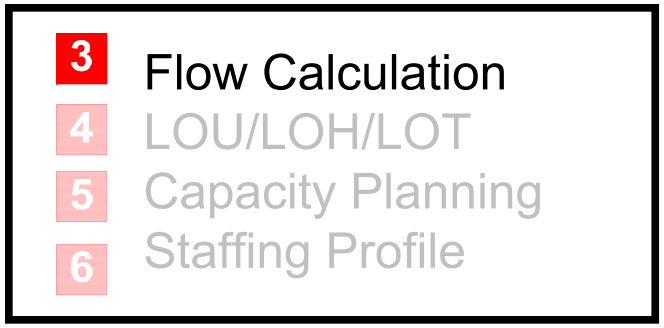
Flow Calculation Tool



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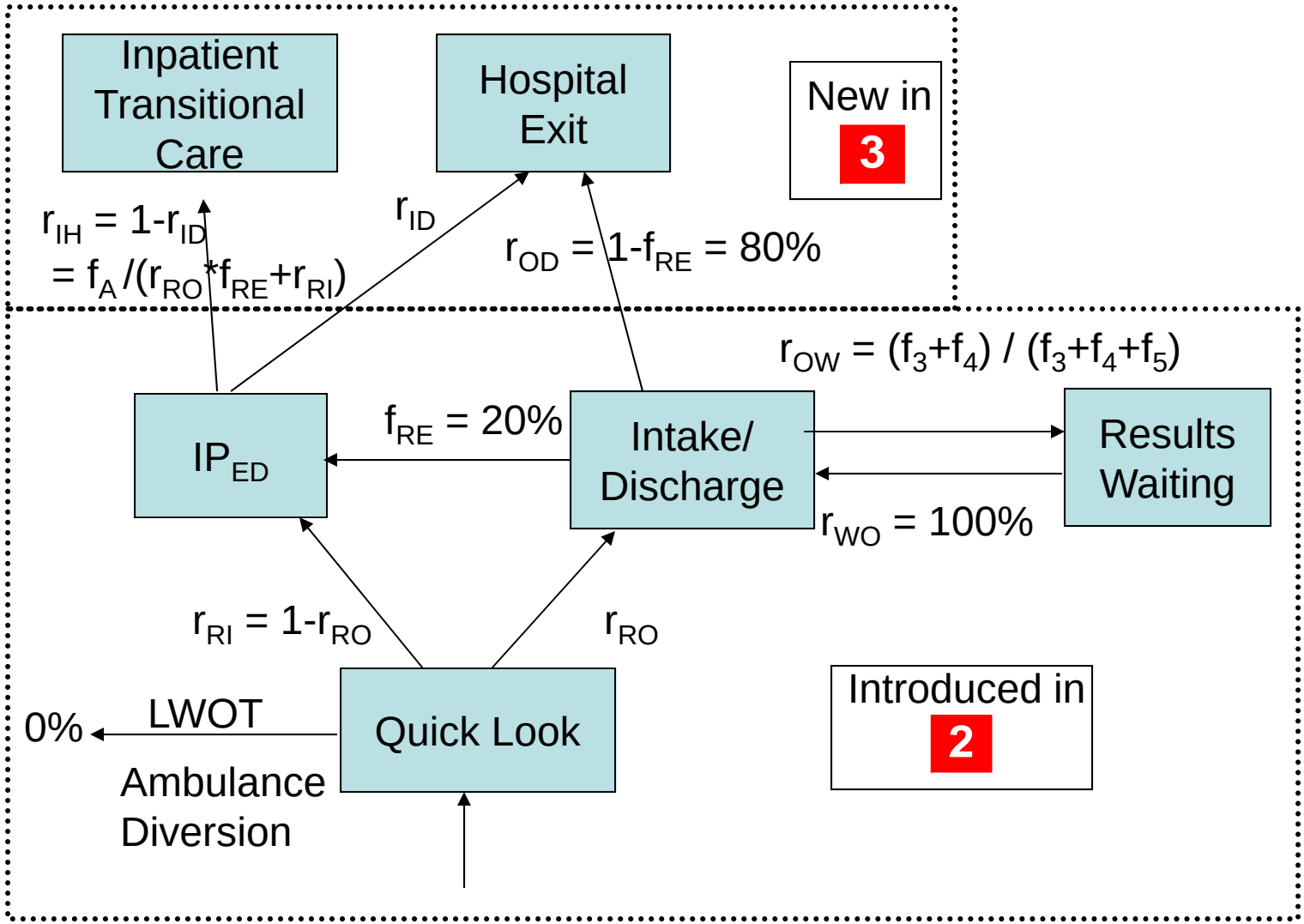
Analysis Goals

- With this tool, the user will be able to answer the question: “How many patients per hour will arrive to each area of the Split ED?”
- The answer is based upon patient acuity mix (f_1, f_2, f_3, f_4, f_5) and volume, and the percentage of patients admitted to the inpatient units (f_A) from the ED.

Patient Flows in the Split ED

- Remember, in Tool **2**, we ‘push’ patients into the front of the Split ED on the basis of acuity.
- Now in Tool **3**, patients are ‘pulled’ out of the back-half to match the ED’s admit percentage.
  - The ‘Inpatient Transitional Care’ area accommodates patients ‘boarding’ in the ED while waiting for inpatient bed placement.
  - For more information on the “whole-hospital” effect of ED admits, see [1] and [2]
- The next slide shows all Split ED areas combined graphically. In this Tool, all patients flows in the diagram will be calculated.

Combining Flows in the Split ED



Tool 3 Inputs

- Percent of patients admitted to inpatient bed units from the ED.

Percent Admitted to IP Department from ED (f_A):	22%

- Inputs from Tool **2**
  - Daily planning volume including LWOTs.
  - Patient acuity mix (f_1, f_2, f_3, f_4, f_5) and the default Intake/Discharge to IP_{ED} transfer percentage (f_{RE}).

INPUT:	
Daily Planning Volume (Including LWOTS)	265
Acuity:	
Level 1 (f_1)	0.03%
Level 2 (f_2)	8.28%
Level 3 (f_3)	68.73%
Level 4 (f_4)	20.53%
Level 5 (f_5)	2.18%
Sum (must equal 100%):	100%

Default OP_{ED} to IP_{ED} transfer percentage (f_{RE}):	20%

Tool 4 Outputs

Queuing Network Flow Balance Equations[3],[4]

- r_{OI} is same as used in **2** and f_A is the percentage of ED patients admitted to an inpatient unit.

Peak period multiplier

$$Quick\ Look\ (QL)\ Arrivals = \begin{cases} Daily\ Planning\ Volume / 24 * 1.30 \\ Daily\ Planning\ Volume / 24 * 0.70 \end{cases}$$

Off-Peak period multiplier

$$Intake/Discharge\ Arrivals = Quick\ Look\ Arrivals * 2 * \left(f_3 + f_4 + f_5 \right)$$

$$Results\ Waiting\ Arrivals = QL\ Arrivals * \left[\left(f_3 + f_4 + f_5 \right) + \left(\frac{f_3 + f_4}{f_3 + f_4 + f_5} \right) \right]$$

$$IP_{ED}\ Arrivals = QL\ Arrivals * \left[\left(f_1 + f_2 \right) + f_{RE} * \left(f_3 + f_4 + f_5 \right) \right]$$

$$Inpatient\ Transitional\ Care\ Arrivals = IP_{ED}\ Arrivals * \frac{f_A}{f_{RE} * \left(f_3 + f_4 + f_5 \right) + f_1 + f_2}$$

$$Hospital Exit\ Arrivals = QL\ Arrivals * \left(1 - f_{RE} \right) * \left(f_3 + f_4 + f_5 \right) + IP_{ED}\ Arrivals * \left(1 - \frac{f_A}{f_{RE} * \left(f_3 + f_4 + f_5 \right) + f_1 + f_2} \right)$$

The EXCEL® Tool 3

Purpose: Calculate, using daily arrivals and urgency mix, the hourly patient flow to each split flow area

INPUT:	
Percent Admitted to IP Department from ED (f_A):	22%
Daily Planning Volume (Including LWOTs):	233
Acuity:	
Level 1 (f_1)	0.03%
Level 2 (f_2)	8.28%
Level 3 (f_3)	68.73%
Level 4 (f_4)	20.53%
Level 5 (f_5)	2.18%
Sum (must equal 100%):	100%
Default OP_{ED} to IP_{ED} transfer percentage (f_{RE}):	20%

3 Flow Calculation
4 LOU/LOH/LOT
5 Capacity Planning
6 Staffing Profile

Split Flow
Admit Hold
Time Stamps
Target Utilization
Integer Effect

From 2

OUTPUT:

Patient Arrivals per Hour	Quick Look	Intake/Discharge	Results Waiting	IP_{ED}	Inpatient Transitional Care
Peak Period (9am - 9pm):	12.62	23.08	11.27	3.36	2.78
Off-Peak Period (9pm - 9am):	6.80	12.43	6.07	1.81	1.50
Overall Daily Average	9.71	17.75	8.67	2.58	2.14

USED IN 5, 6

Note: Tool 6 is the staffing tool.

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Using Tool 3 Output

- The tool's output shows, during peak and off-peak periods, the arrival rate to Split ED areas.
- The output is directly useful for staffing.
  - For example, if a doctor and team serve 2 patients per hour in the IP_{ED}, then:

$$IP_{ED}\ Doc\ Teams\ Needed = \frac{IP_{ED}\ Arrival\ Rate/Hr}{2\ patients/Hr}$$

$$IP_{ED}\ Doc\ Teams\ Needed = \frac{2.58}{2} = 1.3 \approx 1-2\ Doc\ teams\ needed$$

  - Tools **5** & **6** allocate space and providers, respectively, to the Split ED areas in more detail.

Links to Next Tools

- Hourly patient arrivals
  - Re-enter, *don't copy and paste*, into Tools **5** & **6** the numbers circled below where requested.

OUTPUT:

Patient Arrivals per Hour	Quick Look	Intake/Discharge	Results Waiting	IP $_{ED}$	Inpatient Transitional Care
Peak Period (9am - 9pm):	12.62	23.08	11.27	3.36	2.78
Off-Peak Period (9pm - 9am):	6.80	12.43	6.07	1.81	1.50
Average	9.71	17.75	8.67	2.58	2.14

Re-enter

5 **6**

References

[1] quantifies demand for inpatient resources by patients originating in the ED.
[2] provides more information on the effect of the ED on the whole hospital.
[3] defines flow balance theory in queuing networks.
[4] shows an example of its use to model an entire hospital's patient flow.

[1] Cochran JK, Roche KT, (in revisions). A queuing-based decision support methodology to estimate hospital inpatient bed demand. *Journal of the Operational Research Society*.

[2] Roche KT. A queuing and simulation-based approach to non-linear hospital bed planning. MS Thesis, Ira A. Fulton School of Engineering, Arizona State University 2005.

[3] Gross D, Harris CM. *Fundamentals of Queueing Theory, 3rd edition.* New York: John Wiley and Sons Inc., Section 4.2: Open Jackson Networks 1998;174-183.

[4] Cochran JK, Bharti A. A multi- stage stochastic methodology for whole hospital bed planning under peak loading. *International Journal of Industrial and Systems Engineering* 2006;1(1):8-36.