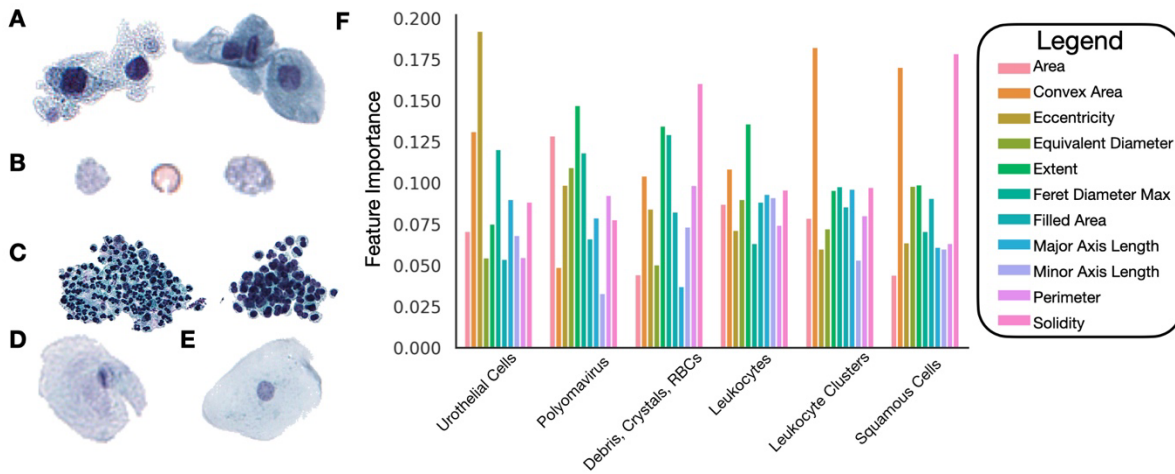
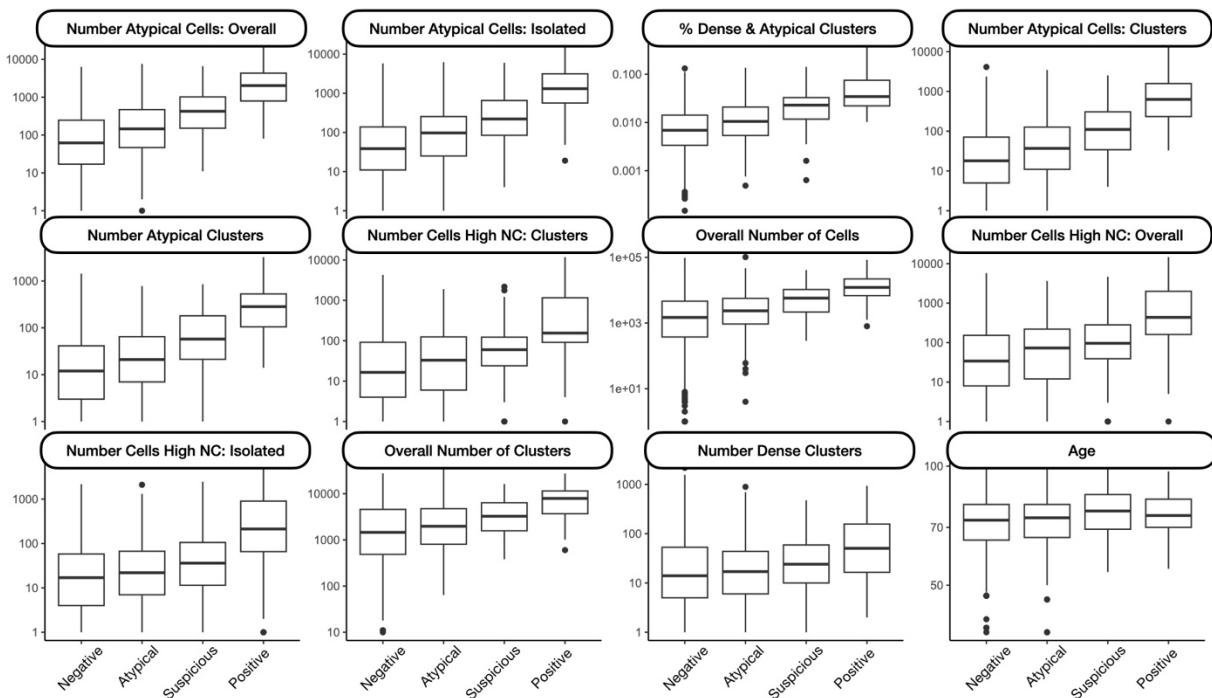


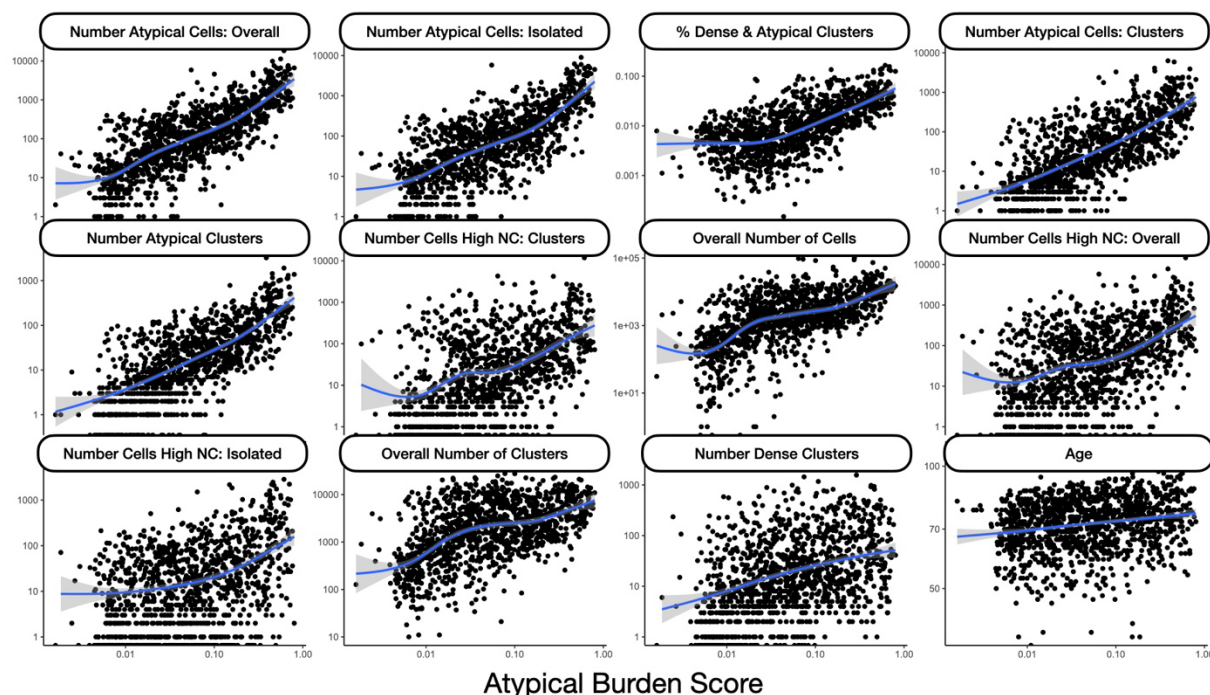
1026 **Appendix**



1027 **Supplementary Figure 1: Important morphometric measures:** A) Urothelial cells with high  
 1028 eccentricity; B) RBCs and crystals with high solidity; C) Leukocyte clusters with high convex  
 1029 area; D) Squamous cell with high convex area; E) Squamous cell with high solidity; F)  
 1030 Important morphometric features as determined using IntegratedGradients to accompany raw  
 1031 image features  
 1032  
 1033



1034 **Supplementary Figure 2: Correlation Each Slide Feature and UC Atypia,** ordered by  
 1035 predictiveness of each feature (spearman correlation / ordinal regression)  
 1036  
 1037



1038  
1039 **Supplementary Figure 3: Correlation Each Slide Feature and ABS**, ordered by  
1040 predictiveness of each feature for UC diagnostic category (spearman correlation / ordinal  
1041 regression)  
1042

1043 **Supplementary Table 1: Spearman correlation between imaging predictors, ABS and original**  
1044 **UC Class**

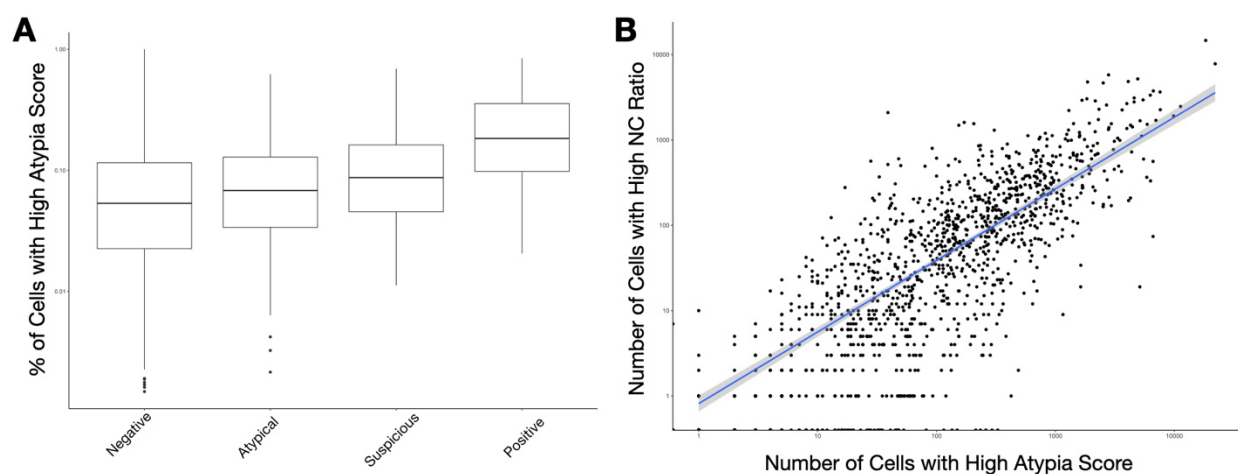
Predictor	ABS				Original Diagnosis				
	r	2.5% CI	97.5% CI	p-value	r	2.5% CI	97.5% CI	p-value	
Overall number atypical cells	0.78	0.76	0.8	<0.001	0.38	0.33	0.42	<0.001	
Overall number cells with high NC	0.53	0.48	0.56	<0.001	0.27	0.22	0.32	<0.001	
Number of cells	0.63	0.6	0.67	<0.001	0.29	0.24	0.34	<0.001	
Number of isolated atypical cells	0.73	0.7	0.75	<0.001	0.37	0.32	0.42	<0.001	
Number of isolated cells with high NC	0.44	0.39	0.48	<0.001	0.24	0.19	0.29	<0.001	
Number of atypical cells in clusters	0.75	0.73	0.78	<0.001	0.36	0.31	0.41	<0.001	
Number of cells in clusters with high NC	0.57	0.53	0.61	<0.001	0.3	0.25	0.35	<0.001	
Number of dense clusters	0.45	0.4	0.49	<0.001	0.14	0.09	0.2	<0.001	
Number of clusters	0.53	0.49	0.57	<0.001	0.21	0.15	0.26	<0.001	
Number of dense/atypical clusters	0.68	0.65	0.71	<0.001	0.37	0.32	0.41	<0.001	
Number of atypical clusters	0.77	0.75	0.79	<0.001	0.36	0.31	0.41	<0.001	
Age	0.21	0.16	0.26	<0.001	0.11	0.06	0.16	<0.001	

1045  
1046 **Supplementary Table 2: Summary statistics (median, interquartile range) for each slide level**  
1047 **feature and UC Class**

	Overall	Negative	Atypical	Suspicious	Positive	p
<b>N</b>	<b>1252</b>	<b>810</b>	<b>296</b>	<b>98</b>	<b>48</b>	
Overall number atypical cells (median [IQR])	111.00 [24.00, 374.50]	59.00 [16.00, 240.50]	145.50 [46.75, 469.00]	424.50 [151.50, 1018.50]	2029.50 [795.50, 4322.00]	<0.001
Overall number cells with high NC (median [IQR])	39.00 [6.00, 170.50]	24.00 [3.00, 120.75]	68.00 [10.00, 197.75]	96.00 [36.00, 279.25]	436.00 [160.50, 1995.75]	<0.001
Number of cells (median [IQR])	2046.50 [590.25, 5856.25]	1480.00 [370.25, 4604.25]	2345.50 [933.50, 5629.50]	5734.00 [2165.50, 10514.00]	12178.00 [6810.00, 22094.75]	<0.001

<b>Number of isolated atypical cells (median [IQR])</b>	57.50 [14.75, 212.25]	36.00 [9.00, 130.25]	94.50 [25.00, 252.75]	220.50 [84.50, 652.00]	1308.50 [565.25, 3127.50]	<0.001
<b>Number of isolated cells with high NC (median [IQR])</b>	11.00 [1.00, 53.00]	7.00 [1.00, 38.00]	17.00 [3.00, 60.00]	28.00 [6.25, 89.75]	194.00 [51.00, 821.00]	<0.001
<b>Number of atypical cells in clusters (median [IQR])</b>	24.00 [5.00, 110.25]	15.00 [3.00, 65.00]	36.00 [10.00, 123.75]	110.50 [34.25, 306.75]	631.50 [236.75, 1578.50]	<0.001
<b>Number of cells in clusters with high NC (median [IQR])</b>	16.00 [2.00, 94.25]	9.00 [1.00, 53.00]	29.00 [5.00, 118.25]	59.00 [23.25, 122.00]	155.00 [92.25, 1159.25]	<0.001
<b>Number of dense clusters (median [IQR])</b>	14.00 [4.00, 50.00]	11.00 [3.00, 45.75]	15.00 [4.75, 40.25]	22.50 [9.25, 59.00]	51.00 [16.50, 157.00]	<0.001
<b>Number of clusters (median [IQR])</b>	1838.50 [674.75, 5228.50]	1455.50 [486.25, 4579.75]	1974.00 [807.50, 4744.25]	3255.00 [1574.25, 6367.25]	7917.50 [3695.50, 11501.00]	<0.001
<b>% clusters dense/atypical (median [IQR])</b>	0.01 [0.00, 0.02]	0.01 [0.00, 0.01]	0.01 [0.01, 0.02]	0.02 [0.01, 0.03]	0.03 [0.02, 0.07]	<0.001
<b>Number of atypical clusters (median [IQR])</b>	14.50 [3.00, 54.25]	9.00 [2.00, 36.00]	20.00 [6.00, 62.25]	57.50 [21.25, 180.75]	283.50 [105.50, 530.50]	<0.001
<b>ABS (median [IQR])</b>	0.05 [0.02, 0.15]	0.03 [0.01, 0.08]	0.07 [0.03, 0.18]	0.24 [0.15, 0.40]	0.42 [0.29, 0.57]	<0.001

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1051 **Supplementary Figure 4: Additional associations with specimen atypia: A)** Boxplots

1052 depicting correlation between the percentage of urothelial cells with high atypia and UC Class;

1053 **B)** Scatterplot demonstrating correlation between slide level atypia via number of cells with high

1054 atypia and high NC ratio

1055

### AUTOPARIS-X WEB APPLICATION DEMO

Instructions:

[Watch Tutorial](#)

1. Select patient to return atypical burden score.
2. Select urothelial cells using cutoff probability.
3. Select malignant cells using lasso tool.
4. Click 'Toggle Annotations', inspect via WSI/table.

Select Patient: Atypical Burden Score:

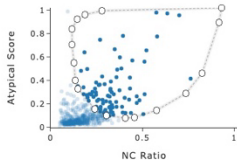
Patient 2, Atypical 0.14

Select Urothelial Threshold (0-1):

[More Info](#)

Select Malignant Cells:

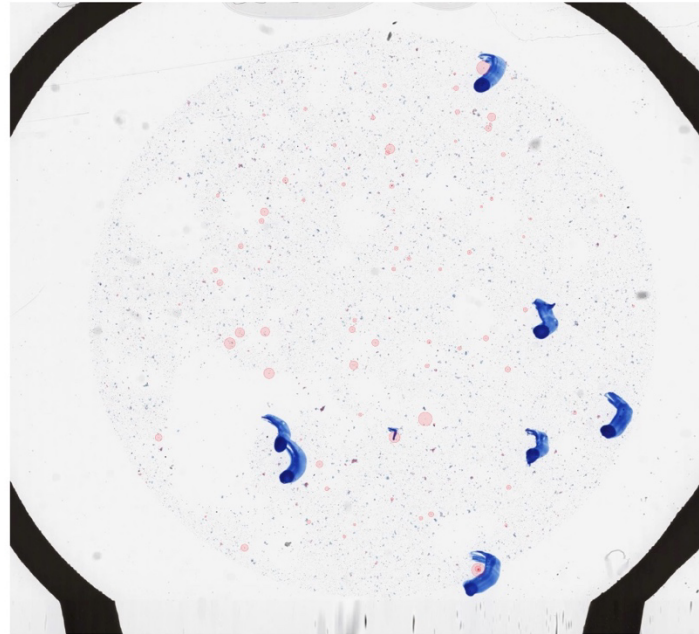
[More Info](#)



Emphasis on malignant cells?:

[More Info](#)

NO SCALING
  NC RATIO
  ATYPYA SCORE
  UROTHELIAL SCORE



### VIEW MALIGNANT CELL TABLE

Sort table on:

[More Info](#)

NO SORT
  NC RATIO
  ATYPYA SCORE

Max number cells in table:

50 75 100 125 150 175 200

IMAGE	NC RATIO	ATYPYA
	0.763	0.417
	0.701	0.956
	0.636	0.972
	0.522	0.657
	0.512	0.284
	0.511	0.561
	0.484	0.232
	0.469	0.266
	0.445	0.572
	0.408	0.125
	0.404	0.253
	0.393	0.128
	0.389	0.177
	0.363	0.494
	0.359	0.429
	0.357	0.318
	0.349	0.667
	0.344	0.284
	0.341	0.109
	0.337	0.128

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**Supplementary Figure 5: Example of identifying malignant cells in atypical slide**

### AUTOPARIS-X WEB APPLICATION DEMO

Instructions:

[Watch Tutorial](#)

1. Select patient to return atypical burden score.
2. Select urothelial cells using cutoff probability.
3. Select malignant cells using lasso tool.
4. Click 'Toggle Annotations', inspect via WSI/table.

Select Patient: Atypical Burden Score:

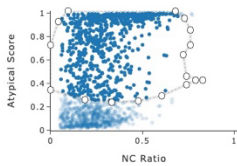
Patient 3, Suspicious 0.6

Select Urothelial Threshold (0-1):

[More Info](#)

Select Malignant Cells:

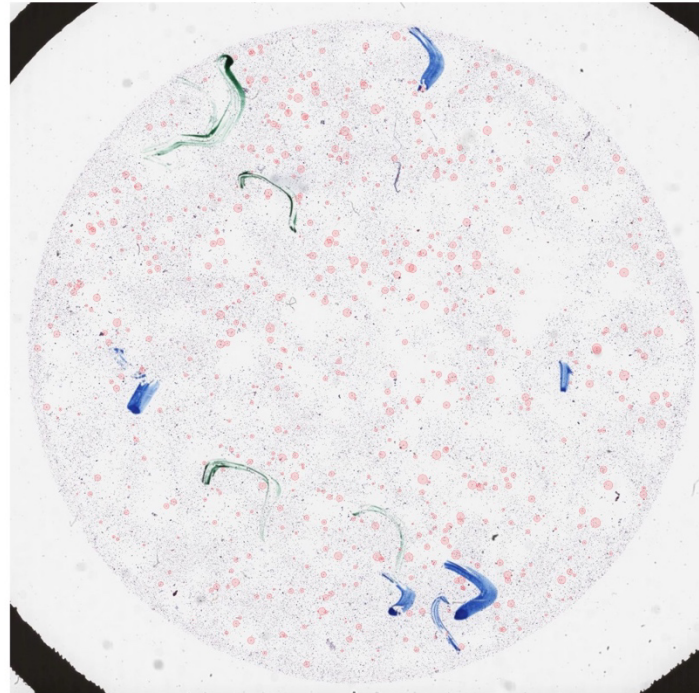
[More Info](#)



Emphasis on malignant cells?:

[More Info](#)

NO SCALING
  NC RATIO
  ATYPYA SCORE
  UROTHELIAL SCORE



### VIEW MALIGNANT CELL TABLE

Sort table on:

[More Info](#)

NO SORT
  NC RATIO
  ATYPYA SCORE

Max number cells in table:

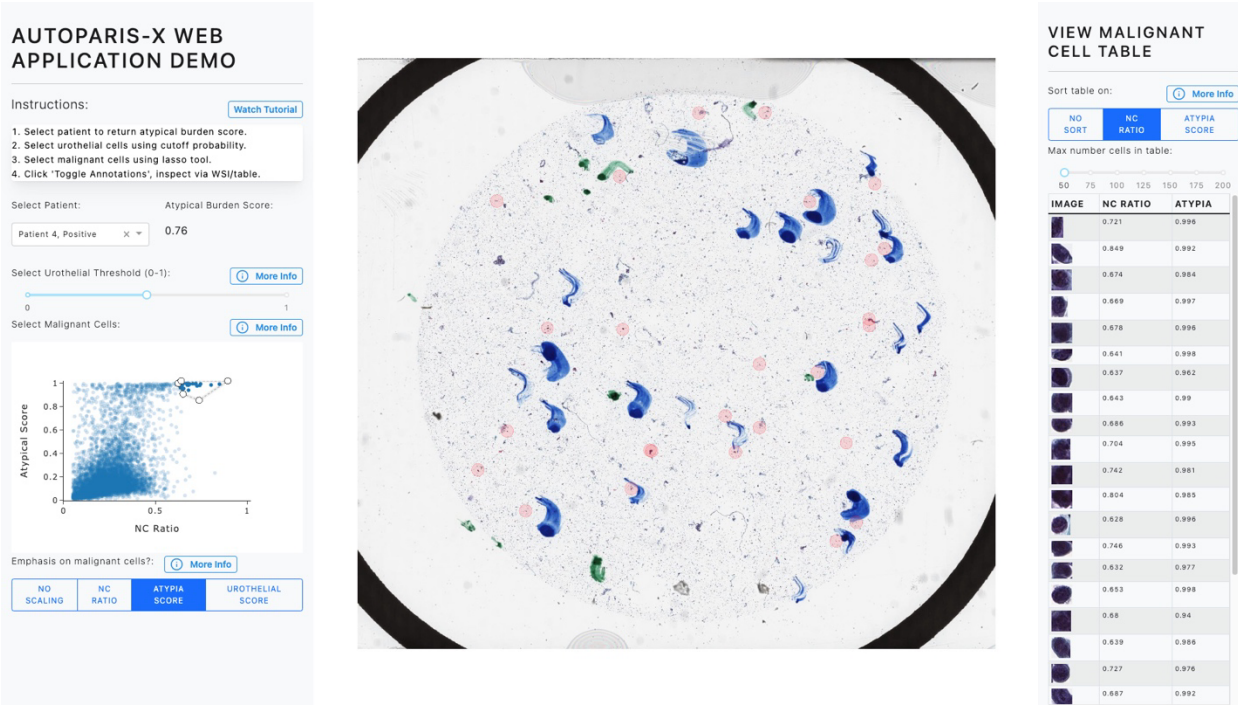
50 75 100 125 150 175 200

IMAGE	NC RATIO	ATYPYA
	0.636	0.879
	0.626	0.34
	0.594	0.995
	0.586	0.953
	0.559	0.979
	0.538	0.82
	0.526	0.413
	0.519	0.972
	0.499	0.992
	0.492	0.992
	0.435	0.361
	0.423	0.868
	0.415	0.974
	0.39	0.972
	0.385	0.434
	0.379	0.823
	0.363	0.98
	0.35	0.275
	0.345	0.787
	0.298	0.927
	0.295	0.85

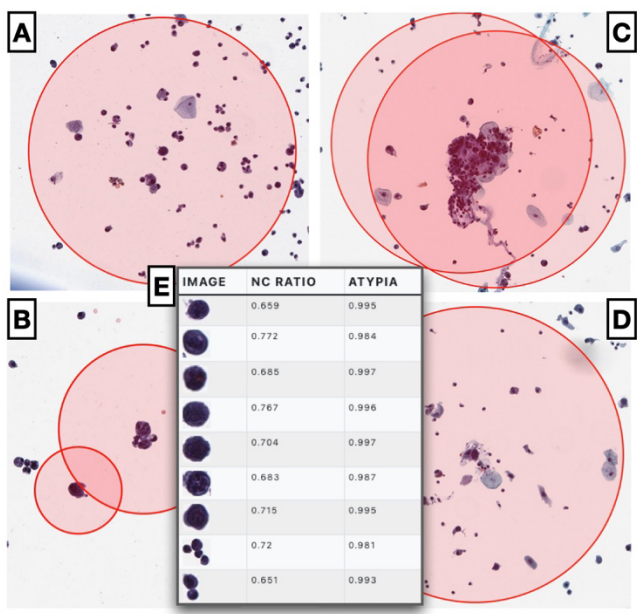
1059  
1060  
1061

**Supplementary Figure 6: Example of identifying malignant cells in suspicious slide**





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1063 **Supplementary Figure 7: Example of identifying malignant cells in positive slide, only**  
1064 **focusing on those with high atypia**  
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1067 **Supplementary Figure 8: Example of atypical cells identified using Autoparis-X web**  
1068 **application within demonstration on example atypical/positive slides: A) Isolated cell, B)**  
1069 **Two cells with differing atypia; cell with larger red dot has higher atypia, C-D) Focusing on**  
1070 **specific cells identified using BorderDet in hard-to-separate clusters; E) Example table of**  
1071 **malignant cells with reported atypia scores from suspicious case**  
1072  
1073