

1
2 **Comparison of respiratory pathogen yields from Nasopharyngeal/Oropharyngeal**
3 **swabs and sputum specimens collected from hospitalized adults in rural Western**
4 **Kenya**

5 Bryan O. Nyawanda^{1*}, Henry N. Njuguna², Clayton O. Onyango³, Caroline Makokha¹,
6 Shirley Lidechi¹, Barry Fields², Jonas M. Winchell², Jim S. Katieno¹, Jeremiah Nyaundi¹,
7 Fredrick Ade¹, Gideon Emukule⁴, Joshua A. Mott², Nancy Otieno¹, Marc-Alain
8 Widdowson³, Sandra S. Chaves^{2,4}

9
10 ¹ Kenya Medical Research Institute - Center for Global Health Research; ² Centers for
11 Disease Control and Prevention, Atlanta, GA, USA; ³ Division of Global Health Protection,
12 Centers for Disease Control and Prevention, Kenya; ⁴ Influenza Program, Centers for
13 Disease Control and Prevention, Kenya

14
15 ***Corresponding author:**

16 Email: oteebryan@gmail.com or bnyawanda@kemricdc.org

17 Phone: +254 -725-765138

18 Kenya Medical Research Institute - P.O BOX 1578 – 40100 Kisumu – Kenya

19 <https://orcid.org/0000-0003-0069-1473>

21
22**Supplementary Table S1: Comparison of respiratory pathogen yields in nasopharyngeal/oropharyngeal vs sputum specimens among HIV+ and HIV- patients, March 2014 – July 2015**

Pathogens	HIV Positive n=115		p-value	HIV Negative n=179		p-value
	NPOP n (%)	Sputum n (%)		NPOP n (%)	Sputum n (%)	
Any pathogen	84 (73)	70 (61)	0.03	116 (65)	100 (56)	0.07
Any Bacterial pathogen	64 (56)	55 (48)	0.14	77 (43)	86 (48)	0.30
Any Viral pathogen	45 (39)	19 (17)	<0.01	70 (39)	26 (15)	<0.01
Bacterial pathogens						
<i>Streptococcus pneumoniae</i>	36 (31)	27 (23)	0.05	40 (22)	34 (19)	0.29
<i>Streptococcus pyogenes</i>	0	1 (1)		1 (1)	1 (1)	
<i>Haemophilus influenzae- All</i>	25 (22)	16 (14)	0.04	30 (17)	31 (17)	1.00
<i>Haemophilus influenzae B 1</i>	3 (3)	1 (1)	0.50	1 (1)	2 (1)	1.00
<i>Haemophilus influenzae B 2</i>	1 (1)	2 (2)	1.00	2 (1)	2 (1)	
<i>Staphylococcus aureus</i>	21 (18)	12 (10)	0.06	20 (11)	16 (9)	0.56
<i>Pseudomonas aeruginosa</i>	11 (10)	6 (5)	0.30	7 (4)	13 (7)	0.21
<i>Legionella spp.</i>	0	0		0	0	
<i>Klebsiella pneumoniae</i>	5 (4)	11 (10)	0.15	8 (4)	16 (9)	0.08
<i>Bordetella pertussis</i>	0	0		0	0	
<i>Mycoplasma pneumoniae</i>	1 (1)	0		0	0	
<i>Chlamydia pneumoniae</i>	0	0		1 (1)	0	
<i>Moraxella catarrhalis</i>	16 (14)	10 (9)	0.07	19 (11)	12 (7)	0.12
Viral pathogens						
Influenza A	1 (1)	2 (2)	0.99	11 (6)	6 (3)	0.06
Influenza B	2 (2)	2 (2)	1.00	1 (1)	2 (1)	0.99
Para-influenza 1	0	0		1 (1)	0	
Para-influenza 2	4 (3)	1 (1)	0.25	1 (1)	0	
Para-influenza 3	1 (1)	0		4 (2)	2 (1)	0.50
Para-influenza 4	0	0		2 (1)	0	
Resp. syncytial virus (RSV)	3 (3)	0		8 (4)	2 (1)	0.07
Rhinovirus	26 (23)	11 (10)	<0.01	37 (21)	12 (7)	<0.01
Enterovirus	4 (3)	0		6 (3)	0	
Human metapneumovirus	0	0		5 (3)	2 (1)	0.25
Adenovirus	1 (1)	2 (2)	1.00	0	2 (1)	
HCoV 1 (229E)	0	0		0	0	
HCoV 2 (NL63)	9 (8)	1 (1)	0.01	0	0	
HCoV 3 (OC43)	3 (3)	1 (1)	0.50	3 (2)	0	
HCoV 4 (HKU1)	0	0		3 (2)	0	
Mycobacteria						
<i>Mycobacterium tuberculosis</i>	1 (1)	12 (10)	<0.01	2 (1)	4 (2)	0.63
Fungi						
<i>Pneumocystis jirovecii</i>	0	0		0	0	

23
24

25
26
27**Supplementary Table S2: Comparison of respiratory pathogen yields in nasopharyngeal/oropharyngeal vs sputum specimens among patients with and without malaria, March 2014 – July 2015**

Pathogens	Malaria Positive n=57		p-value	Malaria Negative n=237		p-value
	NPOP n (%)	Sputum n (%)		NPOP n (%)	Sputum n (%)	
Any pathogen	38 (67)	27 (47)	0.03	162 (68)	143 (60)	0.04
Any Bacterial pathogen	23 (40)	22 (39)	1.00	118 (50)	119 (50)	1.00
Any Viral pathogen	23 (40)	10 (18)	<0.01	92 (39)	35 (15)	<0.01
Bacterial pathogens						
<i>Streptococcus pneumoniae</i>	12 (21)	6 (11)	0.03	64 (27)	55 (23)	0.16
<i>Streptococcus pyogenes</i>	0	1 (2)		1 (0)	1 (0)	
<i>Haemophilus influenzae- All</i>	7 (12)	6 (11)	1.00	48 (20)	41 (17)	0.30
<i>Haemophilus influenzae B 1</i>	0	0		4 (2)	3 (1)	1.00
<i>Haemophilus influenzae B 2</i>	0	0		3 (1)	4 (2)	1.00
<i>Staphylococcus aureus</i>	7 (12)	3 (5)	0.29	34 (14)	25 (11)	0.19
<i>Pseudomonas aeruginosa</i>	1 (2)	7 (12)	0.03	17 (7)	12 (5)	0.42
<i>Legionella spp.</i>	0	0		0	0	
<i>Klebsiella pneumoniae</i>	2 (4)	4 (7)	0.69	11 (5)	23 (10)	0.02
<i>Bordetella pertussis</i>	0	0		0	0	
<i>Mycoplasma pneumoniae</i>	0	0		1 (0)	0	
<i>Chlamydia pneumoniae</i>	0	0		1 (0)	0	
<i>Moraxella catarrhalis</i>	4 (7)	1 (2)	0.25	31 (13)	21 (9)	0.04
Viral pathogens						
Influenza A	3 (5)	2 (4)	1.00	9 (4)	5 (2)	0.22
Influenza B	0	0		3 (1)	4 (2)	1.00
Para-influenza 1	1 (2)	0		0	0	
Para-influenza 2	0	0		5 (2)	1 (0)	0.13
Para-influenza 3	0	0		5 (2)	2 (1)	0.25
Para-influenza 4	0	0		2 (1)	0	
Resp. syncytial virus (RSV)	2 (4)	1 (2)	1.00	9 (4)	1 (0)	0.02
Rhinovirus	14 (25)	5 (9)	<0.01	49 (21)	18 (8)	<0.01
Enterovirus	3 (5)	0		7 (3)	0	
Human metapneumovirus	0	0		5 (2)	2 (1)	0.25
Adenovirus	0	1 (2)		1 (0)	3 (1)	0.63
HCoV 1 (229E)	0	0		0	0	
HCoV 2 (NL63)	1 (2)	0		8 (3)	1 (0)	0.02
HCoV 3 (OC43)	2 (4)	1 (2)	1.00	4 (2)	0	
HCoV 4 (HKU1)	0	0		3 (1)	0	
Mycobacteria						
<i>Mycobacterium tuberculosis</i>	0	1 (2)		3 (1)	15 (6)	<0.01
Fungi						
<i>Pneumocystis jirovecii</i>	0	0		0	0	

28

29
30**Supplementary Table S3. Comparison of respiratory pathogen yields in nasopharyngeal/oropharyngeal vs sputum specimens by disease severity*, March 2014 – July 2015**

Pathogens	Severe n=88		p-value	Non-severe n=206		p-value
	NPOP n (%)	Sputum n (%)		NPOP n (%)	Sputum n (%)	
Any pathogen	55 (63)	60 (68)	0.44	145 (70)	110 (53)	<0.01
Any Bacterial pathogen	43 (49)	48 (55)	0.47	98 (48)	93 (45)	0.60
Any Viral pathogen	24 (27)	13 (15)	0.01	91 (44)	32 (16)	<0.01
Bacterial pathogens						
<i>Streptococcus pneumoniae</i>	24 (27)	20 (23)	0.34	52 (25)	41 (20)	0.06
<i>Streptococcus pyogenes</i>	0	1 (1)		1 (1)	1 (1)	1.00
<i>Haemophilus influenzae- All</i>	17 (19)	13 (15)	0.39	38 (18)	34 (17)	0.57
<i>Haemophilus influenzae B 1</i>	2 (2)	2 (2)		2 (1)	1 (0)	1.00
<i>Haemophilus influenzae B 2</i>	2 (2)	3 (3)	1.00	1 (0)	1 (0)	
<i>Staphylococcus aureus</i>	12 (14)	10 (11)	0.80	29 (14)	18 (9)	0.06
<i>Pseudomonas aeruginosa</i>	5 (6)	6 (7)	1.00	13 (6)	13 (6)	1.00
<i>Legionella spp.</i>	0	0		0	0	
<i>Klebsiella pneumoniae</i>	8 (9)	13 (15)	0.30	5 (2)	14 (7)	0.02
<i>Bordetella pertussis</i>	0	0		0	0	
<i>Mycoplasma pneumoniae</i>	0	0		1 (1)	0	
<i>Chlamydia pneumoniae</i>	1 (1)	0		0	0	
<i>Moraxella catarrhalis</i>	12 (14)	10 (11)	0.69	23 (11)	12 (6)	0.01
Viral pathogens						
Influenza A	3 (3)	1 (1)	0.50	9 (4)	6 (3)	0.38
Influenza B	1 (1)	1 (1)		2 (1)	3 (1)	1.00
Para-influenza 1	0	0		1 (1)	0	
Para-influenza 2	3 (3)	0		2 (1)	1 (1)	1.00
Para-influenza 3	1 (1)	1 (1)		4 (2)	1 (1)	0.25
Para-influenza 4	0	0		2 (1)	0	
Resp. syncytial virus (RSV)	3 (3)	1 (1)	0.50	8 (4)	1 (1)	0.04
Rhinovirus	10 (11)	7 (8)	0.45	53 (26)	16 (8)	<0.01
Enterovirus	2 (2)	0		8 (4)	0	
Human metapneumovirus	0	0		5 (2)	2 (1)	0.25
Adenovirus	1 (1)	2 (2)	1.00	0	2 (1)	
HCoV 1 (229E)	0	0		0	0	
HCoV 2 (NL63)	3 (3)	1 (1)	0.50	6 (3)	0	
HCoV 3 (OC43)	0	0		6 (3)	1 (1)	0.06
HCoV 4 (HKU1)	1 (1)	0		2 (1)	0	
Mycobacteria						
<i>Mycobacterium tuberculosis</i>	1(1)	10 (11)	0.01	2 (1)	6 (3)	0.13
Fungi						
<i>Pneumocystis jirovecii</i>	0	0		0	0	

31
32

*Disease severity assessed by prolonged hospitalization (severe = >7 days in hospital; non-severe = ≤7 days in hospital).

33
34**Supplementary Table S4. Comparison of respiratory pathogen yields in nasopharyngeal/oropharyngeal vs sputum specimens by duration of illness*, March 2014 – July 2015**

Pathogens	Acute illness n=116		p-value	Non-acute illness n=178		p-value
	NPOP n (%)	Sputum n (%)		NPOP n (%)	Sputum n (%)	
Any pathogen	80 (69)	65 (56)	0.02	120 (67)	105 (59)	0.08
Any Bacterial pathogen	53 (46)	53 (46)	1.00	88 (49)	88 (49)	1.00
Any Viral pathogen	48 (41)	21 (18)	<0.01	67 (38)	24 (13)	<0.01
Bacterial pathogens						
<i>Streptococcus pneumoniae</i>	28 (24)	25 (22)	0.61	48 (27)	36 (20)	0.02
<i>Streptococcus pyogenes</i>	1 (1)	1 (1)		0	1 (1)	
<i>Haemophilus influenzae- All</i>	20 (17)	20 (17)	1.00	35 (20)	27 (15)	0.13
<i>Haemophilus influenzae B 1</i>	0	1 (1)		4 (2)	2 (1)	0.50
<i>Haemophilus influenzae B 2</i>	0	1(1)		3 (2)	3 (2)	
<i>Staphylococcus aureus</i>	17 (15)	9 (8)	0.12	24 (13)	19 (11)	0.42
<i>Pseudomonas aeruginosa</i>	6 (5)	8 (7)	0.75	12 (7)	11 (6)	1.00
<i>Legionella spp.</i>	0	0		0	0	
<i>Klebsiella pneumoniae</i>	7 (6)	8 (7)	1.00	6 (3)	19 (11)	0.01
<i>Bordetella pertussis</i>	0	0		0	0	
<i>Mycoplasma pneumoniae</i>	1 (1)	0		0	0	
<i>Chlamydia pneumoniae</i>	1 (1)	0		0	0	
<i>Moraxella catarrhalis</i>	13 (11)	9 (8)	0.29	22 (12)	13 (7)	0.04
Viral pathogens						
Influenza A	6 (5)	4 (3)	0.50	6 (3)	3 (2)	0.38
Influenza B	0	0		3 (2)	4 (2)	1.00
Para-influenza 1	1 (1)	0		0	0	
Para-influenza 2	1 (1)	1 (1)		4 (2)	0	
Para-influenza 3	2 (2)	1 (1)	1.00	3 (2)	1 (1)	0.50
Para-influenza 4	1 (1)	0		1 (1)	0	
Resp. syncytial virus (RSV)	2 (2)	0		9 (5)	2 (1)	0.04
Rhinovirus	32 (28)	12 (10)	<0.01	31 (17)	11 (6)	<0.01
Enterovirus	4 (3)	0		6 (3)	0	
Human metapneumovirus	3 (3)	2 (2)	1.00	2 (1)	0	
Adenovirus	0	2 (2)		1 (1)	2 (1)	1.00
HCoV 1 (229E)	0	0		0	0	
HCoV 2 (NL63)	1 (1)	0		8 (4)	1 (1)	0.02
HCoV 3 (OC43)	1 (1)	0		5 (3)	1 (1)	0.13
HCoV 4 (HKU1)	1 (1)	0		2 (1)	0	
Mycobacteria						
<i>Mycobacterium tuberculosis</i>	2 (2)	4 (3)	0.63	1 (1)	12 (7)	<0.01
Fungi						
<i>Pneumocystis jirovecii</i>	0	0		0	0	

35
36

*Duration of illness measured by time from illness onset to hospital admission (acute illness= <5 days; non-acute illness= ≥5 days)

37 **Supplementary Table S5. Co-detection of respiratory pathogens from nasopharyngeal/ oropharyngeal swabs**

Pathogens	Code	Bacterial pathogens														Viral pathogens												mytb	pnji		
		stpn	gast	hiat	hitb1	hitb2	stau	psae	lspp	klpn	bop1	mypn	chpn	moca	FluA	FluB	piv1	piv2	piv3	piv4	resv	rhiv	entv	hmpv	aden	hev1	hev2			hev3	hev4
Bacterial pathogens																															
<i>Streptococcus pneumoniae</i>	stpn	76																													
<i>Streptococcus pyogenes</i>	gast	1	1																												
<i>Haemophilus influenzae- All</i>	hiat	29	1	55																											
<i>Haemophilus influenzae B 1</i>	hitb1	2	0	3	4																										
<i>Haemophilus influenzae B 2</i>	hitb2	0	0	2	1	3																									
<i>Staphylococcus aureus</i>	stau	12	0	10	0	0	41																								
<i>Pseudomonas aeruginosa</i>	psae	8	0	4	0	0	4	18																							
<i>Legionella spp.</i>	lspp	0	0	0	0	0	0	0	0																						
<i>Klebsiella pneumoniae</i>	klpn	6	0	4	0	0	3	1	0	13																					
<i>Bordetella pertussis</i>	bop1	0	0	0	0	0	0	0	0	0	0																				
<i>Mycoplasma pneumoniae</i>	mypn	0	0	0	0	0	1	1	0	0	0	1																			
<i>Chlamydia pneumoniae</i>	chpn	0	0	0	0	0	1	0	0	0	0	0	1																		
<i>Moraxella catarrhalis</i>	moca	19	0	18	2	0	5	3	0	3	0	0	1	35																	
Viral pathogens																															
Influenza A	FluA	4	0	3	0	0	1	0	0	0	0	0	0	2	12																
Influenza B	FluB	0	0	0	0	0	0	0	0	0	0	0	0	0	3																
Para-influenza 1	piv1	0	0	1	0	0	0	0	0	1	0	0	0	0	0	1															
Para-influenza 2	piv2	2	0	1	0	0	3	0	0	0	0	0	0	1	0	0	5														
Para-influenza 3	piv3	2	0	3	0	1	0	1	0	0	0	0	0	0	0	0	5														
Para-influenza 4	piv4	1	0	2	0	0	0	0	0	0	0	0	0	1	0	0	0	2													
Resp. syncytial virus (RSV)	resv	4	0	2	0	0	2	1	0	0	0	0	0	3	2	0	0	0	0	11											
Rhinovirus	rhiv	19	0	19	1	1	11	2	0	2	0	0	7	0	0	0	2	1	0	63											
Enterovirus	entv	2	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	1	0	0	6	10									
Human metapneumovirus	hmpv	0	0	2	0	0	1	0	0	1	0	0	0	2	0	0	0	0	0	0	2	0	5								
Adenovirus	aden	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1							

HCoV 1 (229E)	hcv1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0							
HCoV 2 (NL63)	hcv2	3	0	3	0	0	0	1	0	0	0	0	0	3	0	0	0	0	0	0	0	0	4	1	0	0	0	9					
HCoV 3 (OC43)	hcv3	2	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	6				
HCoV 4 (HKU1)	hcv4	1	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	3				
Mycobacteria																																	
<i>Mycobacterium tuberculosis</i>	mytb	0	0	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	3		
Fungi																																	
<i>Pneumocystis jirovecii</i>	pnji	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

38

39

40

HCoV 1 (229E)	hcv1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0										
HCoV 2 (NL63)	hcv2	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1								
HCoV 3 (OC43)	hcv3	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1								
HCoV 4 (HKU1)	hcv4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Mycobacteria																																				
<i>Mycobacterium tuberculosis</i>	mytb	0	0	0	0	0	2	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	16						
Fungi																																				
<i>Pneumocystis jirovecii</i>	pnji	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

42

43