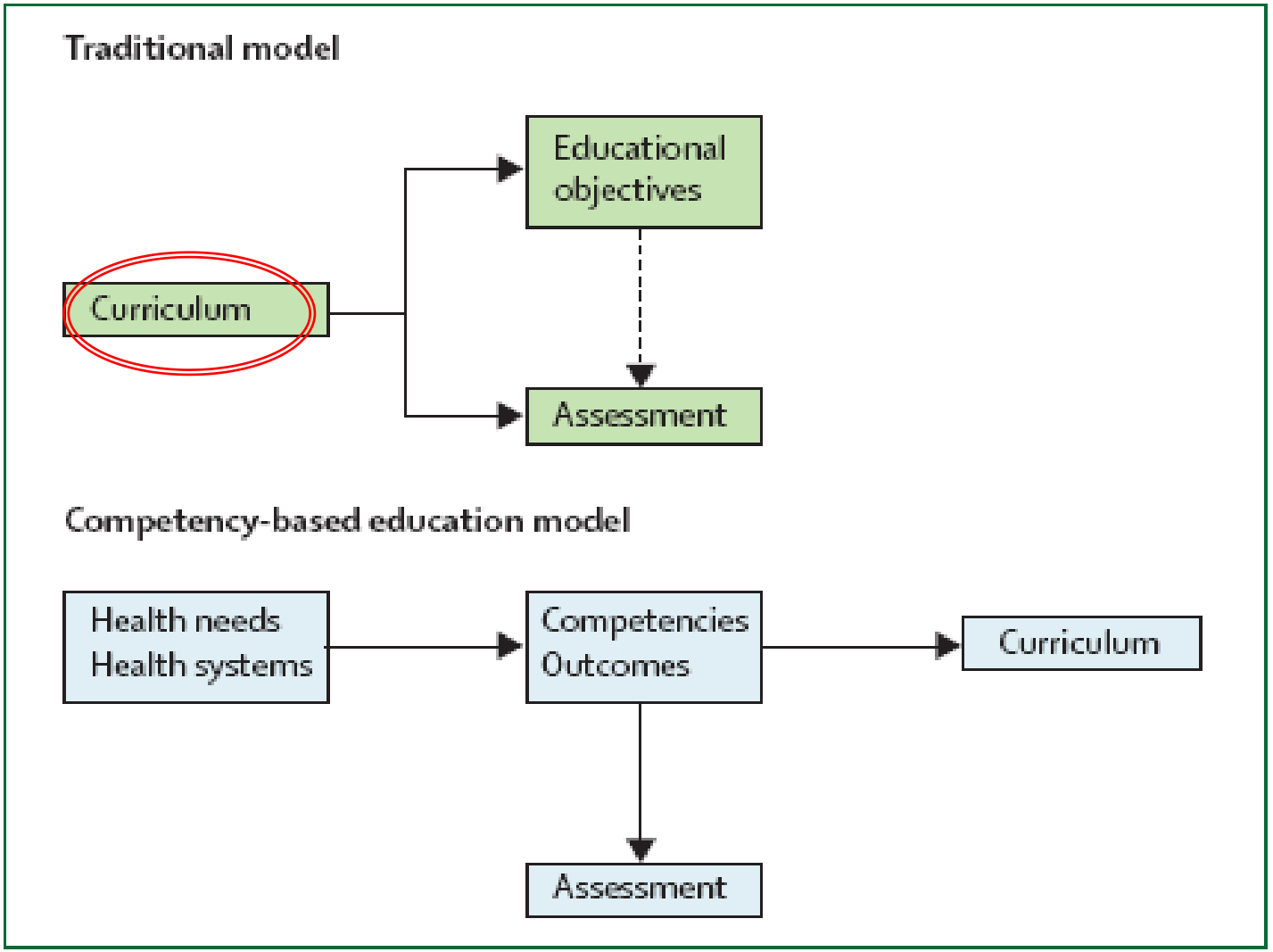
When the ACGME was established in 1981, the GME environment was facing two major stresses: variability in the quality of resident education[8] and the emerging formalization of subspecialty education. In response, the ACGME's approach emphasized program structure, increased the amount and quality of formal teaching, fostered a balance between service and education, promoted resident evaluation and feedback, and required financial and benefit support for trainees. These dimensions were incorporated into program requirements that became increasingly more specific during the next 30 years.





*N Engl J Med*, 366:1051-6;2012.

# Why We Need a Competency-Based Approach




Frenk J. Health professionals for a new century: transforming education to strengthen health systems in an interdependent world. Lancet. 2010



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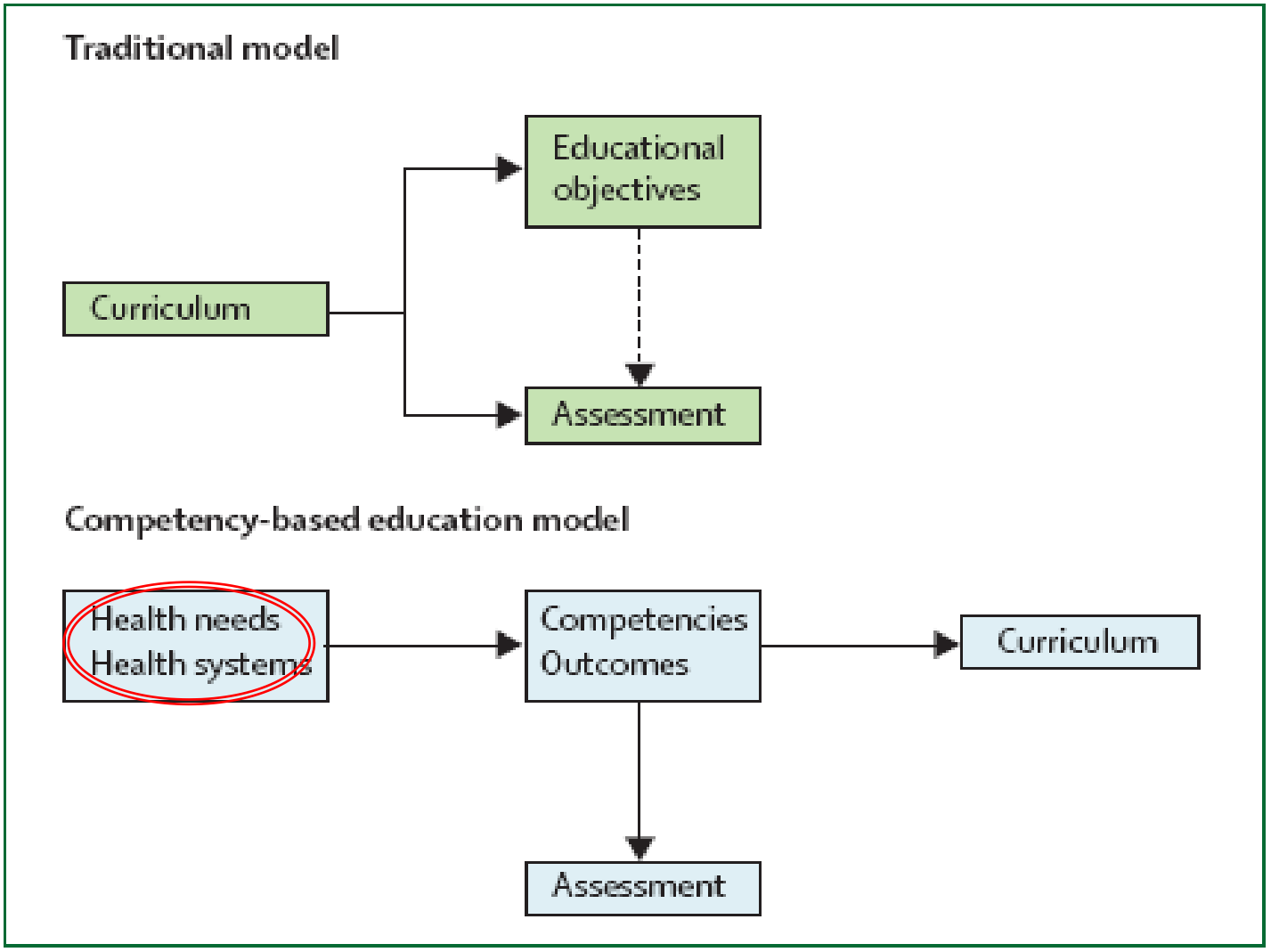
# Why We Need a Competency-Based Approach




Frenk J. Health professionals for a new century: transforming education to strengthen health systems in an interdependent world. Lancet. 2010



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# Domains of Competence

- What do they know? (Medical Knowledge)
- What can they do? (Patient Care)



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# Competence **is Multi-Dimensional**

- What do they know? (Medical Knowledge)
- What can they do? (Patient Care)
- **How do they conduct themselves?** (Interpersonal and Communication Skills, Professionalism)
- **Are they critical and reflective?** (Practice-based Learning and Improvement, Systems-based Practice)



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# Dreyfus Developmental Model of Learning

| Dreyfus Stage | Description |
|---|---|
| Novice | Rule driven; analytic thinking; little ability to prioritize information |
| Advanced beginner | Able to sort through rules based on experience; analytic and non-analytic for some common problems |
| Competent | Embraces appropriate level of responsibility; dual processing of reasoning for most common problems; can see big picture; Complex problems default to analytic reasoning. Performance can be exhausting. |
| Proficient | More fully developed non-analytic and dual process thinking; comfortable with evolving situations; able to extrapolate; situational discrimination; can live with ambiguity |
| Expert | Experience in subtle variations; distinguishes situations |

# Sample Milestones…

| **Patient Care: Brain Tumor** | | | | |
|---|---|---|---|---|
| Level 1 | Level 2 | Level 3 | Level 4 | Level 5 |
| Performs history and physical examination in patients with a brain tumor<br><br>Performs lumbar puncture; Assists with craniotomy set-up, opening and closing<br><br>Provides routine peri-operative care for brain tumor patients | Explains risks and benefits of craniotomy for brain tumor<br><br>Assists with routine craniotomy for brain tumor<br><br>Recognizes and initiates work-up of routine complications (e.g. brain edema, CSF leak) | Formulates a diagnostic and treatment plan for a patient with a brain or spinal cord tumor<br><br>Performs routine craniotomy for brain tumor; Assists with complex craniotomy for brain tumor<br><br>Manages routine complications and recognizes complex complications (e.g. hematoma, hydrocephalus) | Adapts standard treatment plans and techniques to special circumstances (e.g. recurrence, bone marrow suppression)<br><br>Performs complex craniotomy for brain tumor; Assists with expert craniotomy for brain tumor<br><br>Manages complex complications | Leads an interdisciplinary tumor board discussion<br><br>Performs expert craniotomy for brain tumor<br><br>Utilizes patient outcome data for quality improvement or the development of adjunctive therapy protocols |



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# Milestones: Key Points

- Articulate shared understanding of expectations
- Describe trajectory from a beginner in the specialty to an exceptional resident or practitioner
- Set aspirational goals of excellence
- Organized under six domains of clinical competency
- Used as *one indicator* of a resident's educational progress



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# Qualitative Evaluation*: General Themes

Benefit to the Program Director:

- Changes in the remediation process
  - Catching struggling residents earlier
  - Targeted improvements for individual learners
  - Identifying gaps in otherwise high performers
- Structuring of learning goals
- Making defensible decisions
  - Milestones provide “built-in” documentation

**Conforti et al. The effect and use of Milestones in the assessment of neurological surgery residents and residency programs. J Surg Educ. 2018;75(1):147-55.*

# Patient Care

| | List of PC Sub-Competencies_TY |
|---|---|
| PC01 | History |
| PC02 | Physical Examination |
| PC03 | Differential Diagnosis and Assessment |
| PC04 | Clinical Management |
| PC05 | Urgent and Emergent Medical Conditions |
| PC06 | Care of Diverse Patients |



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# # of Sub-Competencies per Specialty

| Specialty | Total # Sub-comp | PC | MK | SBP | PBLI | PROF | ICS |
|---|---|---|---|---|---|---|---|
| Neurosurgery | 24 | 8 | 8 | 2 | 2 | 2 | 2 |
| Orthopedic Surgery | 41 | 16 | 16 | 3 | 2 | 2 | 2 |
| Emergency Medicine | 23 | 14 | 1 | 3 | 1 | 2 | 2 |
| Diagnostic Radiology | 12 | 2 | 2 | 2 | 3 | 1 | 2 |
| Urology | 32 | 9 | 1 | 4 | 7 | 6 | 5 |
| Internal Medicine | 22 | 5 | 2 | 4 | 4 | 4 | 3 |
| Pediatrics | 21 | 5 | 1 | 3 | 4 | 6 | 2 |
| Transitional Year | 23 | 7 | 2 | 3 | 3 | 4 | 4 |
| ..average: | 22 | 5 | 5 | 3 | 3 | 3 | 3 |



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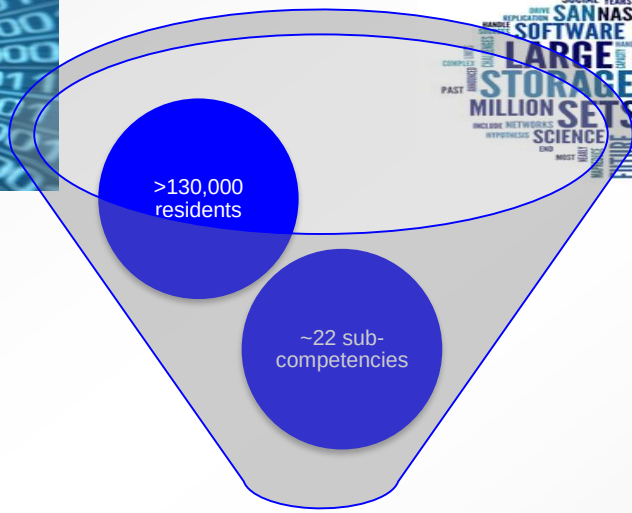



*3.2M data points*



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# Outline

1) A Review of Milestones

2) **Learning Analytics**

   1) **Concepts**

   2) **Examples**

   3) **Implementation**

3) Future Directions



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Learning Analytics...

# CONCEPTS



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# “Entrustability”

- Can we develop a system to ensure residents and fellows are ready for unsupervised practice by graduation?



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# Learning Analytics

"Learning analytics refers to the interpretation of a wide range of data produced by and gathered on behalf of students in order to assess academic progress, predict future performance, and spot potential issues"

-U.S. Dept of Ed 2012



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Learning Analytics...

# EXAMPLES



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# Generic Milestones Template

| Milestone Description: Template | | | | |
|---|---|---|---|---|
| Level 1 | Level 2 | Level 3 | Level 4 | Level 5 |
| What are the expectations for a beginning resident? | What are the milestones for a resident who has advanced over entry, but is performing at a lower level than expected at mid-residency? | What are the key developmental milestones mid-residency?<br><br>What should they be able to do well in the realm of the specialty at this point? | What does a graduating resident look like?<br><br>What additional knowledge, skills & attitudes have they obtained?<br><br>Are they ready for certification? | Stretch Goals – Exceeds expectations |
| ☐ | ☐ | ☐ | ☐ | ☐ ☐ ☐ ☐ ☐ |
| **Comments:** | | | | |



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Level 4 is designed as the graduation *target* and does not represent a graduation *requirement*. Making decisions about readiness for graduation is the purview of the residency program director. Study of milestone performance data will be required before the ACGME and its partners will be able to determine whether Level 4 milestones and milestones in lower levels are in the appropriate level within the developmental framework, and whether milestone data are of sufficient quality to be used for high stakes decisions.

Allows for a QI approach…

# LEVEL 4 IS NOT A REQUIREMENT



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Cross-Sectional Analysis

# (1) AT THE SPECIALTY LEVEL...



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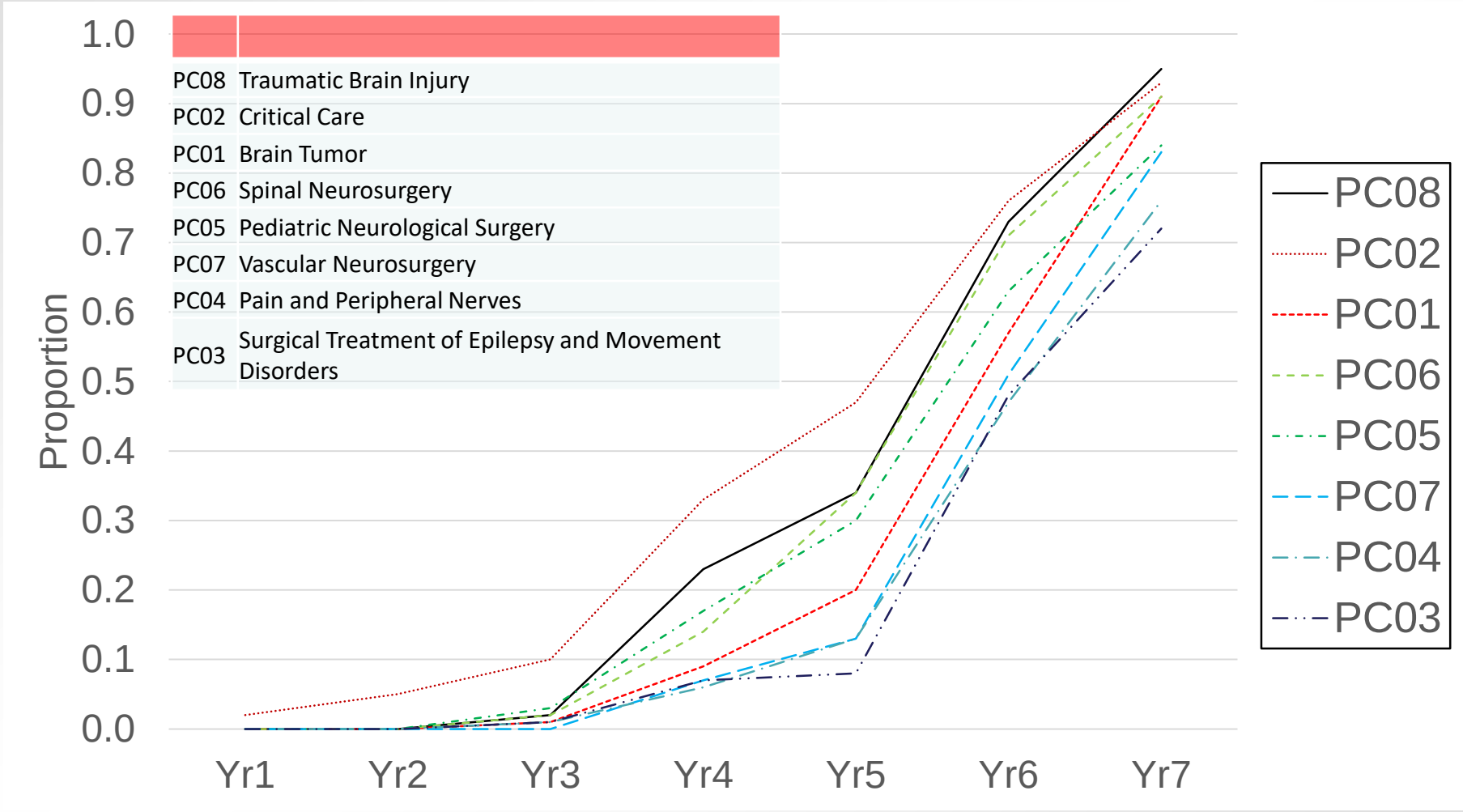
# Proportion of Residents Attaining Level 4 or Higher: PC Sub-Competencies (June 2015) – Neurological Surgery



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Longitudinal Analysis

# (2) AT THE INDIVIDUAL LEVEL...



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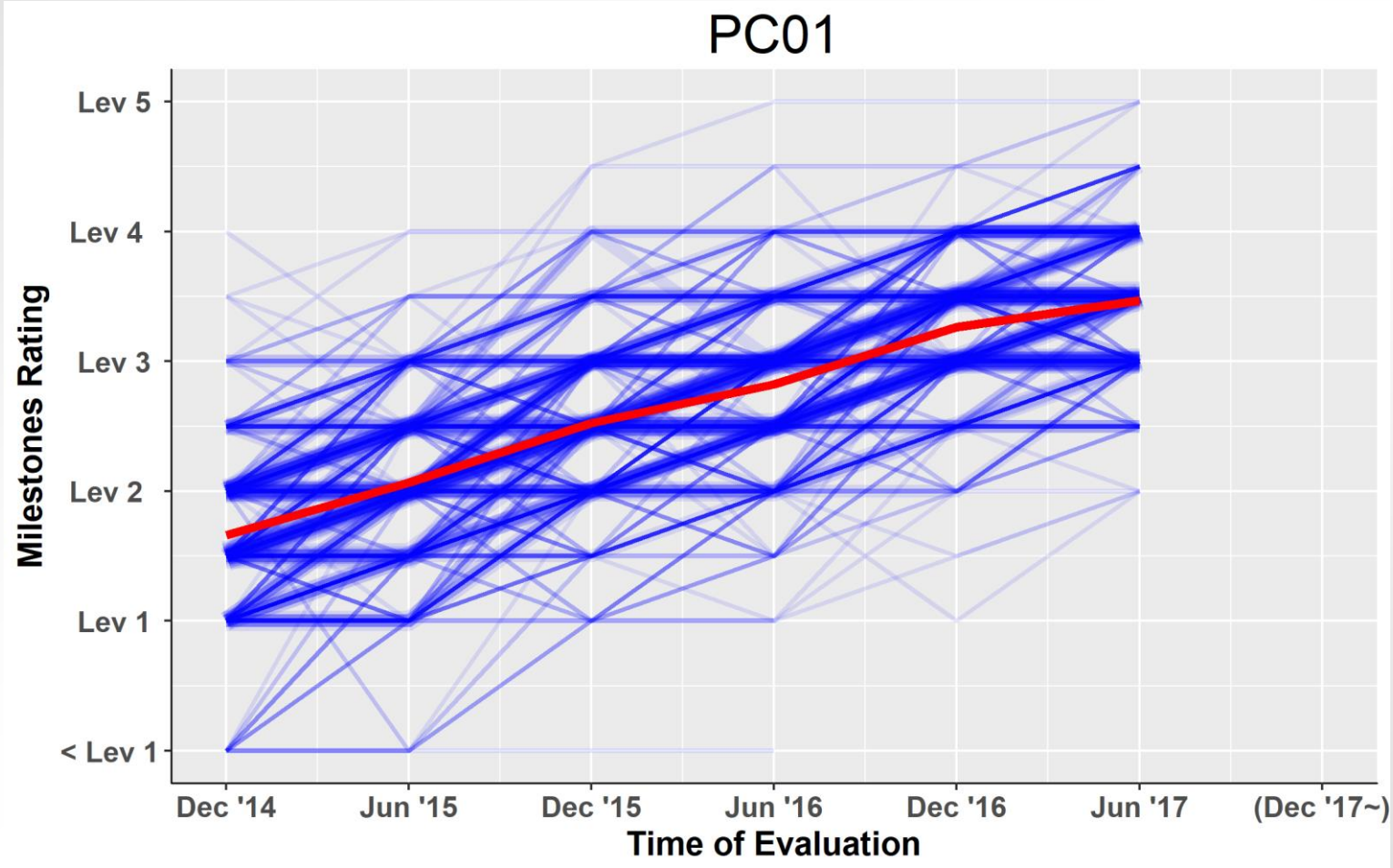
# Resident-Level Trajectories of Milestones Ratings - Pathology



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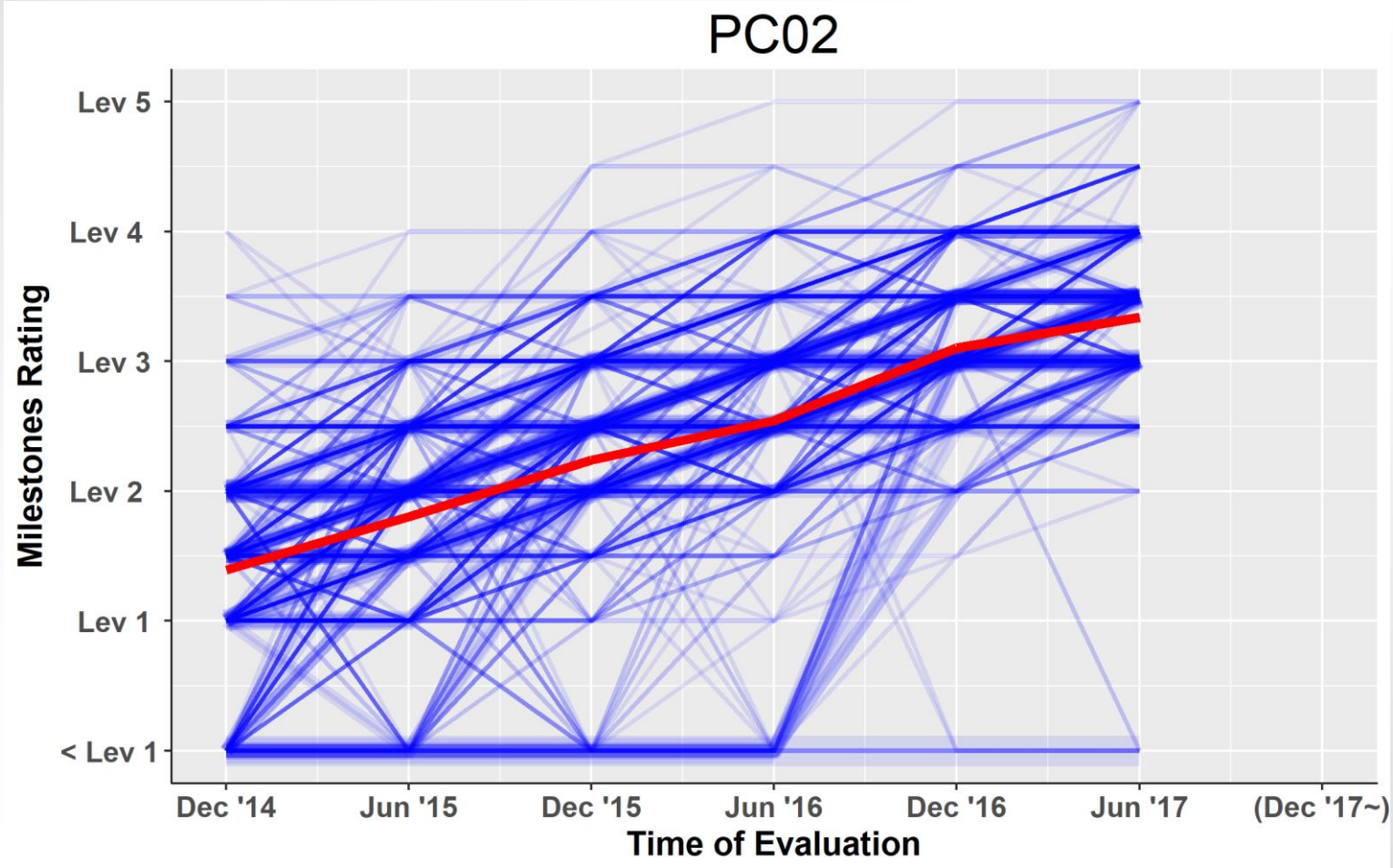
# Resident-Level Trajectories of Milestones Ratings - Pathology



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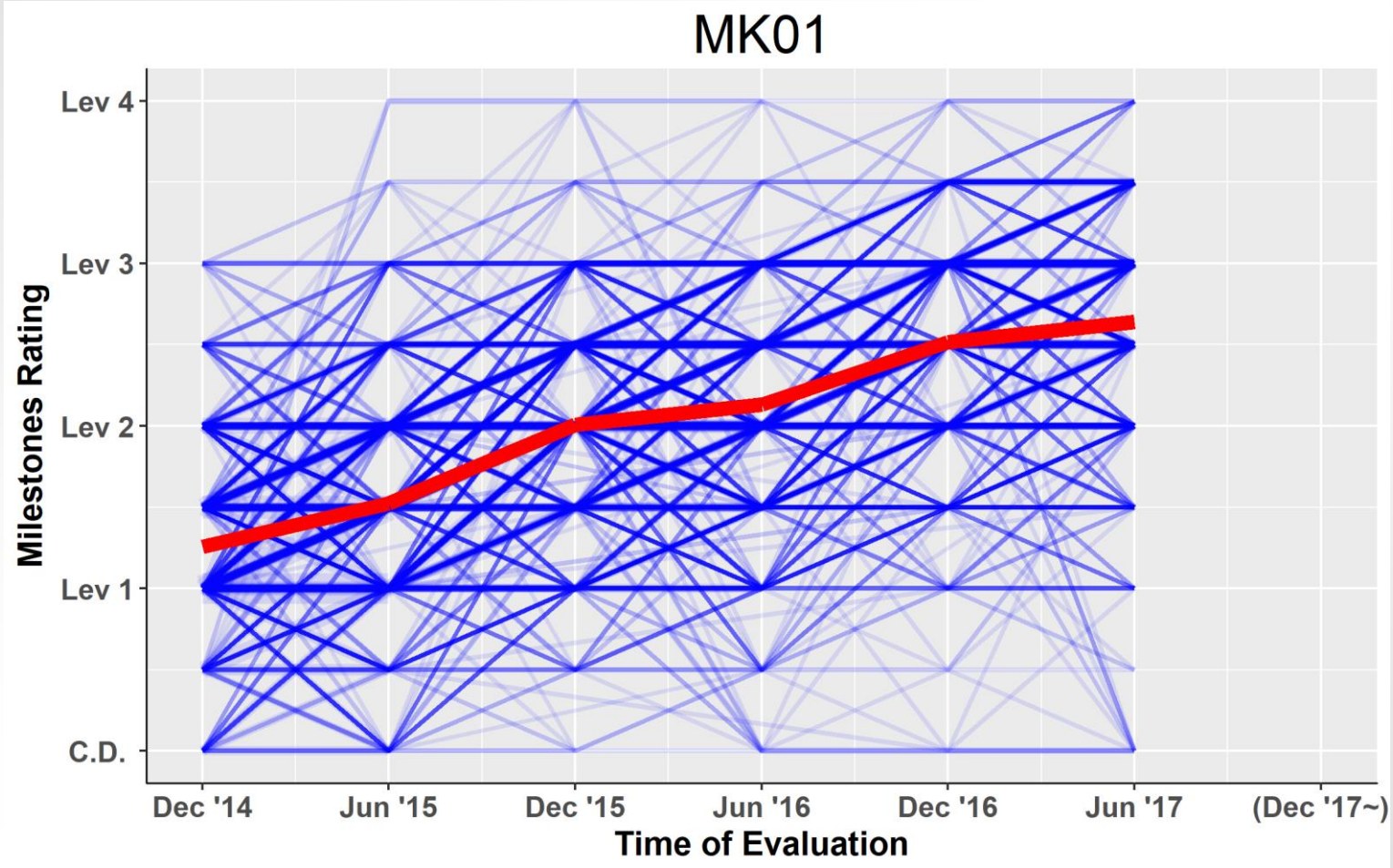
# Resident-Level Trajectories of Milestones Ratings – Surgery



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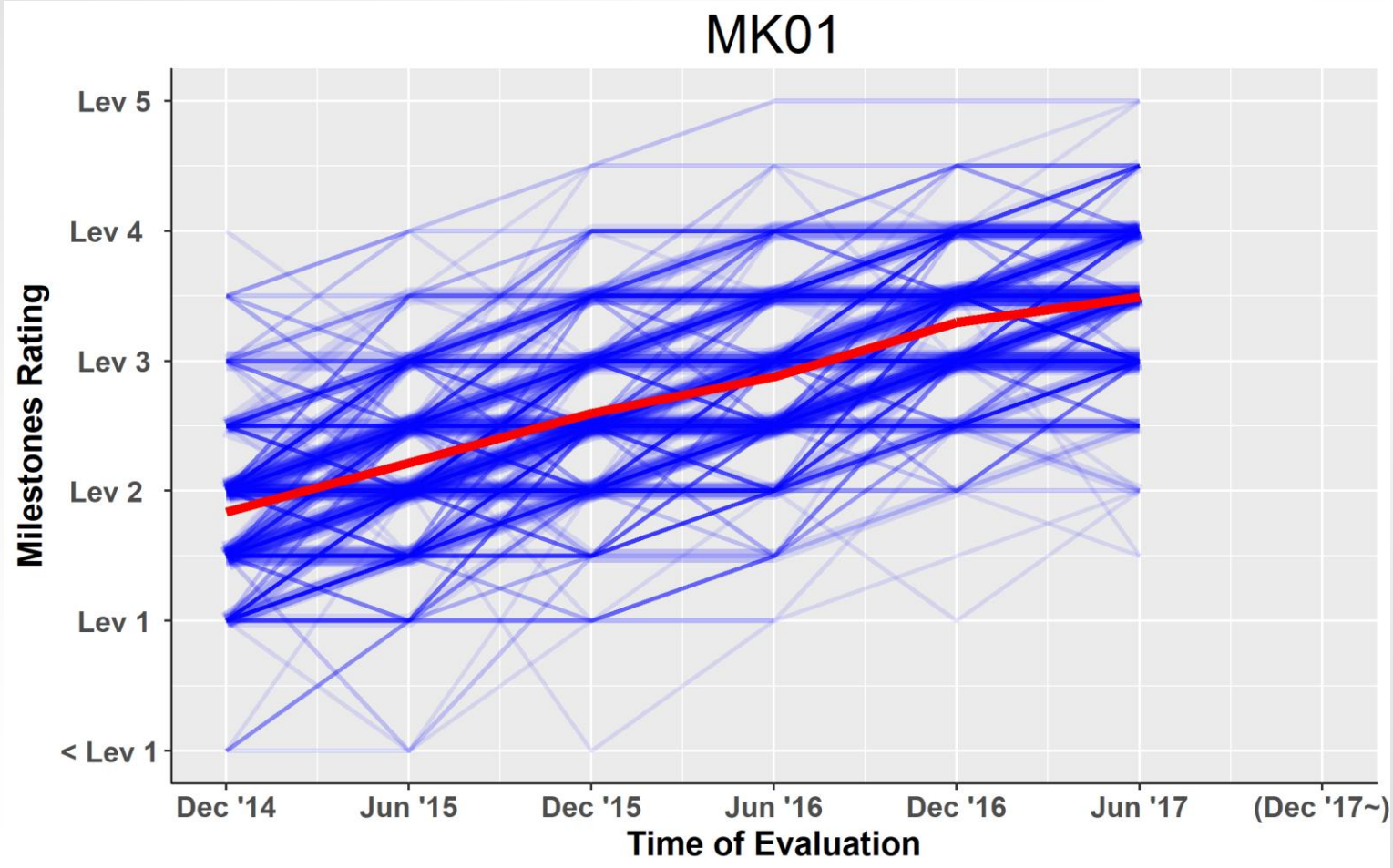
# Resident-Level Trajectories of Milestones Ratings - Pathology



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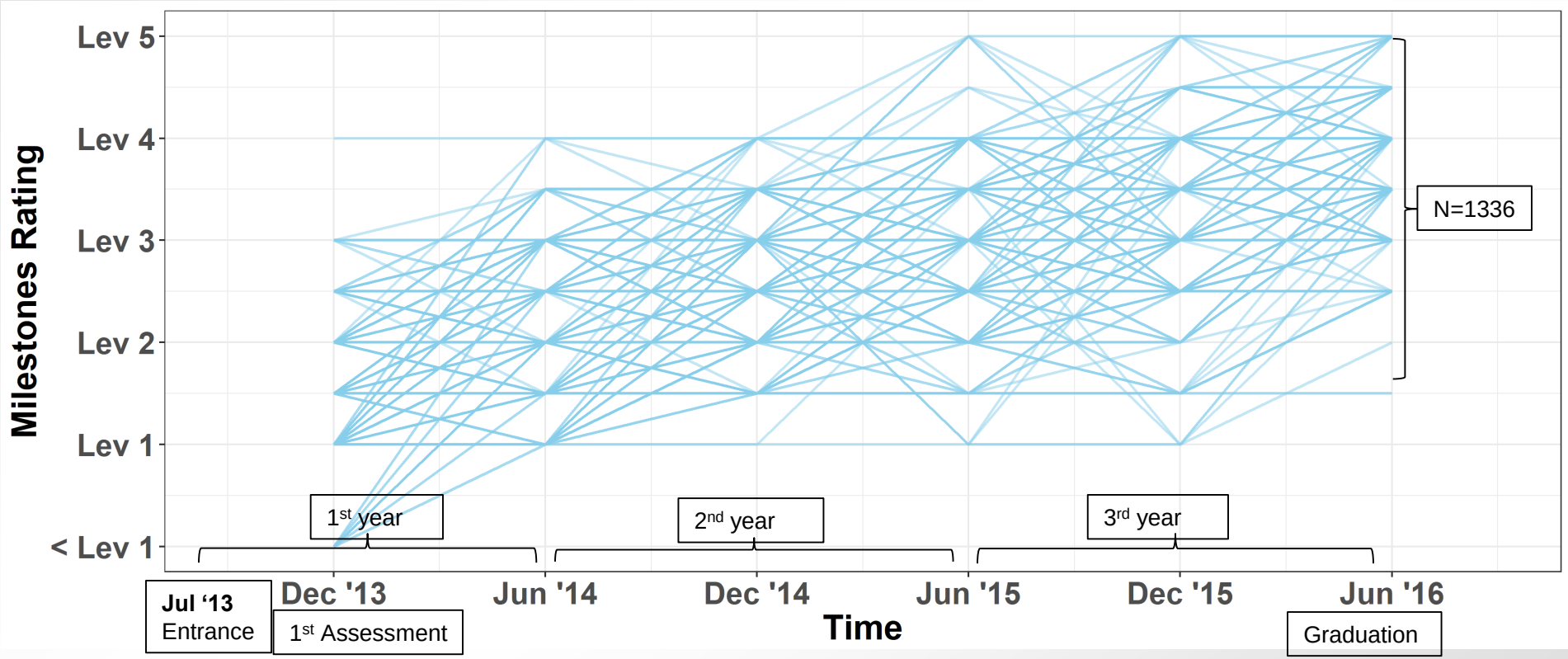
# Mapping Individual Trajectories

Residents' Milestones trajectories over time (e.g., Wound Management)



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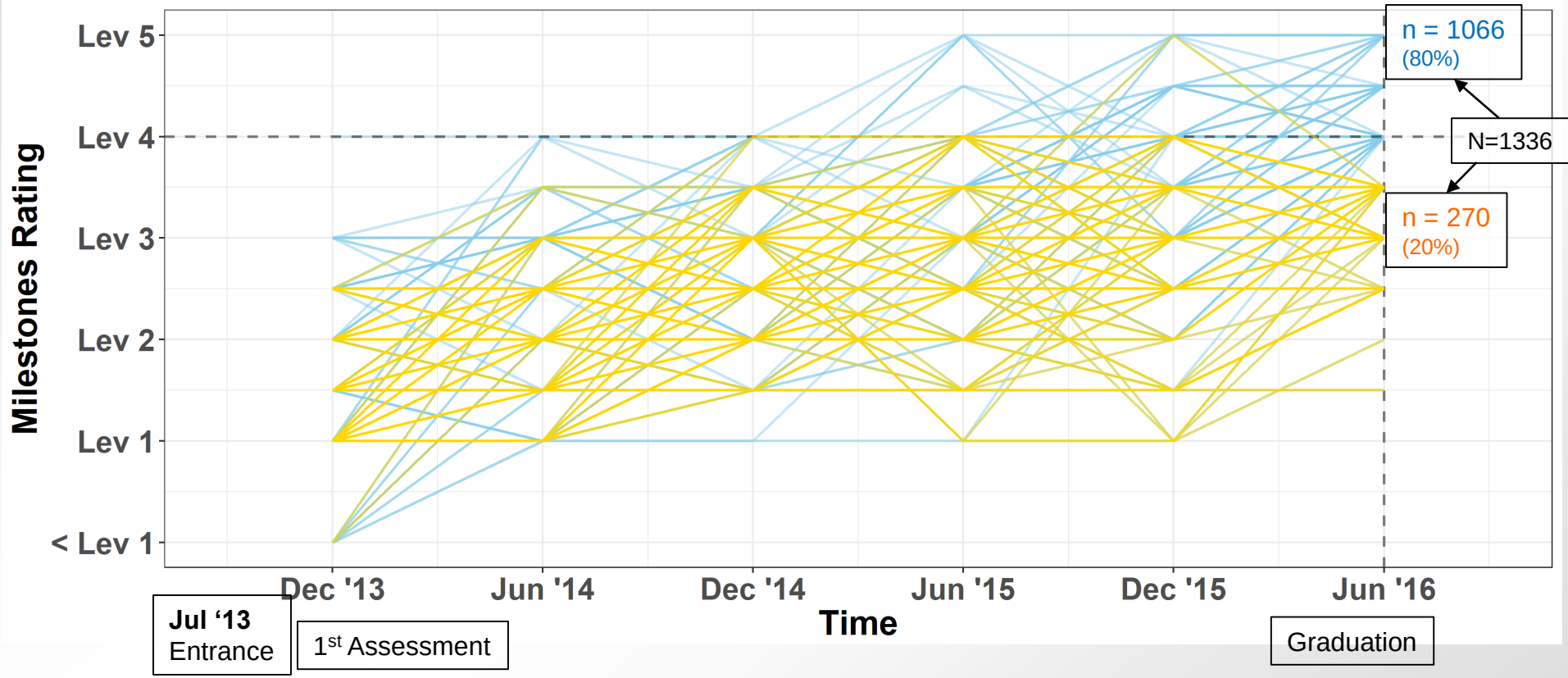
# Results – EM Wound Management

Milestones trajectories for those who attained Level 4 and those who did not



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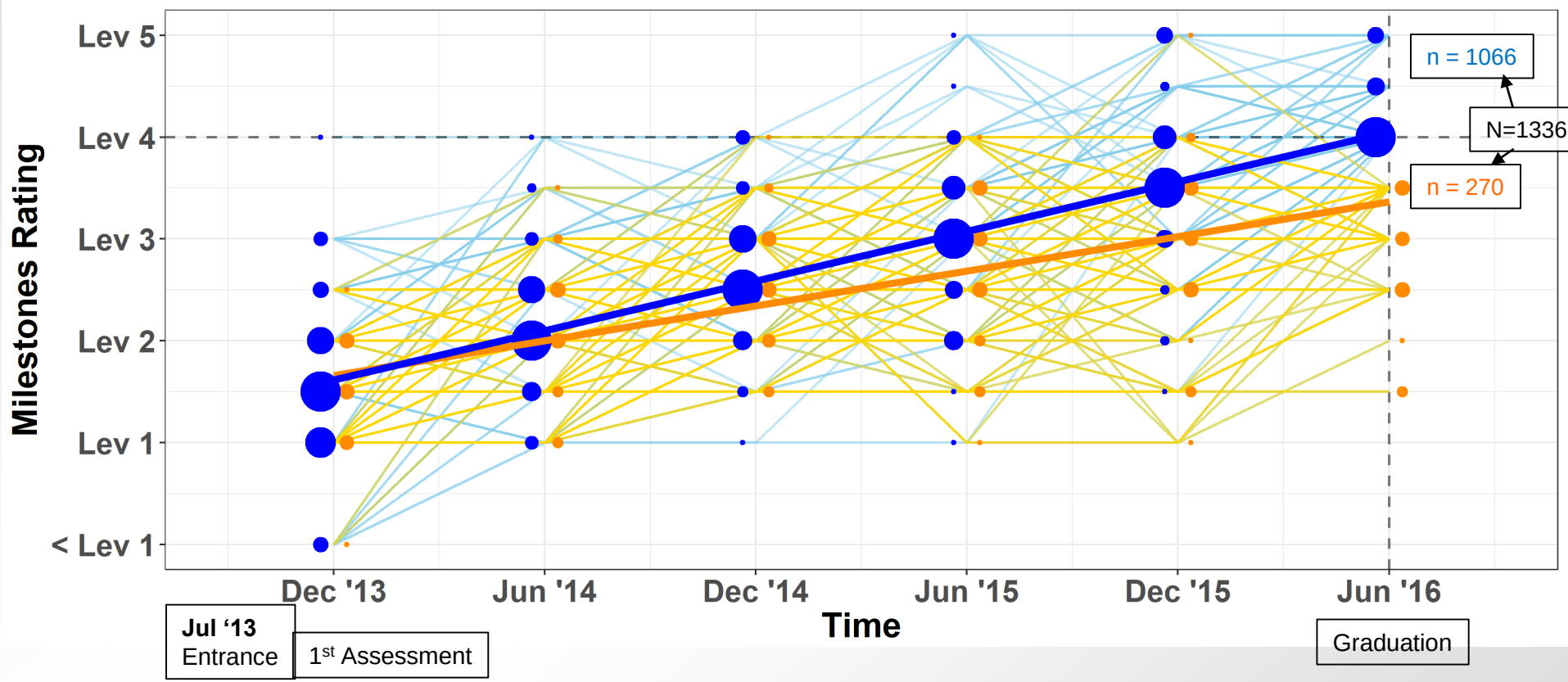




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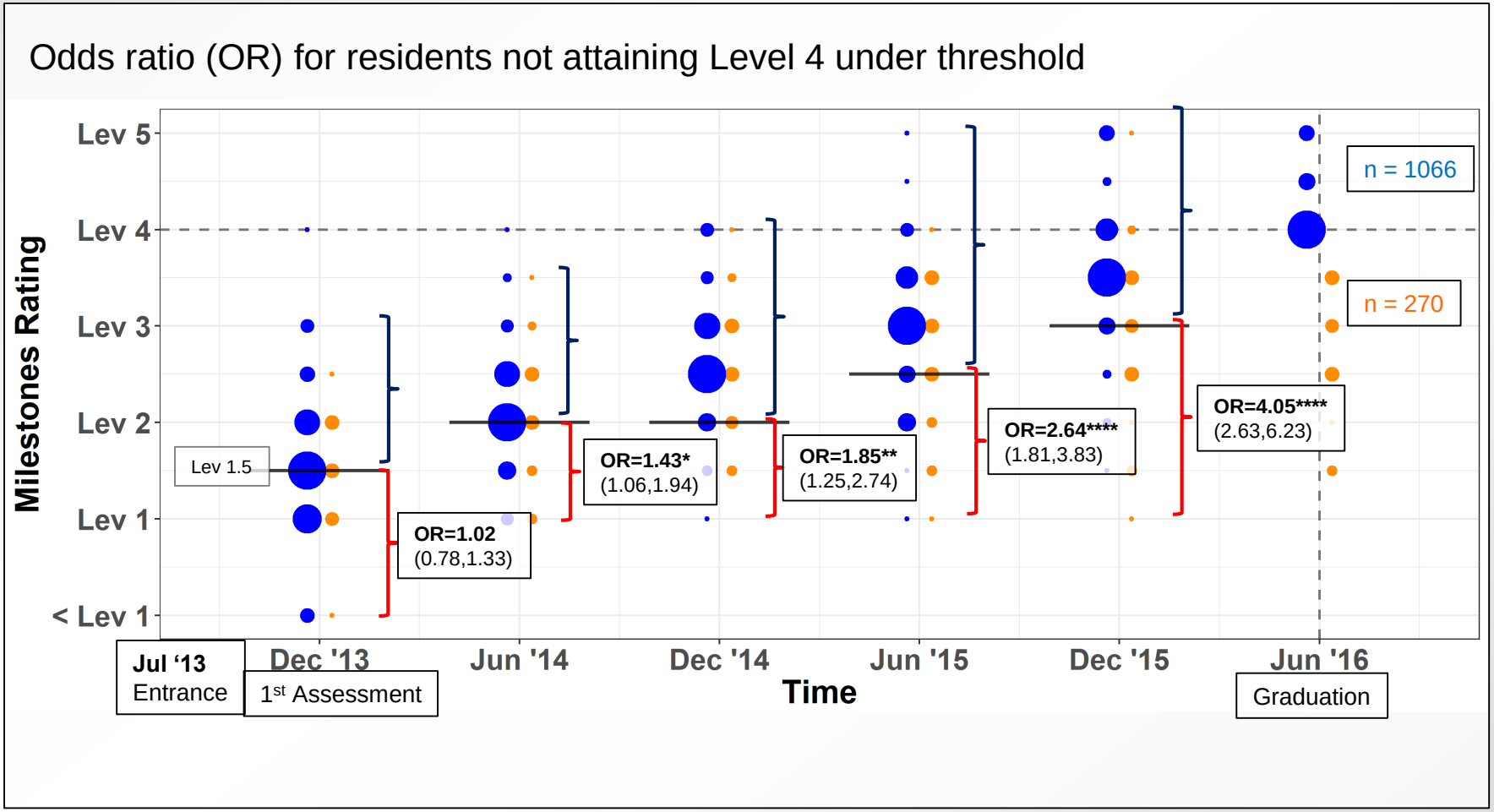
# Milestone Level Thresholds



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Qualitative Research

# (3) HOW DO RATERS MAKE DECISIONS?



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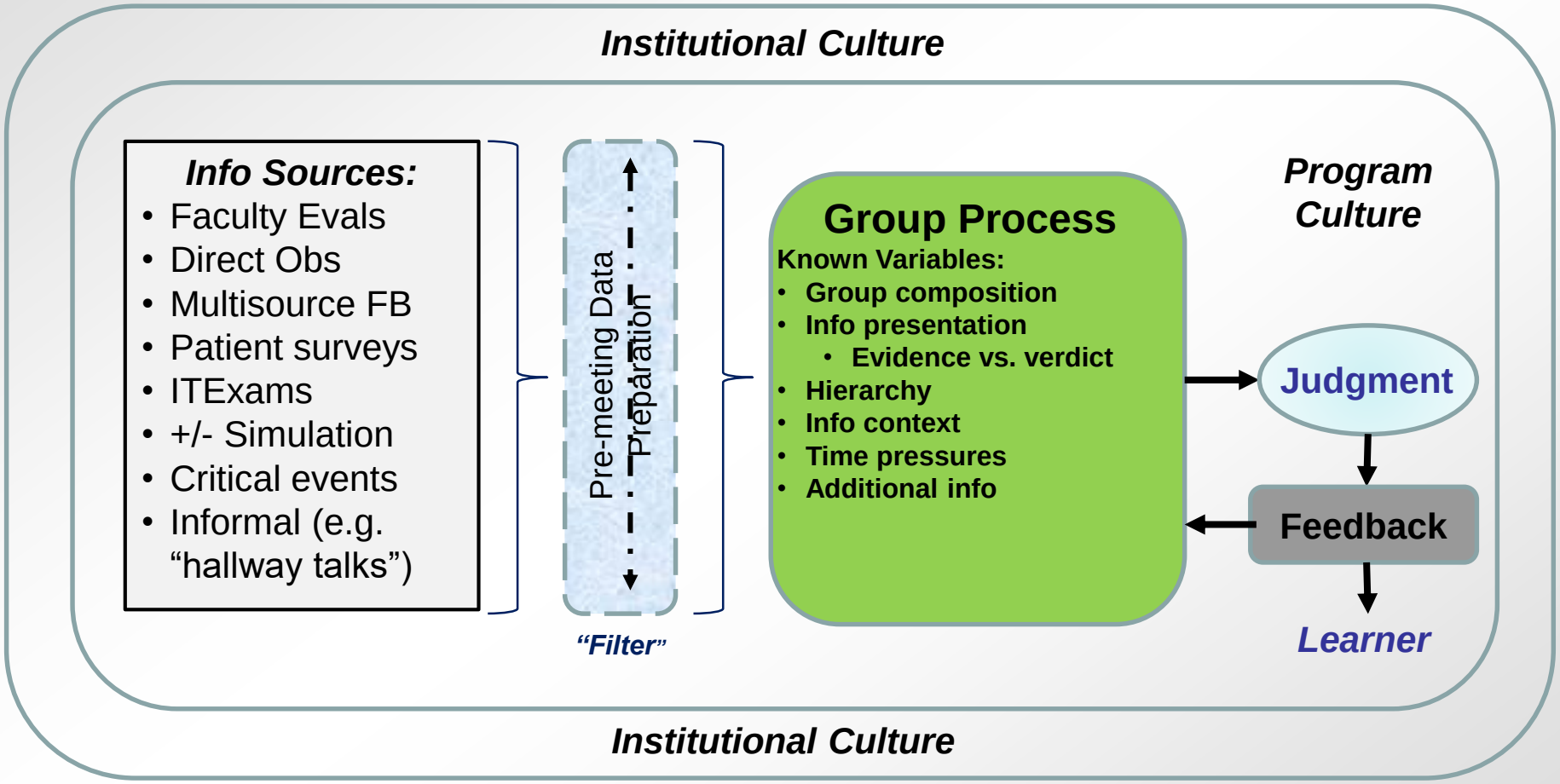
# Milestones Guide Group Judgments



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# Typical Evaluation Form

| | | | | | |
|---|---|---|---|---|---|
| **Diagnosis (PC1)** | | | | | |
| N<br>Not observed | 0<br>Unable to perform an accurate H+P | 1<br>Performs a focused, efficient and accurate H+P of all patients including critically ill patients | 2<br>Accurately diagnoses many common conditions and initiates management for some | 3<br>Accurately diagnoses and initiates management for most common conditions | 4<br>Recognizes atypical presentations of a large number of conditions |
| **Post-op care (PC2)** | | | | | |
| N<br>Not observed | 0<br>Does not recognize or manage common post op problems | 1<br>Manages common post op problems with a senior physically present | 2<br>Manages common post op problems with a senior available by phone | 3<br>Manages common and complex post op problems independently | 4<br>Supervises junior residents managing common and complex postoperative problems |
| **Technical skills (PC3)** | | | | | |
| N<br>Not observed | 0<br>Lacks basic surgical skills (e.g. knot tying, NG tube, foley, I+D, art line) | 1<br>Has basic surgical skills (e.g. knot tying, NG tube, foley, I+D, art line) | 2<br>Has respect for tissue and developing instrument handling | 3<br>Proficient at most instrument handling and exhibits efficiency | 4<br>Proficiency in use of all instruments and equipment for essential operations |
| **Knowledge about diseases (MK1)** | | | | | |
| N<br>Not observed | 0<br>Lacks basic knowledge expected of a medical student | 1<br>Understands signs, symptoms and treatment of some common conditions | 2<br>Basic knowledge and recognizes variations in presentation of many common conditions | 3<br>Significant knowledge of many common conditions | 4<br>Comprehensive knowledge of common conditions and basic knowledge of advanced conditions |
| **Knowledge about operations (MK2)** | | | | | |
| N<br>Not observed | 0<br>Does not know steps of common operations | 1<br>Basic knowledge of steps of common operations | 2<br>Basic knowledge of steps and perioperative care for many common operations | 3<br>Significant knowledge of most common operations, basic knowledge of some complex operations | 4<br>Comprehensive knowledge of common operations, basic knowledge of many complex operations |



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## ACGME Milestone Evaluations - Neurological Surgery

### Program Name - Neurological Surgery

**Resident Name:**
**Year in Program:**
**Position Type:**
**Start Date:**
**Expected End Date:**

Select the level corresponding to the resident's knowledge, skills, attitudes, and other attributes in each area below. Your selections should take into account the resident's demonstration of milestones throughout the program with updates to reflect recent progress. Evaluations must be based on evidence with an emphasis on that obtained by direct observation.

### Patient Care

| | | Not Yet Rotated | Level 1 | | Level 2 | | Level 3 | | Level 4 | | Level 5 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| a) | Brain Tumor | | | | | | | | | | |
| b) | Critical Care | | | | | | | | | | |
| c) | Surgical Treatment of Epilepsy and Movement Disorders | | | | | | | | | | |
| d) | Pain and Peripheral Nerves | | | | | | | | | | |
| e) | Pediatric Neurological Surgery | | | | | | | | | | |
| f) | Spinal Neurosurgery | | | | | | | | | | |
| g) | Vascular Neurosurgery | | | | | | | | | | |
| h) | Traumatic Brain Injury | | | | | | | | | | |



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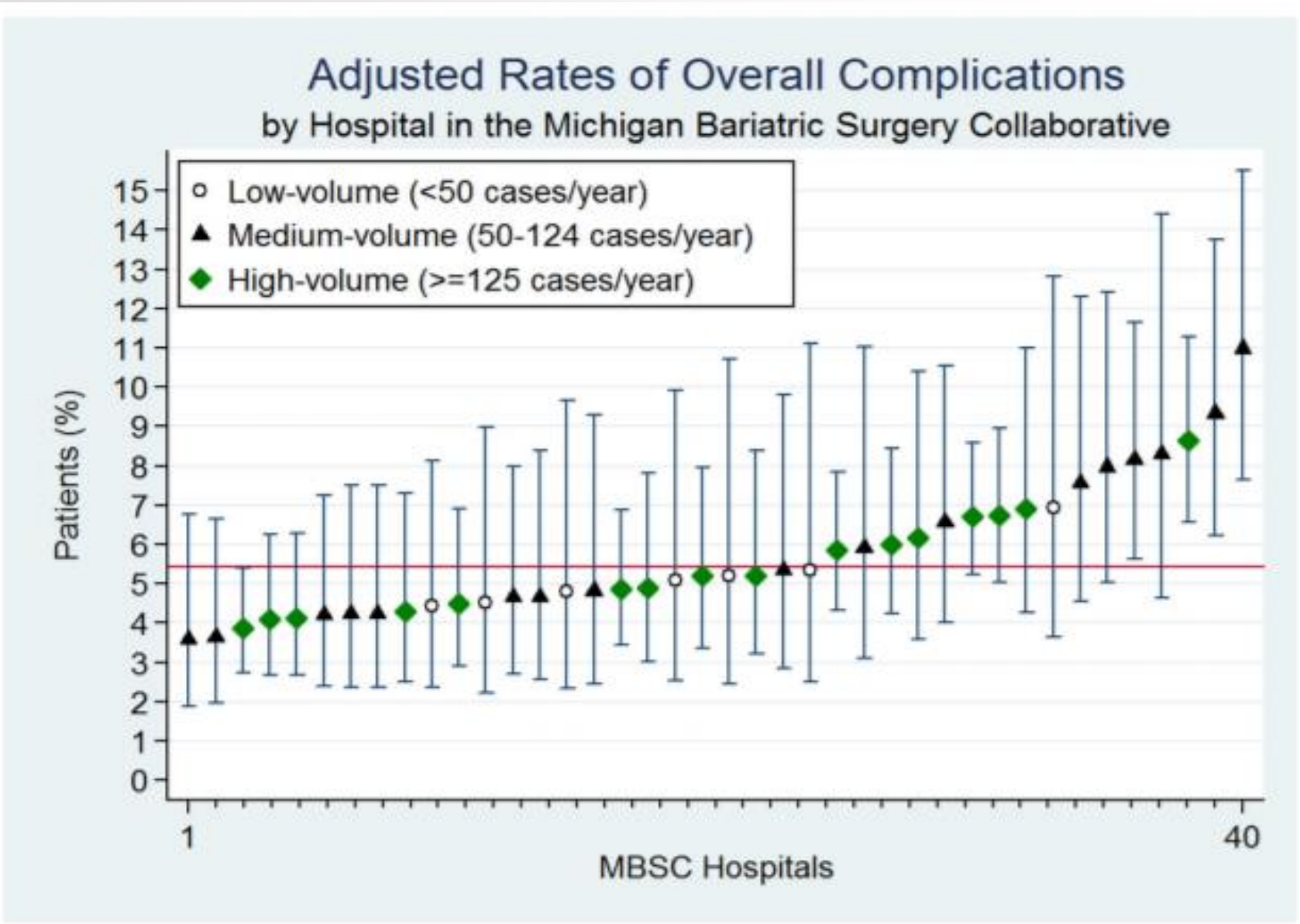
# Rates of Straight-Lining by Specialty

| Specialty Code | Length of Training | SpecialtyName | N Resident | N Subcomp | Yr1 | Yr2 | Yr3 | Yr4 | Yr5 | Yr6 | Yr7 | ord |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 421 | 1 | Abdominal radiology | 45 | 13 | 15.6 | | | | | | | 113 |
| 426 | 1 | Musculoskeletal radiology | 29 | 14 | 17.2 | | | | | | | 114 |
| 423 | 1 | Neuroradiology | 280 | 14 | 21.1 | | | | | | | 115 |
| 424 | 1 | Pediatric radiology | 55 | 14 | 3.6 | | | | | | | 116 |
| 427 | 1 | Vascular and interventional radiology | 294 | 14 | 19.7 | | | | | | | 117 |
| 416 | 5 | **Interventional radiology - integrated** | 62 | 20 | 18.2 | 0.0 | 0.0 | 6.7 | 0.0 | | | 118 |
| 440 | 5 | **Surgery** | 8499 | 16 | 23.5 | 15.9 | 14.2 | 16.8 | 38.9 | | | 119 |
| 446 | 2 | Complex general surgical oncology | 107 | 23 | 11.1 | 17.0 | | | | | | 120 |
| 445 | 2 | Pediatric surgery | 81 | 22 | 0.0 | 2.7 | | | | | | 121 |
| 442 | 1 | Surgical critical care | 262 | 30 | 17.6 | | | | | | | 122 |
| 450 | 2 | **Vascular surgery** | 247 | 31 | 0.8 | 5.7 | | | | | | 123 |
| 451 | 5 | **Vascular surgery - integrated** | 272 | 31 | 3.3 | 1.7 | 1.7 | 3.8 | 10.3 | | | 124 |
| 460 | 3 | **Thoracic surgery (2-year programs)** | 84 | 26 | 11.5 | 10.3 | 20.7 | | | | | 125 |
| 460 | 2 | **Thoracic surgery (3-year programs)** | 137 | 26 | 1.4 | 3.0 | | | | | | 125 |
| 466 | 1 | Congenital cardiac surgery | 12 | 9 | 33.3 | | | | | | | 127 |
| 461 | 6 | **Thoracic surgery - integrated** | 183 | 26 | 8.3 | 10.8 | 5.7 | 7.4 | 7.4 | 23.8 | | 128 |
| 480 | 4 | **Urology** | 1288 | 34 | 9.3 | 8.0 | 10.6 | 17.4 | | | | 129 |
| 486 | 3 | Female pelvic medicine and reconstructive surgery (Urology) | 35 | 23 | 7.1 | 8.3 | 22.2 | | | | | 130 |
| 485 | 1 | Pediatric urology | 24 | 22 | 12.5 | | | | | | | 131 |
| 999 | 1 | **Transitional year** | 1332 | 23 | 15.4 | | | | | | | 132 |

# The Power of a "QI" Approach






*Pradarelli et al. Surgery. 2016 Apr;159(4):1113-20.*

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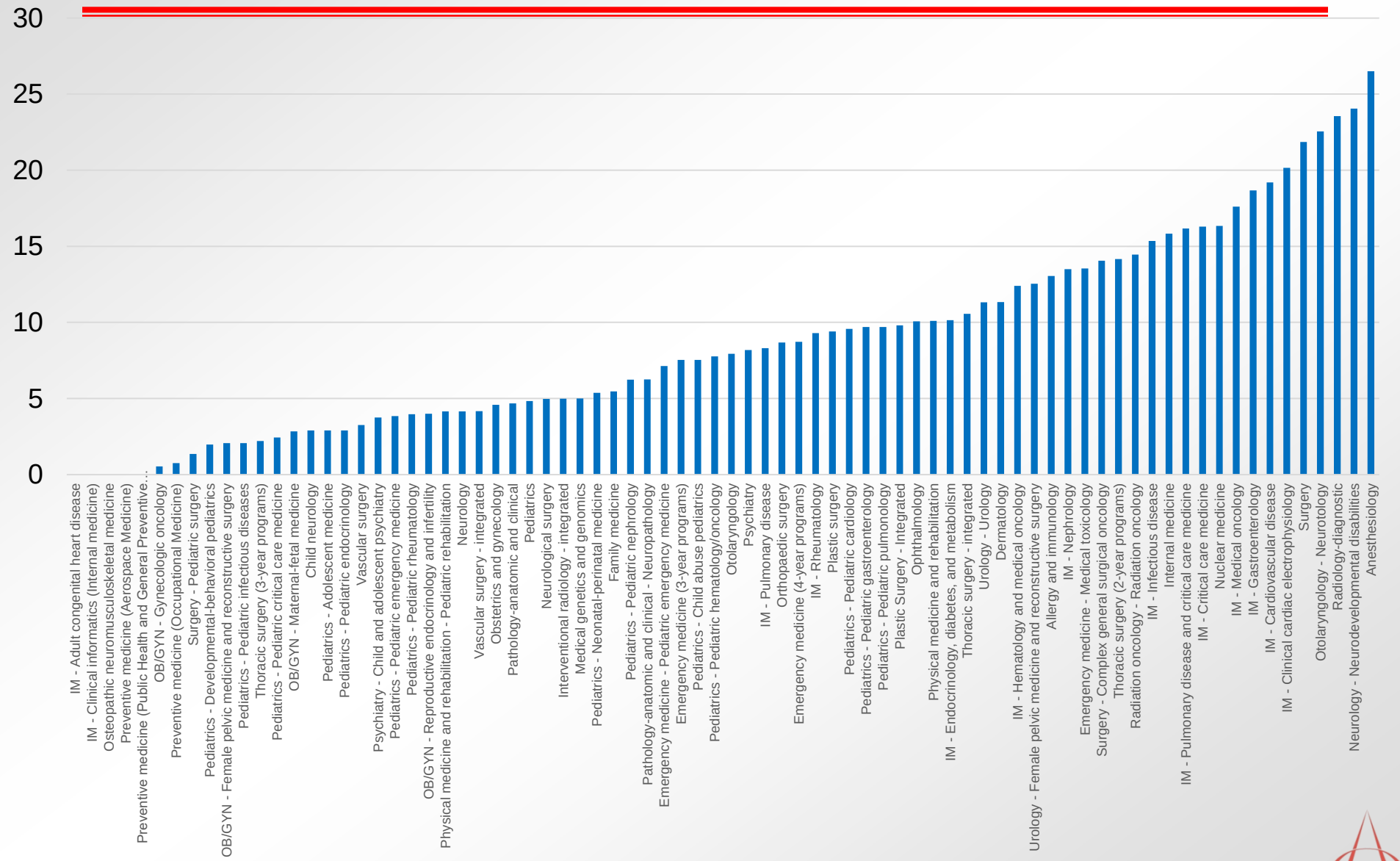
# Rate of Straight-Lining (June 2018)
# (Average of year-end ratings per specialty)



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Learning Analytics...

# IMPLEMENTATION



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# Implementation

1) Strategies for Interpretation
   - input from SMEs
2) Revisit Overall Purpose
3) Revision of Content/Structure



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# Qualitative Evaluation*: General Themes

Areas of Milestone Challenges:

- Logistics and data handling
- Assessment processes
  - Need for more faculty development
  - How to map assessments onto a Milestone judgment
- Language in some Milestones
- Time and resources for core faculty
- Better assessment tools (need to be *feasible*)

**Conforti et al. The effect and use of Milestones in the assessment of neurological surgery residents and residency programs. J Surg Educ. 2018;75(1):147-55.*

Content Validity...

# MILESTONES 2.0



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# Differences – Structure

**Critical Care – Patient Care**

| Level 1 | Level 2 | Level 3 | Level 4 | Level 5 |
|---|---|---|---|---|
| • Performs a history and physical examination in critically-ill patients<br>• Orders positioning, analgesics, sedation, neuromuscular blockade, intravenous (IV) fluids and nutrition in critically-ill patients<br>• Diagnoses and formulates treatment plans for common pulmonary diseases<br>• Use electrocardiogram (EKG) to diagnose cardiac arrhythmia; initiates hemodynamic monitoring<br>• Performs a brain death examination | • Explains risks and benefits of ventilatory support<br>• Interprets diagnostic studies (e.g., chest x-ray [CXR], brain computed tomography [CT], echocardiogram)<br>• Manages intra-cranial hypertension (e.g., hyperosmolar agents, cerebral spinal fluid [CSF] drainage)<br>• Manages airway and performs endotracheal intubation<br>• Inserts arterial and central venous catheters<br>• Diagnoses and manages spinal or hypovolemic shock | • Formulates work-up and treatment plan for a comatose patient<br>• Manages refractory intra-cranial hypertension (e.g., blood pressure, cerebral perfusion pressure [CPP])<br>• Obtains confirmatory tests and make an accurate diagnosis of brain death<br>• Initiates management of pneumonia or systemic infection | • Independently formulates a treatment plan for complex patients (e.g., failure of cerebral autoregulation, multi-organ failure, non-recoverable central nervous system [CNS] injury)<br>• Diagnoses and initiates management of adult respiratory distress syndrome<br>• Manages difficult and emergency airways<br>• Diagnose and manages CSF leak<br>• Initiates management of cardiac rhythm disturbances | • Systematically reviews outcomes for neurocritical care patients<br>• Participates in quality improvement for a neurocritical care unit<br>• Develops a standard neurocritical care unit management protocol<br>• Leads multidisciplinary neurocritical care team<br>• Manages respiratory failure (e.g., mechanical ventilation, bronchoscopy)<br>• Manages cardiac rhythm disturbances |
| ☐ | ☐ | ☐ | ☐ | ☐ |

**Comments:**

Not yet rotated ☐

**Patient Care 8: Critical Care**

| Level 1 | Level 2 | Level 3 | Level 4 | Level 5 |
|---|---|---|---|---|
| Performs a history and physical examination in critically-ill patients | Manages transient intracranial hypertension (e.g., hyperosmolar agents, CSF drainage) | Manages refractory intracranial hypertension (e.g., cerebral perfusion pressure directed therapy, advanced monitoring, decompressive craniectomy) | Diagnoses and initiates management of acute respiratory distress syndrome | Leads a multidisciplinary neurocritical care team |
| Inserts arterial and central venous catheters | Assists with routine neurocritical care unit procedures; manages airway and performs endotracheal intubation | Performs routine and assists with complex neurocritical care unit procedures; manages difficult and emergency airways | Performs complex and assists with advanced neurocritical care unit procedures; manages or initiates management of surgical airways | Performs advanced neurocritical care unit procedures; performs bronchoscopy |
| Manages neurocritical care unit admissions and discharges | Recognizes and initiates work-up of routine systemic complications (e.g., pneumonia, infection, pulmonary embolus, cardiac dysrhythmia, myocardial infarction) | Manages routine systemic complications and prioritizes simultaneous critical clinical events | Manages metabolic and nutritional support for critically-ill patients | Manages complex critically-ill patients (e.g., septic shock, organ failure); designs care pathways for critically-ill patients |
| ☐ | ☐ | ☐ | ☐ | ☐ |

**Comments:**

Not Yet Achieved Level 1 ☐



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# DIFFERENCES – CONTENT



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# Old Version:

| PC2. Physical Examination: Performs a comprehensive physical examination | | | | | |
|---|---|---|---|---|---|
| Has not Achieved Level 1 | Level 1 | Level 2 | Level 3 | Level 4 | Level 5 |
| | Performs a basic physical exam | Performs a comprehensive exam and collects relevant physical findings for the chief complaint | Consistently performs an accurate, thorough, and focused physical examination, and correlates findings with important clinical events | Performs a sophisticated specialty-specific physical exam with effective use of bedside skills | Serves as a role model and educator in the use of specialty-specific exam skills |
| ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Comments: | | | | | |

# New Version:

| Patient Care 2: Physical Examination | | | | |
|---|---|---|---|---|
| Level 1 | Level 2 | Level 3 | Level 4 | Level 5 |
| Performs a basic physical exam accurately | Performs and reports an accurate, organized physical exam, and identifies appropriate physical findings for the chief complaint | Consistently performs an accurate and thorough physical examination, and reports relevant findings in support of likely clinical diagnosis | Consistently identifies and concisely reports subtle physical findings; is proficient with advanced maneuvers | Consistently serves as a role model and educator in the performance of an advanced physical exam |
| ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ | | | | |
| Comments: Not Yet Completed Level 1 ☐ | | | | |

# Outline

1) A Review of Milestones

2) Learning Analytics

3) **Future Directions**



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# Questions to Consider

1. Reflect on your own context:
   - Consider barriers and facilitators to implementing large data collection system
2. How would Learning Analytics help your learners?
   - Your teachers?
   - Your patients?
3. Share



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# THE FUTURE…



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# The Art of the Possible

- What the technology now affords
- Implications/new challenges:
  1. the challenge of interpretation
     - Descriptive summaries of learning trajectories aren't that helpful
     - How do you '**make meaning**' from the data?
  2. strategies for communication
     - Translate implications of data to learners and educators
  3. implementation science/KT
     - Engage stakeholders for feedback, data visualization

# Questions?

@stanhamstra

1) A Review of Milestones
   - purpose
2) Learning Analytics
   - Concepts
   - Examples
   - Implementation
3) Future Directions

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