

**VIROLOGIC RESPONSE TO FIRST-LINE EFAVIRENZ- OR NEVIRAPINE-BASED
ANTI-RETROVIRAL THERAPY IN HIV-INFECTED AFRICAN CHILDREN**

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Abstract

Background: Poorer virologic response to nevirapine vs efavirenz-based antiretroviral therapy (ART) has been reported in adult systematic reviews and paediatric studies.

Methods: We compared drug discontinuation and viral load (VL) response in ART-naïve Ugandan/Zimbabwean children aged ≥ 3 years initiating ART with clinician-chosen nevirapine vs efavirenz in the ARROW trial. Predictors of suppression <80 , <400 and <1000 copies/ml at 36, 48 and 144 weeks were identified using multivariable logistic regression with backwards elimination ($p=0.1$).

Results: 445(53%) children received efavirenz and 391(47%) nevirapine. Children receiving efavirenz were older (median 8.6 years vs 7.5 nevirapine, $p<0.001$) and had higher CD4% (12% vs 10%, $p=0.05$) but similar pre-ART VL ($p=0.17$). The initial non-nucleoside-reverse-transcriptase-inhibitor (NNRTI) was permanently discontinued for adverse events in 7/445 (2%) children initiating efavirenz vs 9/391 (2%) initiating nevirapine ($p=0.46$); at switch to second-line in 17 vs 23, for tuberculosis in 0 vs 26, for pregnancy in 6 vs 0, and for other reasons in 15 vs 5. Early (36-48 week) virological suppression <80 copies/ml was superior with efavirenz, particularly in children with higher pre-ART VL ($p=0.0004$); longer-term suppression was superior with nevirapine in older children ($p=0.05$). Early suppression was poorer in the youngest and oldest children, regardless of NNRTI ($p=0.02$); longer-term suppression was poorer in those with higher pre-ART VL regardless of NNRTI ($p=0.05$). Results were broadly similar for <400 and <1000 copies/ml.

Conclusion: Short-term VL suppression favoured efavirenz, but long-term relative performance was age-dependent, with better suppression in older children with nevirapine, supporting WHO's recommendation that nevirapine remain an alternative NNRTI.

1 INTRODUCTION

2 Globally, >3 million children/adolescents are living with HIV, >90% in sub-Saharan
3 Africa(1). WHO guidelines recommend children/adolescents ≥ 3 years initiate two
4 nucleoside-reverse-transcriptase-inhibitors (NRTI) plus one non-nucleoside-reverse-
5 transcriptase-inhibitor (NNRTI). The preferred NNRTI is efavirenz (with nevirapine an
6 alternative) based on systematic reviews indicating better viral load (VL) response(2)
7 and short-term toxicity(3). However, paediatric nevirapine-based fixed-dose-
8 combinations are widespread in resource-limited settings(4); understanding whether
9 nevirapine is associated with poorer virological response in children initiating ART aged
10 ≥ 3 years has continuing programmatic relevance.

11
12 In adults, a 2010 Cochrane review concluded that nevirapine and efavirenz had
13 equivalent efficacy based on 7 randomised controlled trials(5). A separate examination
14 of 5 observational studies in low- and middle-income countries generally favoured
15 efavirenz; 6 studies in high-income countries were more heterogeneous. The 2012
16 systematic review(2), on which the WHO guidelines were based, included 26 trials and
17 7 observational studies with tenofovir+lamivudine or tenofovir+emtricitabine
18 backbones(6). This review, and a 2013 meta-analysis(7) of 10 trials and 28 studies with
19 no 2NRTI backbone restriction, concluded efavirenz had superior efficacy. However, a
20 2012 systematic review(8) restricted to 7 trials in resource-limited settings concluded
21 that nevirapine and efavirenz showed similar efficacy.

22
23 In children, observational studies have also generally concluded that efavirenz had
24 superior efficacy. In 804 Botswana children aged 3-16 years initiating ART with
25 nevirapine (median age 7 years) or efavirenz (8 years) (NNRTI chosen by clinician),
26 101/383 (26%) receiving nevirapine and 57/421 (14%) efavirenz experienced

virological failure (lack of suppression to <400 copies/ml by 6 months or confirmed ≥ 400 copies/ml post-suppression) (unadjusted hazard ratio (HR)=2.0 [95% CI 1.4-2.7] $p < 0.001$, adjusted HR (aHR) reported as similar)(9). Thai studies have generally reported similar results(10, 11), most recently in 2015(11) where nevirapine was a predictor for virologic failure (≥ 1000 copies/ml after ≥ 24 weeks ART) (aHR=1.63 [1.14-2.32] $p = 0.004$), although a 2011 study(12) reported no significant difference (unadjusted HR=1.46 [0.66-3.22]). In 675 children <18 years (84% ≥ 3 years) in the UK/Ireland Collaborative HIV Paediatric Study (CHIPS) initiating 2NRTI plus nevirapine (median age 4 years) or efavirenz (10 years), suppression <400 copies/ml within 12 months did not significantly differ (adjusted rate ratio (aRR)(efavirenz:nevirapine)=1.16 [0.95-1.41]) but over all follow-up, risk of subsequent virological failure (confirmed >400 copies/ml) was lower with efavirenz (aRR=0.54 [0.40-0.72])(13). Differences were most pronounced in the first 2 years (interaction $p = 0.03$). Two cross-sectional Tanzanian studies reported that risk of virologic failure was lower with efavirenz(14, 15). A study of 250 Ugandan children/adolescents (median age 9 years, range 0-18) compared efavirenz predominantly with zidovudine+lamivudine vs nevirapine predominantly with stavudine+lamivudine. 12-month virologic failure was higher in nevirapine (adjusted odds ratio(aOR)(nevirapine:efavirenz)=2.46 [1.23-4.90] $p = 0.01$)(16).

Considering toxicity, a meta-analysis found nevirapine had more adverse events (AEs) resulting in drug substitution or treatment discontinuation (OR=2.2 [1.9-2.6] in adults ≥ 15 years; limited data in infants/children with each study reporting different outcomes)(3). However, with efavirenz, one concern is central nervous system (CNS) events, with a risk ratio (vs nevirapine) of 1.4 [0.75-2.59] in children/adolescents ≥ 5 years in one Ugandan study(17). However, in the recent CHIPS study, discontinuation due to toxicity was 27/370 (7.3%) with 2 or 3 NRTIs plus nevirapine vs 32/424 (7.5%)

1 with efavirenz(13).

2

3 We therefore compared VL response and treatment discontinuation on first-line

4 nevirapine- and efavirenz-based ART initiated in children aged ≥ 3 years in the ARROW

5 trial(18).

6

1 MATERIALS AND METHODS

2 Observational analyses included 836 previously untreated Ugandan/Zimbabwean
3 children initiating efavirenz- or nevirapine-based ART, aged 3-17 years in the ARROW
4 trial (ISCRTN24791884)(18). Children were randomised 1:1:1 to open-label
5 lamivudine+abacavir+NNRTI continuously (Arm-A, control, no zidovudine); induction-
6 maintenance with 4-drug lamivudine+abacavir+NNRTI+zidovudine for 36 weeks, then
7 lamivudine+abacavir+NNRTI (Arm-B; short-term zidovudine) or
8 lamivudine+abacavir+zidovudine (Arm-C; long-term zidovudine). The NNRTI
9 (nevirapine/efavirenz) was chosen by clinicians; both were available in all centres
10 throughout the trial for initial ART and substitutions. Simultaneously, children were
11 randomised 1:1 in a factorial design to clinically driven monitoring vs laboratory plus
12 clinical monitoring for toxicity (haematology/biochemistry) and efficacy (CD4). After ≥36
13 weeks, eligible children taking lamivudine+abacavir twice-daily were randomised to
14 continue twice-daily or move to once-daily. Children were recruited from one
15 Zimbabwean (University of Zimbabwe, Harare) and three Ugandan centres (Joint
16 Clinical Research Centre, Kampala; Baylor-Uganda, Mulago; MRC/UVRI Uganda
17 Research Unit on AIDS, Entebbe). ARROW was approved by Research Ethics
18 Committees in Uganda, Zimbabwe and the UK. Caregivers gave written consent.
19
20 Post-baseline VL was assayed retrospectively on stored plasma at 4, 24, 36, 48 and
21 144 weeks in all children <5 years at ART initiation. VL was also assayed at these
22 timepoints and 24-weekly post-week 48 in a subset of children enrolled post-June 2008
23 (immunology substudy); and at, and 48 and 96 weeks after, randomisation to once- vs
24 twice-daily lamivudine+abacavir (shown to be virologically equivalent)(19). Assays used
25 Abbott RealTime and Roche Amplicor 1.5: because many samples had low volumes
26 and had to be diluted 1:2, the lower limit of detection was 80 copies/ml. Analysis used

closest measurements to nominal timepoints in equally spaced windows (results available for 37%(n=309), 35%(n=282), 42%(n=341), 44%(n=241), 49%(n=265), respectively, of those alive and in follow-up, broadly similar in nevirapine vs efavirenz). In 145 Arm-A/B immunology substudy children alive and in follow-up at 24 weeks (with complete VLs), virological failure was defined as ≥ 400 copies/ml at week 24 or subsequent confirmed ≥ 400 copies/ml through 3 years(9, 13, 16).

The primary (non-randomised) exposure was NNRTI received at ART initiation (efavirenz vs nevirapine) using intention-to-treat. Child characteristics were compared across these groups using chi-squared (categorical factors) and Wilcoxon (continuous factors) tests. Suppression < 80 , < 400 and < 1000 copies/ml with efavirenz and nevirapine was compared using generalised estimating equations for global tests over time (binomial distribution, independent working correlation). 36, 48 and 144 weeks post-ART initiation, predictors of suppression < 80 , < 400 and < 1000 copies/ml were identified using logistic regression, forcing efavirenz vs nevirapine and age at ART initiation into models. Models included children with VL at baseline and the relevant timepoint (92/89/83% of those with VLs at 36/48/144 weeks). Other factors considered as potential confounders were pre-ART WHO stage, CD4%, weight/height-for-age(20), VL, gender, centre, ART-strategy randomisation, monitoring randomisation, whether the caregiver/child reported missed doses in the last 4 weeks, and percentage of scheduled visits to date with missed doses in the last 4 weeks. For each timepoint, independent predictors of suppression < 80 copies/ml were identified using backward elimination (exit $p \geq 0.1$ to develop an explanatory models; interactions between variables in final models retained where $p < 0.1$). Additional predictors of suppression < 400 and < 1000 copies/ml were then identified using forward selection (entry $p = 0.1$), forcing in factors included in the < 80 copies/ml model. Factors in any of the models

1 were then included in final timepoint-specific models for each threshold, allowing the
2 impact of the same factor to be assessed over the different thresholds. Nonlinearity
3 was explored using natural cubic splines(21) (knots at 10th, 50th, 90th centiles), then
4 represented by categorization. Potential confounders of the association between
5 efavirenz/nevirapine and early death (before week 36) and permanent discontinuation
6 of initial NNRTI were identified using logistic (adjusting for CD4% only (low number of
7 events)) and Cox regression (backwards elimination) respectively. Analyses used Stata
8 14.1 (StataCorp). p-values are two-sided.

RESULTS

836 previously untreated children aged 3-17 years initiated ART between March 2007-October 2008. 445(53%) received efavirenz and 391(47%) nevirapine. Children on efavirenz were more likely to be male and WHO stage 1/2, were older and less underweight/stunted at ART initiation ($p<0.01$), but had similar VL ($p=0.17$) (Table 1). Reflecting local availability, centre strongly predicted receiving efavirenz vs nevirapine ($p<0.001$).

4/445 (1%) initiating efavirenz and 18/391 (5%) initiating nevirapine died before week 36. Whilst the difference persisted after adjusting for CD4% ($p=0.01$), causes of death were primarily infection-related and similar between efavirenz/nevirapine (septicaemia/meningitis 0/7, pneumonia 1/4, chronic diarrhoea/wasting/hypokalaemia 1/3, stroke/cerebrovascular 1/2, uncertain 1/2), with similarly low CD4% (median(IQR) 8(5-11) vs 3(1-14) respectively),. The initial NNRTI was permanently discontinued before week 36 in 8(2%) initiating efavirenz [2 AE; 4 voluntary decision; 2 pregnancy-related] and 22(6%) initiating nevirapine [9 AE; 13 tuberculosis treatment] ($p=0.001$ Cox regression adjusting for age at ART initiation). At week 36, those randomised to Arm-C (3NRTI maintenance) discontinued NNRTI (excepting five/two previously discontinuing zidovudine (anaemia)/abacavir (hypersensitivity) respectively). Amongst children randomised to 2NRTI+NNRTI maintenance (Arm-A/B), 13 died after week 36 [6/294 (2%) efavirenz; 7/269 (3%) nevirapine]. After week 36, the initial NNRTI was permanently discontinued in 37/294 (13%) initiating efavirenz [5 AE; 17 switch to second-line; 4 pregnancy-related; 1 voluntary decision; 10 other] and 41/269 (15%) nevirapine [23 switch to second-line; 13 tuberculosis treatment; 1 voluntary decision; 4 other] (Cox $p=0.31$ unadjusted, 0.009 adjusted for age and CD4% at ART initiation and centre). Overall, Arm-A/B children initiating efavirenz or nevirapine spent 94.4% and

88.9% follow-up-time through to their last clinic visit (median 4 years follow-up) on efavirenz or nevirapine-containing ART, respectively.

Over total follow-up, the initial NNRTI was permanently discontinued due to an AE in 7/445 (2%) initiating efavirenz (3 lipodystrophy (2 Arm-B previously receiving zidovudine); 2 gynaecomastia; 2 hypersensitivity reaction) and 9/391 (2%) nevirapine (4 hypersensitivity reaction; 1 Stevens-Johnson Syndrome; 1 rash; 1 acute febrile episode; 1 lactic acidosis; 1 raised liver enzymes) ($p=0.46$ Fisher's exact test). In nevirapine, all 9 AEs were <10 weeks post-ART initiation (median 23 days (IQR 15-30)) and 8/9 substituted with efavirenz; in efavirenz, 2 were <10 weeks, the remaining 5 were a median 3.3 years (3.2-3.8) after ART initiation.

459/563 (81.5%) initiating long-term NNRTI (Arm-A/B) had ≥ 1 post-baseline VL. Over all follow-up there was a trend to better suppression <80 copies/ml with efavirenz (global unadjusted $p=0.11$), driven by effects before 36 weeks ($p=0.007$ ≤ 36 weeks, $p=0.83$ ≥ 48 weeks). There was no evidence of difference for <400 copies/ml ($p=0.57$) or <1000 copies/ml ($p=0.33$), with a difference in <1000 copies/ml at week 4 only ($p=0.02$, ≥ 24 weeks $p=0.77$) (Figure 1). Mean VL reduction from weeks 0–4 was $2.4\log_{10}$ with efavirenz and $2.3\log_{10}$ with nevirapine ($p=0.18$, $n=302$). At week 36, 160/200 (80.0%) efavirenz vs 93/141 (66.0%) nevirapine were <80 copies/ml (+14.0% [95% CI 4.5,23.6] $p=0.004$), compared to 181(90.5%) vs 122(86.5%) respectively <400 copies/ml (+4.0% [-3.0,10.9] $p=0.25$). By week 48, suppression <80, <400 and <100 copies/ml was similar for efavirenz and nevirapine ($p=0.97$, $p=0.78$, $p=0.40$ respectively). Despite little switching to second-line ART (similar with both NNRTIs), suppression remained similar at week 144 (106/141 (75.2%) vs 89/124 (71.8%) <80 copies/ml, 116(82.3%) vs 101(81.5%) <400 copies/ml, 118(83.7%) vs 106(85.5%)

1 <1000 copies/ml; $p>0.5$).

2
3 However, in adjusted analyses (Table 2), differences in suppression between efavirenz
4 vs nevirapine differed by both baseline VL and age at ART initiation; and these
5 relationships varied over follow-up. At week 36, suppression <80 copies/ml did not
6 depend on pre-ART VL in efavirenz, but declined with increasing pre-ART VL in
7 nevirapine; the net effect was greater suppression with efavirenz in those with pre-ART
8 VL >35,000 copies/ml (overall effect of efavirenz vs nevirapine $p=0.0004$;
9 heterogeneity/interaction $p=0.007$) (Table 2; Supplementary Figure 1a). Suppression
10 <400 and <1000 copies/ml was broadly similar (Supplementary Table 1). This effect
11 had weakened by week 48 (heterogeneity/interaction $p=0.15$; Table 2; Supplementary
12 Figure 1b), and by week 144 suppression <80 copies/ml was lower in those with higher
13 pre-ART VL ($p=0.05$) in both groups (heterogeneity/interaction $p=0.8$).

14
15 Considering age at ART initiation, at week 36 and 48, suppression was poorer in the
16 youngest and older children, irrespective of NNRTI (global $p=0.02$, $p=0.003$, $p=0.0006$
17 for <80, <400, <1000 respectively at week 36; $p=0.09$, $p=0.009$, $p=0.03$ respectively at
18 week 48). However, at week 144, older children/adolescents had poorer suppression
19 <80 copies/ml on efavirenz (aOR per year older=0.79 [95%CI 0.69-0.90] $p<0.001$) but
20 suppression was independent of age on nevirapine (aOR=0.94 [0.79-1.11] $p=0.46$)
21 (overall effect of efavirenz vs nevirapine $p=0.05$; heterogeneity/interaction $p=0.09$)
22 (Table 2; Supplementary Figure 1c). Effect sizes were similar for <400 copies/ml
23 (efavirenz: aOR per year older=0.74 [0.64-0.87] $p<0.001$; nevirapine: aOR=0.88 [0.72-
24 1.08] $p=0.23$) and <1000 copies/ml (efavirenz: aOR=0.72 [0.61-0.85] $p<0.001$;
25 nevirapine: aOR=0.85 [0.69-1.06] $p=0.14$) but evidence for heterogeneity was weaker
26 ($p=0.15$, 0.19 respectively) (Supplementary Table 1). The relationship in those on

efavirenz increased year-by-year across the age range with no evidence of non-linearity (noting those aged 3-4 years at ART initiation were 5-9 by week 144).

Effects of other factors did not vary by NNRTI ($p > 0.1$ for all thresholds). Suppression at weeks 48 and 144 was generally poorer in those reporting missing ART doses at a greater percentage of scheduled visits, with larger effects on the higher VL thresholds (< 400 , < 1000 copies/ml) than < 80 copies/ml (Supplementary Table 1). Interestingly, at week 144 suppression was lower in lamivudine+abacavir+NNRTI (Arm-A) vs lamivudine+abacavir+NNRTI+36 weeks zidovudine (Arm-B) ($p = 0.05$).

In the subset with regular VLs, there was no evidence of a difference in virological failure (≥ 400 copies/ml at week 24 or subsequent confirmed ≥ 400 copies/ml through 3 years) (18/93 (19.4%) efavirenz vs 8/52 (15.4%) nevirapine, $p = 0.56$ Cox regression adjusting for age at ART initiation and centre).

DISCUSSION

WHO guidelines recommend children/adolescents ≥ 3 years initiate ART with 2NRTI+NNRTI, where the NNRTI efavirenz is preferred over nevirapine. Overall, in this non-randomized comparison in the ARROW trial, short-term suppression favoured efavirenz, particularly for <80 copies/ml, but there was little difference from week 24 at <400 and <1000 copies/ml despite the vast majority remaining on the same NNRTI. Longer-term (≥ 48 weeks) differences were small at all thresholds, although analysis at 144 weeks favoured efavirenz ($p=0.05$). This is broadly consistent with other paediatric studies, which generally found efavirenz associated with better virological outcome (9-11, 13-16). The UK/Irish CHIPS study also found the most pronounced differences were shorter-term (<2 years).

However, short-term performance of efavirenz vs nevirapine also varied by pre-ART VL, with efavirenz similar at 36 and 48 weeks regardless of pre-ART VL but nevirapine better in those with lower VL (Supplementary Figure 1a). Longer-term (144 weeks), this was not apparent: suppression was independently lower in those with higher pre-ART VL regardless of NNRTI received and independently of age, potentially reflecting greater pre-ART reservoir with higher VL, but regardless of cause, highlights the importance of prompt ART initiation. The fact that the initial superiority of efavirenz at high pre-ART VL waned over time raises questions regarding the relevance of short-term suppression as an outcome, since long-term suppression is the goal of treatment.

The other consistent predictor of suppression at every timepoint was age. Contrasting pre-ART VL, effects of age on early suppression occurred independently of NNRTI, with younger and older children having lower suppression at all thresholds, independently of pre-ART VL and self-reported adherence. Children >10 years were

1 predominantly responsible for their own medication intake, highlighting challenges in
2 pre-adolescence and adolescent adherence. Most children >3 years were already
3 taking divided tablets, so poorer adherence with syrups is not the cause of lower
4 suppression in the younger children(22). However, after 3 years ART, in contrast to
5 early suppression, the relative performance of NNRTIs depended on age. Overall there
6 was at most a modest decline in suppression with age in children on nevirapine,
7 contrasting a marked decline on efavirenz (Supplementary Figure 1c), the net result
8 being children aged 10+ years at ART initiation (13+ years at VL measurement) having
9 better long-term suppression with nevirapine, even after adjusting for self-reported
10 adherence. One plausible explanation is the well-documented CNS side-effects of
11 efavirenz; pre-adolescents/adolescents may have taken more unreported treatment
12 interruptions. Certainly, sub-clinical CNS side-effects were commonly reported in
13 adolescents in the weekends-off BREATHER trial(23): at enrolment, adolescents
14 reported CNS side-effects and occasional missed doses which they found difficult to
15 report to clinic staff (S Bernays, personal communication). Children/adolescents with
16 CNS-related signs/symptoms at ART initiation may have been less likely to receive
17 efavirenz, and simultaneously to have lower adherence. If anything, this would tend to
18 favour efavirenz, particularly given necessarily incomplete adjustment for self-reported
19 adherence. It is also unclear whether previous studies investigated varying differences
20 between efavirenz and nevirapine by age (interactions), so these effects may have
21 been missed.

22
23 Interestingly, at 144 weeks, children/adolescents who had received an additional NRTI
24 (zidovudine) until week 36 (Arm-B) had marginally better suppression than those who
25 had not (Arm-A) ($p=0.05$). In contrast in all children(18), including those aged <3 years,
26 there was no evidence of difference (191/259 (73.7%) vs 169/232 (72.8%); $p=0.82$)

(heterogeneity by age <3 vs ≥ 3 years at ART initiation $p=0.08$). Long-term CD4 recovery was also greater in the induction-maintenance Arm-B(24). Long-term 3NRTI+NNRTI has been quite widely used (from infancy) in Europe(13), as this is more palatable than 3-drug lopinavir/ritonavir regimens and potentially more forgiving where persuading children to take medication is problematic.

Our results confirm the generally favourable toxicity profile of both nevirapine and efavirenz, with only eight nevirapine and two efavirenz hypersensitivity reactions, and ~2% permanently discontinuing each NNRTI due to any AE, in a clinical setting where clinicians may not discontinue a drug despite toxicity if the toxicity is not life-threatening. Gynaecomastia resulted in permanent discontinuation of efavirenz in two children, 1% of those receiving it long-term. Permanent discontinuations for non-AE reasons were more frequent with nevirapine, particularly tuberculosis treatment which is an advantage of efavirenz in children at high risk of tuberculosis shortly after ART initiation(25). No switches to second-line treatment occurred before 48 weeks with either regimen.

Although children were not randomised to nevirapine or efavirenz, potential confounders were considered for inclusion in models; nonetheless, there is always the possibility of residual confounding. A major limitation of our study is incomplete VL sampling: however assays were performed to answer questions not depending on receipt of nevirapine or efavirenz, so will not bias this comparison. Although sampling was incomplete, restricting power for interactions particularly, our study is of similar size to others (with 4-year follow-up); the suggestion that older children had better long-term suppression with nevirapine requires further study. All children received the WHO-recommended backbone NRTIs lamivudine+abacavir(6). Although approximately one

1 third also received zidovudine until week 36, this did not affect relative performance of
2 efavirenz vs. nevirapine; other regimens are unlikely to have altered relative impact of
3 different NNRTIs. We considered three thresholds for suppression (<80, <400, <1000
4 copies/ml); while <80 copies/ml provides a sensitive investigation of impact of low-level
5 resistant variants, <400 and <1000 copies/ml may be more relevant in clinical practice,
6 particularly resource-limited settings. Results were generally similar over thresholds.
7 We pre-specified an exit p-value of 0.1 for backwards selection to develop an
8 explanatory model; however this increases the chance of Type I error (false-positives).

9
10 In summary, we confirm results from other paediatric studies that efavirenz is
11 associated with better initial virological outcome than nevirapine, particularly at higher
12 pre-ART VLs, but longer-term we found they are broadly similar, with nevirapine even
13 having some advantage in older children. This supports the 2013 WHO
14 recommendation that nevirapine should continue to be a reasonable alternative to
15 efavirenz, particularly in older children/adolescents. It also suggests there is no
16 particular reason to substitute nevirapine in children doing well on first-line ART. Both
17 nevirapine and efavirenz have generally favourable toxicity profiles, although clinicians
18 need to remain alert to the possibility of hypersensitivity reactions with either.

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1 **FIGURE CAPTIONS**

2 Figure 1 Suppression (a) <80 copies/ml over time, (b) <400 copies/ml over time and (c)
3 <1000 copies/ml over time

4 Footnote 1: Only including long-term NNRTI (Arm-A/B) from week 48 onwards

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1 **Supplementary Digital Content**

2 ARROW_virology_EFV_supplementary_digital_content_v2.0_160401.pdf

3

1 Table 1 Characteristics of children receiving efavirenz and nevirapine at ART

2 initiation

	Efavirenz (n=445)	Nevirapine (n=391)	P*
Male	242 (54%)	176 (45%)	0.007
Age (years): median (IQR)	8.6 (6.4-11.0)	7.5 (4.9-10.1)	<0.001
CD4 (cells/μl): median (IQR)	277 (115-436)	261 (102-476)	0.94
CD4%	12 (6-18)	10 (5-17)	0.05
Weight-for-age Z-score: median (IQR)	-1.7 (-2.6 to -1.0)	-2.4 (-3.6 to -1.5)	<0.001
Height-for-age Z-score: median (IQR)	-1.9 (-2.8 to -1.1)	-2.6 (-3.5 to -1.6)	<0.001
Viral load (copies/ml): median (IQR)	160000 (52000-422000)**	199000 (67000-453000)***	0.17
WHO stage 3/4	269 (60%)	322 (82%)	<0.001
On TB treatment	43 (10%)	0 (0%)	<0.001
Randomized treatment strategy			0.61
Arm-A (3TC/ABC/NNRTI throughout)	141 (32%)	135 (35%)	
Arm-B (3TC/ABC/NNRTI throughout, ZDV until week 36)	153 (34%)	134 (34%)	
Arm-C (3TC/ABC/ZDV throughout, NNRTI until week 36)	151 (34%)	122 (31%)	
Allocated monitoring strategy			0.75
Routine CD4 monitoring	225 (51%)	202 (52%)	
No CD4 monitoring	220 (49%)	189 (48%)	
Country/centre***			<0.001
Uganda/Entebbe	52 (12%)	94 (24%)	
Uganda/JCRC	205 (46%)	25 (6%)	
Uganda/PIDC	98 (22%)	45 (12%)	
Zimbabwe/Harare	90 (20%)	227 (58%)	

*Chi-squared tests for categorical measures and Wilcoxon rank-sum tests for continuous measures unless otherwise indicated

**n=260 (185 no baseline viral loads)

***n=235 (156 no baseline viral load)

***36% received efavirenz in Entebbe, 89% in JCRC, 69% in PIDC, 28% in Harare

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1 **Table 2 Independent predictors of viral load suppression <80 copies/ml at 36, 48 and 144 weeks after ART initiation**

	36 weeks (n=314, Arms A/B/C)		48 weeks* (n=213, Arms A/B)		144 weeks* (n=221, Arms A/B)	
	aOR [95% CI]	P	aOR [95% CI]	P	aOR [95% CI]	P
VL at ART initiation						
Per log ₁₀ higher if taking efavirenz	1.01 [0.58-1.76]	0.96	0.76 [0.39-1.49]	0.42		
Per log ₁₀ higher if taking nevirapine	0.29 [0.15-0.56]	<0.001	0.33 [0.13-0.86]	0.02	0.59 [0.35-1.00]	0.05
Heterogeneity		0.003		0.15		
Efavirenz, vs. nevirapine if VL 200,000 copies/ml at ART initiation	2.55 [1.29-5.03]	0.007	0.62 [0.27-1.43]	0.27		
Efavirenz, vs. nevirapine if aged 10 years at ART initiation					1.14 [0.43-3.08]	0.79
Age at ART initiation						
Per year older if taking efavirenz					0.79 [0.69-0.90]	<0.001
Per year older if taking nevirapine					0.94 [0.79-1.11]	0.46
Heterogeneity						0.09
Age at ART initiation, vs 5-9years		0.02		0.09		
3-4	0.73 [0.36-1.46]	0.37	0.47 [0.19-1.15]	0.10		
10+	0.34 [0.16-0.73]	0.006	0.38 [0.14-1.00]	0.05		
3TC/ABC/NNRTI throughout, vs additional 36 weeks ZDV induction*					0.52** [0.27-1.00]	0.05
Missed any doses in last 4 weeks, vs not missed any doses					0.51 [0.17-1.52]	0.23
% visits to date with missed doses in last 4 weeks (per 10% higher)			0.76 [0.57-1.00]	0.05	0.84 [0.59-1.21]	0.36
Centre, vs. A		0.47***				
B	1.00 [0.45, 2.25]	0.99				
C	0.58 [0.28-1.23]	0.16				
D	0.69 [0.31-1.49]	0.34				
Overall efavirenz vs nevirapine (incorporating interaction effects above)		0.0004		0.26		0.05

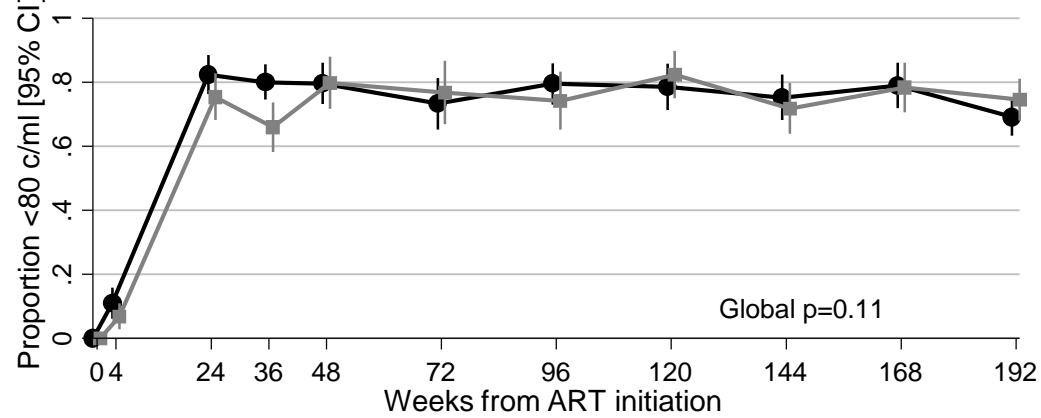
aOR=adjusted odds ratio, n=n complete cases

*Only including children receiving long-term NNRTIs (Arm A/B) in analyses from week 48 onwards

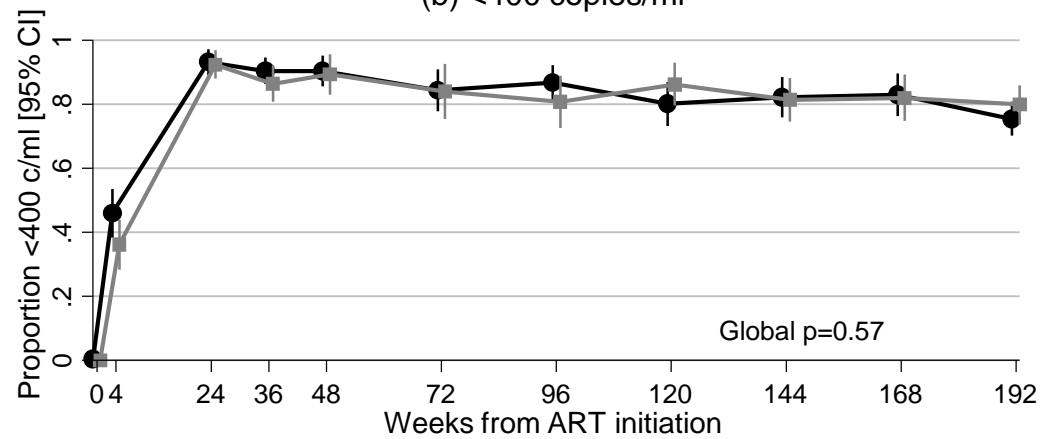
** There was no evidence of interaction between NNRTI and allocated ART strategy (p>0.1).

*** Included because significant variation in suppression <400 copies/ml and <1000 copies/ml by centre at week 36, Supplementary Table 1.

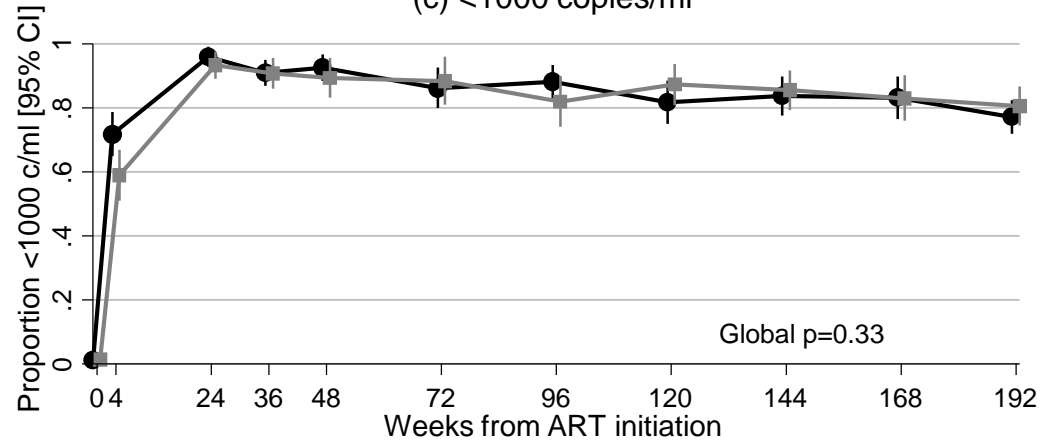
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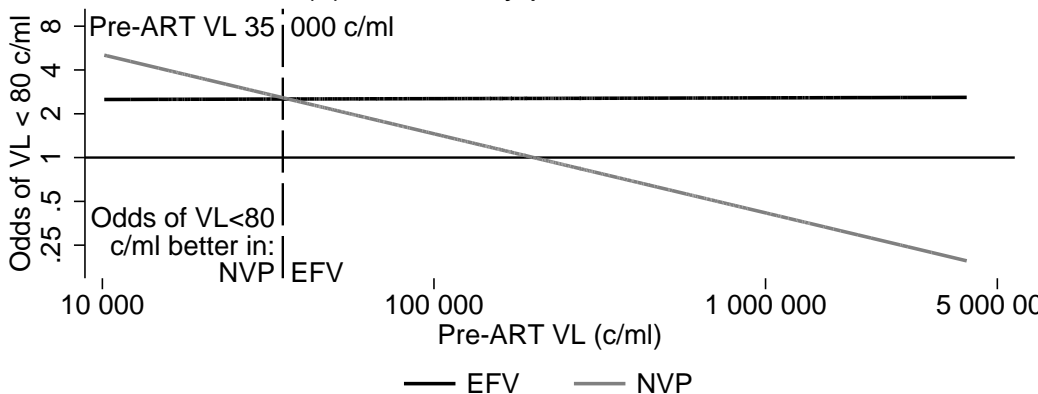
(b) <400 copies/ml



(c) <1000 copies/ml

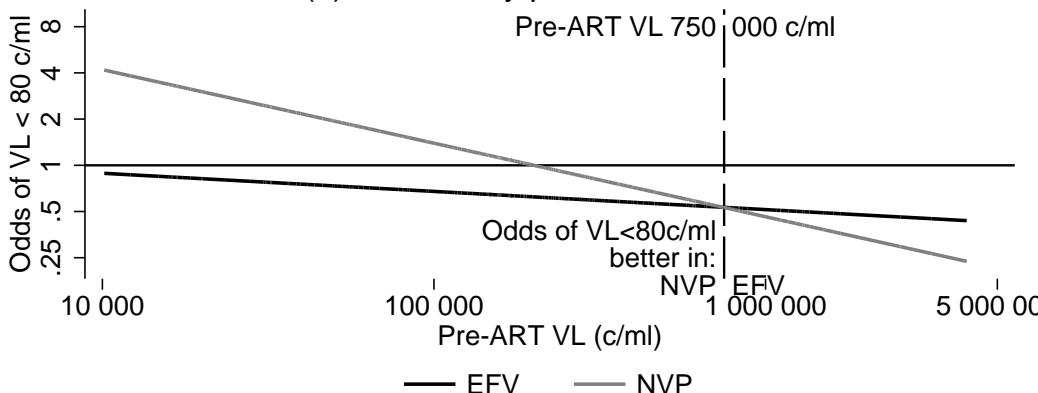


(a) week 36 by pre-ART viral load



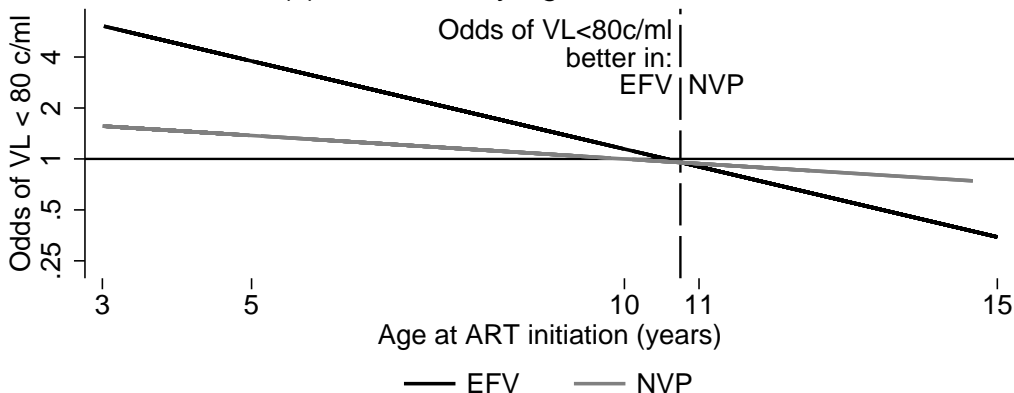
Reference category: Zimbabwean child aged 5-9 years, on NVP; with pre-ART VL 200 000 c/ml

(b) week 48 by pre-ART viral load



Reference category: child aged 5-9 years, on NVP; with pre-ART VL 200 000 c/ml and no reported missed ART doses

(c) week 144 by age at ART initiation



Reference category: child aged 10 at ART initiation, on NVP in Arm A (NNRTI+3TC+ABC); with pre-ART VL 200 000 c/ml and no reported missed ART doses

Supplementary Table 1 Independent predictors of viral load suppression <80, <400 and <1000 copies/ml at 36, 48 and 144 weeks after ART initiation

Factor	36 weeks (n=314, Arms A/B/C)						48 weeks (n=213, Arms A/B)						144 weeks (n=221, Arms A/B)					
	<80 copies/ml		<400 copies/ml		<1000 copies/ml		<80 copies/ml		<400 copies/ml		<1000 copies/ml		<80 copies/ml		<400 copies/ml		<1000 copies/ml	
	aOR [95% CI]	P	aOR [95% CI]	P	aOR [95% CI]	p	aOR [95% CI]	P	aOR [95% CI]	p	aOR [95% CI]	P	aOR [95% CI]	P	aOR [95% CI]	p	aOR [95% CI]	P
VL at ART initiation																		
Per log ₁₀ higher if taking efavirenz	1.01 [0.58-1.76]	0.96	0.83 [0.38-1.82]	0.64	0.88 [0.39-1.98]	0.75	0.76 [0.39-1.49]	0.42	0.96 [0.38-2.41]	0.93	0.74 [0.24-2.27]	0.60	0.59 [0.35-1.00]	0.05	0.35 [0.17-0.70]	0.003	0.34 [0.16-0.72]	0.005
Per log ₁₀ higher if taking nevirapine	0.29 [0.15-0.56]	<0.001	0.33 [0.14-0.79]	0.01	0.24 [0.08-0.68]	0.007	0.33 [0.13-0.86]	0.02	0.21 [0.06-0.76]	0.02	0.21 [0.06-0.77]	0.02						
Heterogeneity		0.003		0.11		0.04		0.15		0.05		0.13						
Efavirenz, vs. nevirapine if VL 200,000 copies/ml at ART initiation	2.55 [1.29-5.03]	0.007	2.29 [0.86-6.07]	0.097	1.81 [0.59-5.54]	0.30	0.62 [0.27-1.43]	0.27	0.92 [0.27-3.14]	0.90	1.28 [0.35-4.61]	0.71						
Efavirenz, vs. nevirapine if aged 10 years at ART initiation													1.14 [0.43-3.08]	0.79	1.19 [0.38-3.74]	0.76	1.12 [0.34-3.75]	0.85
Age at ART initiation																		
Per year older if taking efavirenz													0.79 [0.69-0.90]	<0.001	0.74 [0.64-0.87]	<0.001	0.72 [0.61-0.85]	<0.001
Per year older if taking nevirapine													0.94 [0.79-1.11]	0.46	0.88 [0.72-1.08]	0.23	0.85 [0.69-1.06]	0.14
Heterogeneity													0.09		0.15		0.19	
Age at ART initiation, vs 5-9years		0.02		0.003		0.0006		0.09		0.009		0.03						
3-4	0.73 [0.36-1.46]	0.37	0.94 [0.33-2.67]	0.91	0.92 [0.27-3.11]	0.89	0.47 [0.19-1.15]	0.10	0.37 [0.09-1.55]	0.17	0.48 [0.11-2.07]	0.32						
10+	0.34 [0.16-0.73]	0.006	0.22 [0.08-0.61]	0.004	0.16 [0.05-0.50]	0.002	0.38 [0.14-1.00]	0.05	0.12 [0.03-0.53]	0.005	0.15 [0.03-0.68]	0.01						
3TC/ABC/NNRTI throughout (Arm A), vs additional 36 weeks ZDV induction*													0.52** [0.27-1.00]	0.05	0.39** [0.18-0.85]	0.02	0.33** [0.14-0.78]	0.01
Missed any doses in last 4 weeks, vs not missed any doses													0.51 [0.17-1.52]	0.23	0.33 [0.11-1.01]	0.05	0.37 [0.11-1.17]	0.09
% visits to date with missed doses in last 4 weeks (per 10% higher)							0.76 [0.57-1.00]	0.05	0.72 [0.50-1.03]	0.07	0.69 [0.48-1.00]	0.05	0.84 [0.59-1.21]	0.36	0.70 [0.47-1.05]	0.08	0.62 [0.40-0.95]	0.03
Centre, vs. A		0.47		0.07		0.002												
B	1.00 [0.45, 2.25]	0.99	0.47 [0.16-1.41]	0.18	0.19 [0.05-0.73]	0.02												
C	0.58 [0.28-1.23]	0.16	0.29 [0.10-0.83]	0.02	0.15 [0.04-0.54]	0.004												
D	0.69 [0.31-1.49]	0.34	0.85 [0.25-2.93]	0.80	0.72 [0.14-3.62]	0.69												
Overall efavirenz vs nevirapine (incorporating interaction effects above)		0.0004		0.07		0.07		0.26		0.15		0.25		0.05		0.12		0.22
Hosmer-Lemeshow goodness-of-fit***		0.56		0.89		0.85		0.70		0.93		0.37		0.60		0.94		0.43

Predictors of viral load suppression <80 copies/ml as per Table 2

aOR=adjusted odds ratio, n=n complete cases

*Only including Arm A/B receiving long-term NNRTIs from week 48 onwards. At 36 weeks, children in both Arm B and C had both received 36 weeks 3TC/ABC/ZDV/NNRTI, and were therefore pooled in analysis.

** There was no evidence of interaction between NNRTI and allocated ART strategy (p>0.1).

*** Calculated using 10 groups. p>0.05 indicates good model fit.