

**SUPPLEMENTAL DIGITAL CONTENT**

**Table 1. Fundamental Definitions, Derived Equations, Ratios/Rates, Recursive Formulas, and Prevalence Boundary**

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<b>Eq. No.</b>	<b>Category &amp; equations</b>	<b>Dep. Var.</b>	<b>Indep. Var.</b>
	<b>Fundamental Definitions</b>		
1	$x = \text{Sens} = \text{TP}/(\text{TP} + \text{FN})$	x	TP, FN
2	$y = \text{Spec} = \text{TN}/(\text{TN} + \text{FP})$	y	TN, FP
3	$s = \text{PPV} = \text{TP}/(\text{TP} + \text{FP})$	s	TP, FP
4	$t = \text{NPV} = \text{TN}/(\text{TN} + \text{FN})$	t	TN, FN
5	$p = \text{Prev} = (\text{TP} + \text{FN})/N$	p	TP, FN, N
6	$N = \text{TP} + \text{FP} + \text{TN} + \text{FN}$	N	TP, FP, TN, FN
	<b>Derived Equations</b>		
7	PPV = $[\text{Sens} \cdot \text{Prev}]/[\text{Sens} \cdot \text{Prev} + (1 - \text{Spec})(1 - \text{Prev})]$ , or $s = [xp]/[xp + (1 - y)(1 - p)]$ — symbolic version of the equation above	s	x, y, p
8	$p = [s(y - 1)]/[s(x + y - 1) - x]$	p	x, y, s
9	$x = [s(p - 1)(y - 1)]/[p(s - 1)]$	x	y, p, s
10	$y = [sp(x - 1) + s - px]/[s(1 - p)]$	y	x, p, s
11	NPV = $[\text{Spec} \cdot (1 - \text{Prev})]/[\text{Prev} \cdot (1 - \text{Sens}) + \text{Spec} \cdot (1 - \text{Prev})]$ , or $t = [y(1 - p)]/[p(1 - x) + y(1 - p)]$	t	x, y, p
12	$p = [y(1 - t)]/[t(1 - x - y) + y]$	p	x, y, t
13	$x = [pt + y(1 - p)(t - 1)]/[pt]$	x	y, p, t
14	$y = [pt(x - 1)]/[t(1 - p) - 1 + p]$	y	x, p, t
	<b>Ratios</b>		
15	$\text{TP}/\text{FP} = \text{PPV}/(1 - \text{PPV}) = [\text{Sens} \cdot \text{Prev}]/[(1 - \text{Spec})(1 - \text{Prev})]$ , or $[xp]/[(1 - y)(1 - p)]$	TP/FP Ratio	x, y, p
16	$\text{FP}/\text{TP} = (1 - \text{PPV})/\text{PPV} = [(1 - y)(1 - p)]/(xp)$	FP/TP Ratio	x, y, p
17	$\text{FN}/\text{TN} = (1 - \text{NPV})/\text{NPV} = [p(1 - x)]/[y(1 - p)]$	FN/TN Ratio	x, y, p
	<b>Rates</b>		
18	$R_{\text{TP}} = \text{TP}/(\text{TP} + \text{FN}) = x$	$R_{\text{TP}}$	TP, FN
19	$R_{\text{FP}} = \text{FP}/(\text{TN} + \text{FP}) = 1 - \text{Spec} = 1 - y$	$R_{\text{FP}}$	TN, FP
20	$R_{\text{FO}} = \text{FN}/(\text{TN} + \text{FN}) = 1 - \text{NPV} = 1 - t = [p(1 - x)]/[p(1 - x) + y(1 - p)]$	$R_{\text{FO}}$	x, y, p
21	$R_{\text{POS}} = (\text{TP} + \text{FP})/N$	$R_{\text{POS}}$	TP, FP, N

<b>Special Cases</b>			
<i>Recursive formulae for PPV (<math>s_{i+1}</math>) and NPV (<math>t_{i+1}</math>)</i>			
22a	$s_{i+1} = [xp_i]/[xp_i + (1-y)(1-p_i)]$ , where the index, $i = 1, 2, 3 \dots$	$s_{i+1}$	$x, y, p_i$
22b	$t_{i+1} = [y(1-p_i)]/[p_i(1-x) + y(1-p_i)]$	$t_{i+1}$	$x, y, p_i$
<i>Prevalence when sensitivity is 100% (i.e., FN = 0)</i>			
23	Prev = $1 - [(1 - N_+/N)/Spec]$ , or $p = 1 - [(1-POS\%)/y]$	p	POS%, y
<i>PPV when sensitivity is 100%</i>			
24	PPV = $[Prev]/[Prev + (1-Spec) \cdot (1-Prev)]$ , or $s = [p]/[p + (1-y)(1-p)]$	s	y, p
<i>Predictive value geometric mean squared (range 0 to 1)</i>			
25	$PV\ GM^2 = PPV \cdot NPV = s \cdot t = \{[xp]/[xp + (1-y)(1-p)]\} \cdot \{[y(1-p)]/[p(1-x) + y(1-p)]\}$	PV GM <sup>2</sup>	x, y, p
<i>Prevalence boundary for a given R<sub>FO</sub></i>			
26	$PB = \{y(1-t)/[(1-x) - (1-t)(1-x-y)]\} = [yR_{FO}]/[(1-x) - R_{FO}(1-x-y)]$	PB	x, t, R <sub>FO</sub>
<i>Accuracy (not recommended – see note)</i>			
...	$A = (TP + TN)/N = Sens \cdot Prev(dz) + Spec \cdot Prev(no\ dz)$	A	TP, TN, N

### **Abbreviations**

Dep. Var., dependent variable; Indep. Var., independent variable(s)

Eq., equation; i, index from 1 to 3 or more — the number of testing events

N, total number of people tested

N<sub>+</sub>, number of positives (TP + FP) in the tested population

N<sub>-</sub>, number of negatives (TN + FN) in the tested population

PB, prevalence boundary

POS%, (N<sub>+</sub>/N), percent positive of the total number tested (same as R<sub>POS</sub>)

NEG%, (N<sub>-</sub>/N), percent negative of total number tested

Prev, prevalence (p); Prev(dz), same as p; Prev(no dz), prevalence of no disease

PPV, positive predictive value (s); NPV, negative predictive value (t)

PV GM<sup>2</sup>, square of the geometric mean of positive and negative predictive values, (PPV•NPV), expressed as a fraction from 0 to 1

p<sub>i+1</sub>, p<sub>i</sub>, partition prevalences in the recursive formula for PPV and NPV

R<sub>FO</sub>, false omission rate

R<sub>FP</sub>, false positive rate, aka false positive alarm — probability that a false alarm will be raised or that a false result will be reported when the true value is negative

R<sub>POS</sub>, positivity rate

R<sub>TP</sub>, true positive rate, the same as sensitivity

Sens, sensitivity (x); Spec, specificity (y)

TP, true positive; FP, false positive; TN, true negative; FN, false negative

### **Notes**

Sens, Spec, PPV, NPV, and Prev are expressed as percentages from 1 to 100%, or as decimal fractions from 0 to 1 by dividing by 100%.

If denominators of derived equations become indeterminate, then revert to the fundamental definitions, Eq. 1-7.

The formula for accuracy is not recommended, because of duplicity of values with complementary changes in sensitivity and specificity.