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Table 1. Database of all cVDPVs 2000-2019 (n=96). Note that for the final analysis, outliers and serotype 2 outbreaks pre-2010 were removed.

Country	Region	Date first isolate collected	Date last isolate collected	Type	AFP Cases	Isolates	First NC[1]	Smallest NC	Largest NC	NPAFP[2]	Estimated seed date	Days to detect	Emergence lineage[3]	Reference(s)
DOMINICAN REPUBLIC	AMR	24/07/2000	30/01/2001	1	13	21	17	17	23	-	16/01/1999	554	-	(1,2)
PHILIPPINES	WPR	28/03/2001	23/09/2001	1	3	4	28	28	32	-	27/08/1998	943	-	(2,3)
MADAGASCAR	AFR	21/03/2002	12/04/2002	2	4	6	23	23	27	0.30	13/02/2000	766	-	(4,5)
CHINA	WPR	16/06/2004	06/08/2004	1	3	7	9	9	11	1.85	18/09/2003	271	-	(6,7)
DRC	AFR	01/01/2005	31/08/2005	2	7	7	9	6	9	5.10	04/04/2004	271	-	(8–10)
MADAGASCAR	AFR	22/04/2005	24/05/2005	3	1	8	13	9	16	1.30	05/03/2004	413	-	(2,9,11)
MADAGASCAR	AFR	16/06/2005	07/09/2005	2	4	9	21	10	24	1.30	21/07/2003	696	-	
INDONESIA	SEAR	09/06/2005	26/10/2005	1	46	46	10	10	20	2.41	06/08/2004	307	-	(12,13)
NIGERIA	AFR	05/07/2005	08/06/2006	2	3	3	10	-	-	6.50	01/09/2004	307	-	(7,9,14)
CAMBODIA	WPR	26/11/2005	15/01/2006	3	2	2	17	17	22	2.09	20/05/2004	554	-	(9,15)
CHINA	WPR	18/03/2006	16/05/2006	1	1	7	13	13	20	1.99	29/01/2005	413	-	(16,17)
MYANMAR	SEAR	19/04/2006	21/07/2007	1	4	11	14	14	20	2.11	26/01/2005	448	-	(15,17)
NIGERIA	AFR	19/05/2006	04/03/2015	2	384	527	6	6	-	6.60	04/13/2005	165	-	(14,17–22)
NIGERIA	AFR	05/07/2006	07/02/2008	2	6	6	9	-	-	6.60	06/10/2005	271	-	
NIGERIA	AFR	17/07/2006	17/10/2006	2	2	2	15	-	-	6.60	20/03/2005	483	-	
NIGERIA	AFR	26/02/2007	05/03/2009	2	6	6	13	-	-	5.30	09/01/2006	413	-	
SOMALIA	EMR	01/07/2008	09/01/2013	2	19	19	6	6	36	3.96	17/01/2008	165	-	(10,18–20,22–24)
DRC	AFR	19/01/2008	02/03/2009	2	14	14	8	8	16	6.09	28/05/2007	236	-	(8,10,18,19)
DRC	AFR	29/07/2008	25/02/2009	2	5	5	12	10	16	6.09	17/07/2007	377	-	
ETHIOPIA	AFR	04/10/2008	16/02/2009	2	4	4	10	10	11	3.00	02/12/2007	307	-	(20,25)
NIGERIA	AFR	01/12/2008	25/05/2010	2	7	7	12	-	-	6.59	19/11/2007	377	-	(14,19–21)
NIGERIA	AFR	20/04/2009	02/06/2009	2	2	2	17	-	-	7.00	13/10/2007	554	-	(14,19–21)
ETHIOPIA	AFR	27/04/2009	04/11/2010	3	7	7	12	12	28	2.59	14/04/2008	377	-	(20,25)

Country	Region	Date first isolate collected	Date last isolate collected	Type	AFP Cases	Isolates	First NC[1]	Smallest NC	Largest NC	NPAFP[2]	Estimated seed date	Days to detect	Emergence lineage[3]	
AFGHANISTAN	EMR	29/07/2009	13/02/2013	2	15	23	8	8	50	10.99	05/12/2008	236	-	(20,22,26)
INDIA	SEAR	19/10/2009	31/01/2010	2	16	16	9	9	14	9.53	20/01/2009	271	-	(20,25)
DRC	AFR	09/08/2009	24/09/2010	2	5	5	12	12	32	4.68	27/07/2008	377	-	(8,20)
DRC	AFR	20/04/2010	13/10/2010	2	9	9	19	11	19	5.72	03/08/2008	625	-	
MOZAMBIQUE	AFR	10/02/2011	02/06/2011	1	2	2	27	27	39	2.68	16/08/2008	908	-	(20,27)
YEMEN	EMR	09/04/2011	05/10/2011	2	9	11	6	6	14	3.35	25/10/2010	165	-	
DRC	AFR	17/10/2011	04/04/2012	2	30	30	8	6	32	5.53	23/02/2011	236	-	(22,27,28)
CHINA	WPR	18/10/2011	08/02/2012	2	3	4	6	6	11	1.94	05/05/2011	165	-	(23,24,29)
YEMEN	EMR	27/04/2012	25/07/2013	3	4	6	18	18	27	4.26	15/09/2010	589	-	(23,24,30)
CHAD	AFR	15/08/2012	12/05/2013	2	16	16	6	6	16	6.95	02/03/2012	165	-	(23,24,30,31)
PAKISTAN	EMR	30/08/2012	15/06/2014	2	81	87	6	6	33	8.28	17/03/2012	165	-	(30,32–34)
NIGERIA	AFR	16/08/2014	28/05/2015	2	1	6	7	7	13	12.9	27/01/2014	201	-	(33,35–37)
GUINEA	AFR	06/09/2014	25/12/2015	2	6	13	12	12	27	2.60	24/08/2013	377	-	(36–38)
SOUTH SUDAN	AFR	09/09/2014	12/09/2014	2	2	2	9	9	9	4.20	11/12/2013	271	-	(33,36)
MADAGASCAR	AFR	29/09/2014	02/09/2015	1	11	24	20	20	30	4.20	07/12/2012	660	-	(33,35–37)
PAKISTAN	EMR	13/12/2014	28/03/2015	2	1	30	7	7	19	6.50	26/05/2014	201	-	
PAKISTAN	EMR	01/02/2015	09/02/2015	2	2	2	6	6	6	9.20	19/08/2014	165	-	(35,37)
MYANMAR	SEAR	16/04/2015	05/10/2015	2	2	2	13	13	15	2.54	27/02/2014	413	-	
UKRAINE	EUR	30/06/2015	07/07/2015	1	2	2	20	20	26	2.67	07/09/2013	660	-	(35,39,40)
LAO PEOPLE'S DEMOCRATIC REPUBLIC	WPR	07/09/2015	02/06/2016	1	14	43	21	21	35	2.61	11/10/2013	696	-	(35,39)
PAKISTAN	EMR	20/10/2016	28/12/2016	2	1	5	9	9	18	12.5	22/01/2016	271	PAK-QTA-1	(41,42)
NIGERIA	AFR	28/10/2016	24/11/2016	2	1	2	12	12	16	21.2	16/10/2015	377	NIE-SOS-2	
DRC	AFR	20/02/2017	08/06/2018	2	27	37	15	14	29	5.80	25/10/2015	483	-	(43–46)
DRC	AFR	26/03/2017	18/04/2017	2	2	3	7	7	9	5.80	06/09/2016	201	-	(43–46)
SYRIA	EMR	03/03/2017	21/09/2017	2	74	113	22	22	33	3.60	03/03/2015	731	SYR-1	(43,44)

Country	Region	Date first isolate collected	Date last isolate collected	Type	AFP Cases	Isolates	First NC[1]	Smallest NC	Largest NC	NPAFP[2]	Estimated seed date	Days to detect	Emergence lineage[3]	
SOMALIA	EMR	22/10/2017	04/02/2020	2	10	61	38	33	58	6.30	04/04/2014	1297	-	(43,44,47–51)
NIGERIA	AFR	10/01/2018	09/10/2019	2	46	191	13	13	33	10.90	23/11/2016	413	NIE-JIS-1	(44,47,48)
NIGERIA	AFR	30/01/2018	24/03/2019	2	1	18	6	6	14	10.90	17/08/2017	165	NIE-SOS-3	
SOMALIA	EMR	08/03/2018	07/09/2018	3	7	24	14	14	23	4.80	15/12/2016	448	SOM-BAN-2	(43,44,47,49)
CHINA	WPR	18/04/2018	18/08/2019	2	1	5	13	13	33	2.08	01/03/2017	413	CHN-XXX	(44,47)
PAPUA NEW GUINEA	WPR	25/04/2018	04/11/2018	1	26	41	14	13	24	7.90	01/02/2018	448	PNG-MOR-1	(43,44,47)
DRC	AFR	26/04/2018	29/10/2018	2	11	21	19	18	26	6.60	09/08/2016	625	RDC-MON-1	
DRC	AFR	06/10/2018	07/10/2018	2	2	2	7	7	8	6.60	19/03/2018	201	RDC-HKA-1	
MOZAMBIQUE	AFR	21/10/2018	17/12/2018	2	1	3	6	6	10	3.40	08/05/2018	165	MOZ-ZAM-2	
INDONESIA	SEAR	27/11/2018	13/02/2019	1	1	3	58	58	60	2.40	02/06/2013	2004	IDN-PAP-1	
DRC	AFR	08/02/2019	17/03/2019	2	1	3	6	6	7	9.31	26/08/2018	165	RDC-KAS-1	(47,48,50–52)
DRC	AFR	10/02/2019	13/12/2019	2	20	26	8	8	15	9.31	19/06/2018	236	RDC-HLO-2	
NIGERIA	AFR	18/03/2019	10/06/2019	2	0	3	16	16	20	10.27	15/10/2019	519	NIE-SOS-4	
DRC	AFR	03/04/2019	22/06/2019	2	4	5	6	6	11	9.31	19/10/2018	165	RDC-KAS-2	
ANGOLA	AFR	05/04/2019	14/05/2019	2	1	2	7	7	10	4.99	16/09/2018	201	ANG-LNO-2	
DRC	AFR	21/04/2019	30/11/2019	2	32	35	6	6	16	9.31	06/11/2018	165	RDC-SAN-1	
ANGOLA	AFR	27/04/2019	09/02/2020	2	78	105	6	6	16	4.99	12/11/2018	165	ANG-HUI-1	
CENTRAL AFRICAN REPUBLIC	AFR	02/05/2019	20/11/2019	2	5	22	10	7	19	9.19	29//06/2018	307	CAR-BAM-1	
CENTRAL AFRICAN REPUBLIC	AFR	06/05/2019	29/06/2019	2	2	3	9	9	11	9.19	07/08/2018	271	CAR-BIM-1	
CENTRAL AFRICAN REPUBLIC	AFR	06/05/2019	05/02/2020	2	9	22	6	6	17	9.19	21/11/2018	165	CAR-BNG-1	
NIGERIA	AFR	20/05/2019	20/06/2019	2	1	2	14	14	15	10.27	26/02/2018	448	NIE-SOS-5	
CENTRAL AFRICAN REPUBLIC	AFR	27/05/2019	27/05/2019	2	0	3	6	6	6	9.19	12/12/2018	165	CAR-BAM-2	
CENTRAL AFRICAN REPUBLIC	AFR	28/05/2019	11/09/2019	2	0	16	9	9	20	9.19	29/08/2018	271	CAR-BIM-2	
ANGOLA	AFR	01/06/2019	25/12/2019	2	15	16	10	10	20	4.99	29/07/2018	307	ANG-LNO-1	
DRC	AFR	03/06/2019	08/03/2020	2	21	27	8	8	20	9.31	10/10/2018	236	RDC-KAS-3	(47,48,50–52)

Country	Region	Date first isolate collected	Date last isolate collected	Type	AFP Cases	Isolates	First NC[1]	Smallest NC	Largest NC	NPAFP[2]	Estimated seed date	Days to detect	Emergence lineage[3]	
PAKISTAN	EMR	10/06/2019	10/02/2020	2	41	124	6	6	18	24.49	26/12/2018	165	PAK-GB-1	(47,48,50–52)
ANGOLA	AFR	15/06/2019	27/12/2019	2	34	51	6	6	14	4.99	26/02/2019	201	ANG-LUA-1	
MYANMAR	SEAR	23/06/2019	21/08/2019	1	5	12	25	25	33	3.43	08/03/2017	837	-	(47,48,51,53)
PHILIPPINES	WPR	26/06/2019	24/01/2020	2	14	50	61	61	70	4.30	14/09/2013	2110	PHL-NCR-1	(47,48,51,52)
DRC	AFR	27/06/2019	14/08/2019	2	1	2	7	7	7	9.31	08/12/2018	201	RDC-TPA-1	
PAKISTAN	EMR	01/07/2019	28/08/2019	2	0	3	6	6	12	24.49	07/11/2018	236	PAK-GB-2	
PAKISTAN	EMR	01/07/2019	22/08/2019	2	1	2	8	8	9	24.49	16/01/2019	165	PAK-KOH-1	
PHILIPPINES	WPR	01/07/2019	28/11/2019	1	1	24	30	30	40	4.30	20/09/2016	1014	PHL-NCR-2	(48,54)
ZAMBIA	AFR	16/07/2019	25/09/2019	2	1	3	9	9	10	3.75	17/10/2018	271	ZAM-LUA-1	(48,50–52)
NIGERIA	AFR	22/07/2019	26/01/2020	2	3	9	8	8	14	10.27	28/11/2018	236	NIE-KGS-1	
CENTRAL AFRICAN REPUBLIC	AFR	30/07/2019	23/08/2019	2	2	9	7	7	14	9.19	10/01/2019	201	CAR-BIM-3	
NIGERIA	AFR	07/08/2019	17/08/2019	2	2	5	6	6	10	10.27	22/02/2019	165	NIE-KGS-2	
ETHIOPIA	AFR	30/08/2019	30/12/2019	2	0	3	14	14	14	2.91	08/06/2018	448	ETH-SOM-1	
CENTRAL AFRICAN REPUBLIC	AFR	31/08/2019	08/12/2019	2	3	7	7	7	11	9.19	11/02/2019	201	CAR-BER-1	
NIGERIA	AFR	11/09/2019	11/09/2019	2	0	1	10	10	10	10.27	08/11/2018	307	NIE-SOS-6	
ETHIOPIA	AFR	14/09/2019	12/02/2020	2	11	15	10	10	23	2.91	11/11/2018	307	ETH-ORO-1	
ANGOLA	AFR	15/09/2019	18/12/2019	2	12	14	7	7	14	4.99	26/02/2019	201	ANG-MOX-1	
PAKISTAN	EMR	15/09/2019	12/11/2019	2	1	4	6	6	12	24.49	02/04/2019	165	PAK-GB-3	
CHAD	AFR	31/10/2019	05/02/2020	2	8	21	6	6	23	13.35	18/05/2019	165	CHA-NDJ-1	
PAKISTAN	EMR	15/11/2019	03/01/2020	2	2	10	6	6	14	24.49	02/06/2019	165	PAK-TOR-1	
TOGO	AFR	15/11/2019	01/02/2020	2	3	5	13	13	17	4.57	28/09/2018	413	TOG-SAV-1	
ETHIOPIA	AFR	16/12/2019	26/01/2020	2	3	3	11	11	14	2.91	05/05/2018	589	ETH-ORO-2	
ETHIOPIA	AFR	16/12/2019	21/02/2020	2	1	2	18	18	20	2.91	08/01/2019	342	ETH-ORO-3	

[1] Nucleotide divergence of the first isolate
[2] NPAFP rate (per 100,000 children <15) for the first year of the outbreak
[3] Reporting of emergence lineage only began in 2016. Lineage is reported only where data is available.

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Table 2. Final regression model of factors associated with the number of nucleotide differences of the first isolate of VDPV outbreaks. Sample size and dispersion parameter (θ) for the serotypes 1 and 3 model are reported.

Serotypes 1 & 3 (n = 15) θ = 3.91			
Variable	**Factor**	**IRR, multivariable (95% CI)**	**P-value**
Intercept	-	-	
Type of surveillance via which first isolate was detected (AFP case or ES) AFP: n = 14 (93.3%) ES: n = 1 (6.7%)	ES (vs. AFP)	0.22 (0.04, 1.28)	0.077
Unit increase of non-polio AFP rate (cases per 100,000 children aged <15 years old) Mean (95% CI): 3.1 (2.2, 4.0)	Linear term	0.49 (0.21, 1.02)	0.087
Percent of stool samples adequately collected Mean (95% CI): 85.5 (77.1, 93.9) <80%: n = 3 (20%)	Linear term	0.98 (0.95, 1.02)	0.415
Unit increase of non-polio AFP rate * Percent of stool samples adequately collected	Interaction term	1.01 (1.0, 1.03)	<0.05

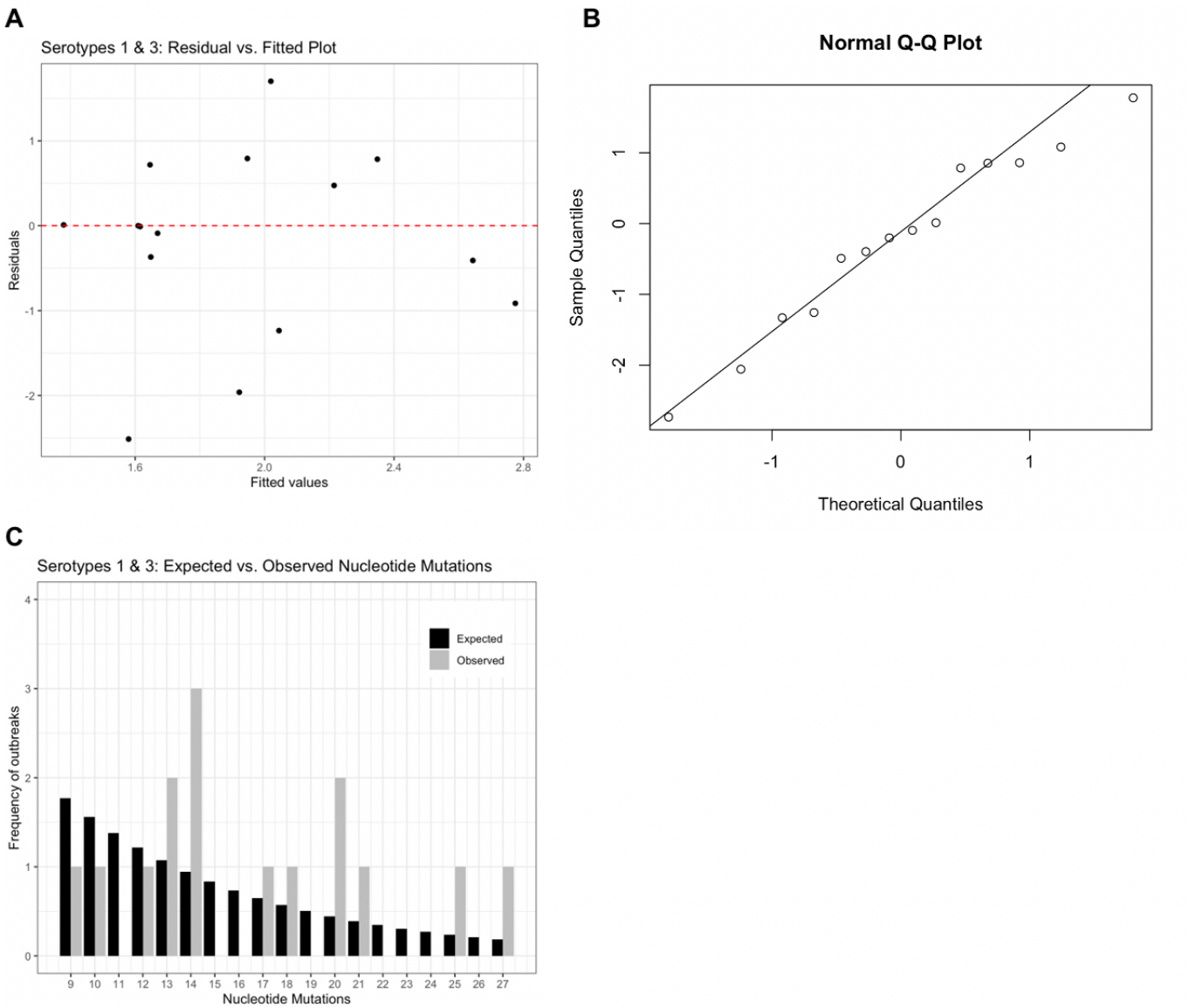

Figure 1. Serotypes 1 & 3 diagnostic plots: (A) residual vs. fitted values, (B) Normal Q-Q plot and (C) Expected vs. observed frequencies of nucleotide mutations assuming a negative binomial distribution. Model residuals (Figure 1a) for the serotypes 1 and 3 model support an appropriate model structure as the plot illustrates homoscedasticity of the residuals. The Q-Q plot (Figure 1b) further supports the assumed theoretical distribution for the final model as most values are centred along the Q-Q line, but the extreme values illustrate deviation from the assumed normal distribution of residuals. Figure 1c provides a visual comparison of expected vs. observed frequencies of nucleotide mutations. For serotypes 1 and 3, some outbreak frequencies corresponding to ≥13 nucleotide mutations are under-estimated while smaller mutations (9-10) are over-estimated by the model.

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