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Awareness and uptake of the Determined, Resilient, Empowered, AIDS-free, Mentored and Safe HIV prevention package over time among population-based cohorts of young women in Kenya and South Africa

Annabelle J. Gourlay[a], Isolde Birdthistle[a], Sarah Mulwa[a,b], Nondumiso T. Mthiyane[c], Faith Magut[d], Natsayi Chimbindi[c], Abdhalah Ziraba[b], Moses Otieno[d], Daniel Kwaro[d], Jane Osindo[b], Vivienne Kamire[d], Maryam Shahmanesh[c,e], Sian Floyd[a], on behalf of the DREAMS Impact Evaluation Study Team

Objectives: To evaluate uptake of a complex intervention for HIV prevention among general populations of adolescent girls and young women (AGYW) in three diverse settings.

Design: Cohorts of ~1500 AGYW were randomly selected from demographic platforms in Kenya (Nairobi and Siaya) and South Africa (uMkhanyakude, KwaZulu-Natal).

Methods: AGYW aged 13/15–22 years were enrolled in 2017 (Nairobi and uMkhanyakude) or 2018 (Siaya), with annual follow-up to 2019. We describe awareness of DREAMS (Determined, Resilient, Empowered, AIDS-free, Mentored and Safe), self-reported invitation to participate, and uptake of DREAMS interventions by: categories and levels of the PEPFAR core package;number of 'primary' interventions (seven in Kenya; five in South Africa). Analyses were stratified by year invited and age at cohort enrolment.

Results: Proportions aware and invited to DREAMS increased across all settings, to $\geq$ 83% aware and $\geq$ 53% invited by 2018 (highest among AGYW aged 13–17 years, e.g. 63 vs. 40% among 18–22 s, uMkhanyakude). HIV testing, school-based interventions and social protection were the most accessed categories, while differences in uptake by DREAMS invitation were greatest for novel DREAMS interventions, for example, social asset building (76% among those invited in 2017 and 2018 vs. 9% among those never-invited in Nairobi). Although few DREAMS invitees accessed all intended primary interventions by 2019 (2% of 15–17 s and 5% of 18–22 s in Gem), many accessed at least three interventions, including combinations across individual, family and community levels.

Conclusion: Over time, DREAMS reached high proportions of AGYW in all settings, particularly younger AGYW. Participation in combinations of interventions improved but uptake of the complete primary packages remained low.

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AIDS 2022, **36** (Suppl 1):S27–S38

[a]Faculty of Epidemiology and Population Health, London School of Hygiene & Tropical Medicine, Keppel Street, London, UK, [b]African Population and Health Research Center, Nairobi, Kenya, [c]Africa Health Research Institute, KwaZulu-Natal, South Africa, [d]Centre for Global Health Research, Kenya Medical Research Institute, Kisumu, Kenya, and [e]Institute for Global Health, University College London, London, UK.

Correspondence to Annabelle J. Gourlay, Faculty of Epidemiology and Population Health, London School of Hygiene & Tropical Medicine, Keppel Street, London WC1E 7HT, UK.

E-mail: annabelle.gourlay@lshtm.ac.uk

Received: 14 December 2020; revised: 7 July 2021; accepted: 13 October 2021.

DOI:10.1097/QAD.0000000000003120

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Keywords: adolescent, Africa, cohort studies, HIV infections, program evaluation

Background

HIV incidence rates among adolescent girls and young women (AGYW) are persistently several times higher than those of their male peers in many sub-Saharan African settings [1–3]. UNAIDS estimated that approximately 20% of the 4400 new HIV infections occurring daily among adults in 2018 were among AGYW aged 15–24 years [4].

For HIV prevention approaches to succeed, particularly among adolescent populations, it has been argued that comprehensive, combination prevention approaches that integrate biomedical, behavioural and structural intervention tools are needed [5], and that such approaches must be evidence-informed, community-owned and rights-based [6]. Following repeated calls to invest in combination prevention interventions and to accelerate HIV prevention programming among AGYW [7–10], the DREAMS (Determined, Resilient, Empowered, AIDS-free, Mentored and Safe) partnership was initiated in 2016, with a geographic focus in sub-Saharan Africa [11]. It brings together a suite of evidence-based prevention tools that, in combination, aims to reduce new HIV cases among AGYW and address the multifaceted needs of AGYW and dimensions of HIV risk [11,12].

A core principle of DREAMS is the 'layering', or integration, of multiple behavioural, biological and structural interventions from the DREAMS core package [12]. This core package is grouped broadly by levels and further organized into categories (Supplemental Digital Content Fig 1, http://links.lww.com/QAD/C380). Individual-level interventions are those that aim to empower AGYW and reduce their risk of HIV directly. Categories include HIV testing services, and social asset building, which promotes networking with peers and female mentors in 'safe spaces', enhances support and facilitates links to other services. Contextual-level interventions aim to strengthen families economically and build positive relationships with parents/caregivers, and to mobilize communities including young men, benefitting AGYW directly and indirectly.

Other examples of adolescent-focussed combination HIV prevention programmes that aim to implement a variety of complementary approaches for maximum impact include 'She Conquers' in South Africa, 'Sauti' in Tanzania, 'DREAMS-like' initiatives by the Global Fund for HIV, TB and malaria, and various 'cash plus' trials (cash transfers with social, behavioural and/or health-related interventions) [5,13–15]. Although the growing momentum in HIV prevention efforts for AGYW is encouraging, there remains a need to rigorously evaluate combination prevention packages, particularly for this population [5], to close the 'implementation gap' [16,17] and determine whether they can be implemented as intended to those most in need, scaled-up and sustained in real-world, non-trial conditions.

Studies evaluating early implementation of DREAMS in Kenya and South Africa reported promising levels of awareness and participation in DREAMS by 2017, although there were challenges in reaching some AGYW considered particularly vulnerable to HIV acquisition for example, those who were older, out of school, or sexually active [18–21]. Given the complexity of the broad intervention package and need for multisectoral collaboration, DREAMS took time to roll out [22]. Understanding whether, over time, implementers were able to widen their reach and enrol more at-risk AGYW, and better deliver integrated interventions, is imperative to inform the expansion of multisectoral programming for HIV prevention [12,23].

Using representative population-based cohorts of AGYW in three diverse settings, we sought to evaluate changes over time in awareness and uptake of DREAMS interventions, layering of interventions and the profile of AGYW reached by the programme after 3 years of implementation.

Methods

Evaluation settings

Independent evaluations of DREAMS were conducted in urban informal settlements in Nairobi, rural Gem in Siaya western Kenya and rural uMkhanyakude in KwaZulu-Natal, South Africa [23]. These settings have historically high HIV prevalence and incidence [24–28] and longstanding health and demographic surveillance systems (HDSS): Nairobi Urban HDSS (NUHDSS) run by the African Population and Health Research Center [29]; the Kenya Medical Research Institute HDSS in western Kenya [30]; and the African Health Research Institute HDSS in uMkhanyakude [31].

Implementation of Determined, Resilient, Empowered, AIDS-free, Mentored and Safe Interventions

DREAMS interventions were introduced in 2016 in all study settings. Roll-out was staggered, and by January 2017 all interventions other than pre-exposure

prophylaxis (PrEP) were underway [22]. As of 2019, DREAMS interventions were still being delivered and refined in Kenya. For example, the sub-set of 'primary' interventions selected by each country evolved and narrowed over time [32]. Primary interventions constituted a minimum set of interventions that all AGYW in their age group should receive, if invited to participate in DREAMS. In Kenya, a minimum set of eight was defined in 2017 but was soon updated to seven [32]. In uMkhanyakude, five were selected initially; updated to four in late 2018 [32]. By late 2018, PEPFAR investments in DREAMS interventions were withdrawn in uMkhanyakude [33] (interventions that were new with DREAMS investments were no longer delivered, while those built on preexisting infrastructure that were not new with DREAMS, for example, HIV testing and contraception services, remained in place and continued to be implemented through the Department of Health).

DREAMS implementing partners (IPs) identified AGYW living in each DREAMS district and context-specific factors associated with vulnerability to target DREAMS interventions [12]. In Kenya, the 'Girl Roster' census method was used to enumerate and invite AGYW considered at greatest risk (examples of targeting criteria included those pregnant, school-age but out of school, orphaned, food insecure or from poor households) to participate in DREAMS [34]. The Girl Roster is a succinct questionnaire tool that collects information on age, marital status, child-bearing, schooling and living arrangements, enabling rapid segmentation of AGYW into different risk profile groups including those considered 'off-track' and at particularly high risk. As the number of AGYW identified as eligible for DREAMS through the Girl Roster exceeded resources, this method was supplemented by consultation with experienced community-based organizations to identify those at greatest risk. AGYW were invited through door-to-door home-visits followed by enrolment interviews. In South Africa, following a national prioritization exercise in which uMkhanyakude was selected for DREAMS investments, IPs collaborated with community-based organizations, school staff, health and social workers to identify vulnerable AGYW, using their registers and networks of orphans and vulnerable children/households [33]. IPs continued to recruit AGYW for DREAMS through 2018, while earlier invitees remained eligible to receive interventions.

Evaluation design, procedures and dates

Closed cohorts of AGYW were randomly selected from general population cross-sectional surveys embedded within each HDSS and followed-up annually for 2 years [23]. In uMkhanyakude and Gem, cohorts were enrolled at age 13–17 and 18–22 years, so they would age into DREAMS target age-bands 15–19 and 20–24 years by end of follow-up. In Nairobi, cohorts were enrolled at age 10–14, 15–17 and 18–22 years, with findings presented elsewhere for the youngest age group [35]. Cohorts were enrolled during March–July 2017 in Nairobi, May 2017–February 2018 in uMkhanyakude and January–October 2018 in Gem (Supplemental Digital Content Fig 2, http://links.lww.com/QAD/C381). Cohorts were followed-up in July–December 2018 and May–August 2019 in Nairobi; April–August 2018 and May–October 2019 in uMkhanyakude; and January–November 2019 in Gem. Between 3 and 6 attempts were made to follow-up participants. In Nairobi and uMkhanyakude, those who were not found in 2018 were visited again in 2019. Efforts to reduce selection bias included intensive tracing, recruitment and follow-up, with dedicated tracking and interviewing teams.

Data capture

Participants were interviewed using a structured questionnaire, administered by trained field staff via tablet devices. Questionnaires were designed to reflect the local context, though were harmonized across settings to capture overall awareness of and self-reported invitation to participate in DREAMS, recent usage of individual DREAMS interventions, sociodemographic/economic characteristics and sexual/pregnancy history.

Analysis

We described proportions of participants who reported awareness ofDREAMS, being invited to participate and participating in DREAMS interventions. We categorized interventions using the DREAMS core package framework [12], to facilitate comparisons across settings, and using country-specific packages of primary interventions [32].

'Layering' of combinations of interventions was assessed by summarising: firstly, participation in intervention categories from across more than one 'level', for example, individual-level interventions PLUS family-level interventions, secondly, number of primary interventions categories accessed and the proportion that received the complete package of primary interventions (seven intended for AGYW in Kenya; five in South Africa, over the time-frame of the evaluation).

Analyses were conducted using *Stata16* and stratified by setting, age at enrolment and invitation to participate in DREAMS. To summarize changes over time, cross-sectional snapshots of participation (in the last 12 months) reported at each round of interview were used. In addition, *cumulative* participation in an intervention category (in the last 12 months) reported in *any* interview round, was analysed to reflect the staggered delivery and concept of completion of some interventions [22]. Stratifying analyses by year of invitation to DREAMS also enabled us to assess how patterns of participation varied over time. We defined a four-category variable – never invited, invited in 2017 only, invited in 2018 only, invited in 2017 and 2018 – and a binary variable – never

invited, vs. invited to participate by 2018 (invitation reported in 2017, 2018 only, or both 2017 and 2018). For those followed-up in 2019 but not in 2018, we used invitation status reported in 2017 and 2019 to infer status by 2018. For Gem, where cohorts were enrolled in 2018, we analysed a binary variable of not invited vs. invited in 2018. We defined invitation to participate up to 2018, as DREAMS IPs extended few new invitations beyond 2018 (those invited continued to be offered interventions during the timeframe of our evaluation).

We compared AGYW profiles of those who self-reported being invited to DREAMS by 2018 vs. never invited, in order to document who, in practice, was reached by DREAMS. In uMkhanyakude and Nairobi, we distinguished between those invited to DREAMS in 2017 and newly invited in 2018, to assess how targeting of AGYW changed over time. Characteristics described included sociodemographic variables, pregnancy history, schooling and socioeconomic vulnerabilities, such as food insecurity that were used by DREAMS IPs to identify AGYW for DREAMS interventions. We then conducted multivariable logistic regression analyses of characteristics associated with invitation to participate in DREAMS by 2018. Variables associated ($P < 0.1$) with the outcome after age adjustment were included in the final multivariable models.

Ethics

Approvals were granted by research ethics committees at the London School of Hygiene and Tropical Medicine (reference 11835), the University of KwaZulu-Natal, Amref Health Africa and the Kenyan Medical Research Institute. Written informed consent was obtained from participants aged $\geq$ 18 years. For legal minors $<$ 18 years, assent with guardian consent was taken.

Results

Participants

Out of 1770 resident AGYW aged 15–22 years who were eligible to participate in Nairobi, 1081 (61%) were enrolled in 2017 (Supplemental Digital Content Table 3a–c, http://links.lww.com/QAD/C382). Of these, 852 (79%) were followed up in 2019. In uMkhanyakude, 86% (2184/2527) were enrolled and 78% (1712/2184) were followed up. In Gem, 93% (1171/1258) were enrolled (in 2018) and 87% (1018/1171) were followed up.

Patterns of loss to follow-up were similar across settings (Supplemental Digital Content Table 4a–c, http://links.lww.com/QAD/C383). AGYW who reported being invited to participate in DREAMS at cohort enrolment were statistically more likely to be followed-up in 2019 than noninvitees. Older AGYW, those sexually active, ever pregnant, out of school, and food secure, were less likely to be followed-up. Some of these associations remained after adjustment for age. Across almost all categories of AGYW characteristics, more than 65% were followed-up.

Among cohort participants followed-up in 2019: more than one of three were from the lowest SES households, and more than 20% reported food insecurity at enrolment across all settings (Table 1). Most (~90%) AGYW aged 13 or 15 to 17 were not sexually active (Supplemental Digital Content Table 5, http://links.lww.com/QAD/C384). The majority of those aged 18–22 reported ever having sex, and 51% or less were ever pregnant (uMkhanyakude; 46% Nairobi; 36% Gem). High proportions of AGYW aged $<$ 18 years were in school – virtually all in uMkhanyakude – and the majority of those aged $\geq$ 18 years had at least some secondary education in each setting.

Awareness and Invitation to Participate

Proportions aware of and invited to participate in DREAMS increased over time. Overall awareness rose to $\geq$ 83% cumulatively by 2018 and $\geq$ 92% by 2019 across all settings (Fig. 1). Awareness was highest in Kenya, and among younger AGYW (e.g. 94% by 2019 for those aged 13–17 vs. 88% for age 18–22 years in uMkhanyakude).

Across settings, cumulatively by 2018, 57% were invited in Gem; 74% in Nairobi (53% invited by 2017 and 21% newly invited in 2018); and 53% in uMkhanyakude (31% by 2017 and 22% in 2018) (Table 1; Supplemental Digital Content Table 5, http://links.lww.com/QAD/C384). In Nairobi and uMkhanyakude, compared with those invited by 2017, greater proportions of AGYW newly invited in 2018 were aged 18–22 years, out of school, ever married (Nairobi), ever had sex/pregnant, from medium-to-higher SES households and had migrated (uMkhanyakude). Proportions food insecure were higher comparing those newly invited in 2018 to those invited by 2017 in uMkhanyakude but lower among new invitees in Nairobi.

Cumulatively by 2018, a greater proportion of AGYW aged 13 or 15 to 17 years at enrolment had been invited compared with those aged 18 to 22 years (80 vs. 67%, Nairobi; 58 vs. 56%, Gem; 63 vs. 40%, uMkhanyakude) (Supplemental Digital Content Tables 6a–c, http://links.lww.com/QAD/C385). After adjusting for age and other factors, characteristics associated with higher odds of invitation to participate in DREAMS by 2018 included: younger age (uMkhanyakude), current schooling and/or secondary-level education (all settings), low SES (Gem and uMkhanyakude), food insecurity (Gem and Nairobi), receipt of a government grant (uMkha-nyakude), never had sex (Gem), never been married (Nairobi), rural residence (uMkhanyakude) and informal settlement subsite (Nairobi) (Supplemental Digital Content Tables 6a–c, http://links.lww.com/QAD/C385).

Table 1. Enrolment profile (characteristics at cohort enrolment) among adolescent girls and young women followed up in 2019, by invitation to participate in Determined, Resilient, Empowered, AIDS-free, Mentored and Safe interventions, in three settings.

Characteristics at cohort enrolment	Gem			Nairobi				uMkhanyakude			
	All (*N* = 1018)	Never invited (*N* = 436)	Invited in 2018 (*N* = 582)	All (*N* = 852)	Never invited (*N* = 224)	Invited by 2017[a] (*N* = 452)	Newly invited in 2018 (*N* = 176)	All (*N* = 1712)	Never invited (*N* = 809)	Invited by 2017[a] (*N* = 528)	Newly invited in 2018 (*N* = 375)
Overall (row%)	*100* col%	42.8 col%	57.2 col %	*100* col%	26.2 col%	53.1 col%	20.7 col%	*100* col%	47.3 col%	30.8 col%	21.9 col%
Age group											
13/15–17	61.1	59.9	62.0	54.5	42.4	61.7	51.1	56.8	45.0	75.0	56.5
18–22	38.9	40.1	38.0	45.5	57.6	38.3	48.9	43.2	55.0	25.0	43.5
Currently in school											
No				36.6	48.7	27.2	45.5	21.0	30.7	8.0	18.4
Yes				63.4	51.3	72.8	54.5	79.0	69.3	92.1	81.6
Education completed											
None/primary	42.7	40.1	44.7								
Secondary/tertiary	36.5	32.8	39.3								
Unknown[b]	20.7	27.1	16.0								
Education completed											
None/incomplete primary				10.8	13.4	9.3	11.4	10.3	8.3	13.1	10.7
Primary/incomplete secondary				68.1	58.0	73.7	66.5	77.3	73.1	81.8	80.0
Secondary/tertiary				21.1	28.6	17.0	22.2	12.4	18.6	5.1	9.3
Ever had sex											
No	68.9	64.0	72.5	65.4	55.8	74.3	54.5	63.4	54.2	77.0	63.5
Yes	31.1	36.0	27.5	34.6	44.2	25.7	45.5	36.7	45.8	23.0	36.5
Ever pregnant											
No	84.4	81.4	86.6	75.9	67.4	83.6	67.1	75.2	67.8	87.8	73.5
Yes	15.6	18.6	13.4	24.1	32.6	16.4	33.0	24.8	32.3	12.2	26.5
Food insecure[c]											
No	77.5	82.6	73.7	66.2	74.1	59.3	73.9	68.8	65.4	77.8	63.6
Yes	22.5	17.4	26.3	33.8	25.9	40.7	26.1	31.2	34.6	22.2	36.4
Socioeconomic status[d]											
Low	41.7	36.0	45.9	35.6	34.4	37.8	31.3	35.9	32.2	41.4	36.3
Medium	19.2	19.0	19.2	32.5	35.3	31.6	31.3	35.0	36.1	32.4	36.3
High	39.2	45.0	34.9	31.9	30.4	30.5	37.5	29.1	31.8	26.2	27.5
Marital status											
Never married				81.6	71.9	89.2	74.4	99.9	99.9	100.0	100.0
Married				18.4	28.1	10.8	25.6	0.1	0.1	0	0
Migrated[e]											
No								83.6	80.1	89.2	83.5
Yes								16.4	19.9	10.8	16.5

[a]Reported being invited in 2017, or both 2017 and 2018.
[b]Unknown category includes those who could not be linked to demographic surveillance data or did not provide education status in demographic surveillance data.
[c]Nairobi-Girl/household member went to sleep hungry because as there was not enough food in the last 4 weeks; uMkhanyakude – any report of reducing the size of food portions or skipping meals by any member of household as there was not enough money to buy food in the past 12 months.
[d]Wealth index, derived using principal component analysis with input variables including, for example, individual/household assets and household structure; 40 missing values overall for socioeconomic status in uMkhanyakude.
[e]Any migration within/outside surveillance area since age 13.

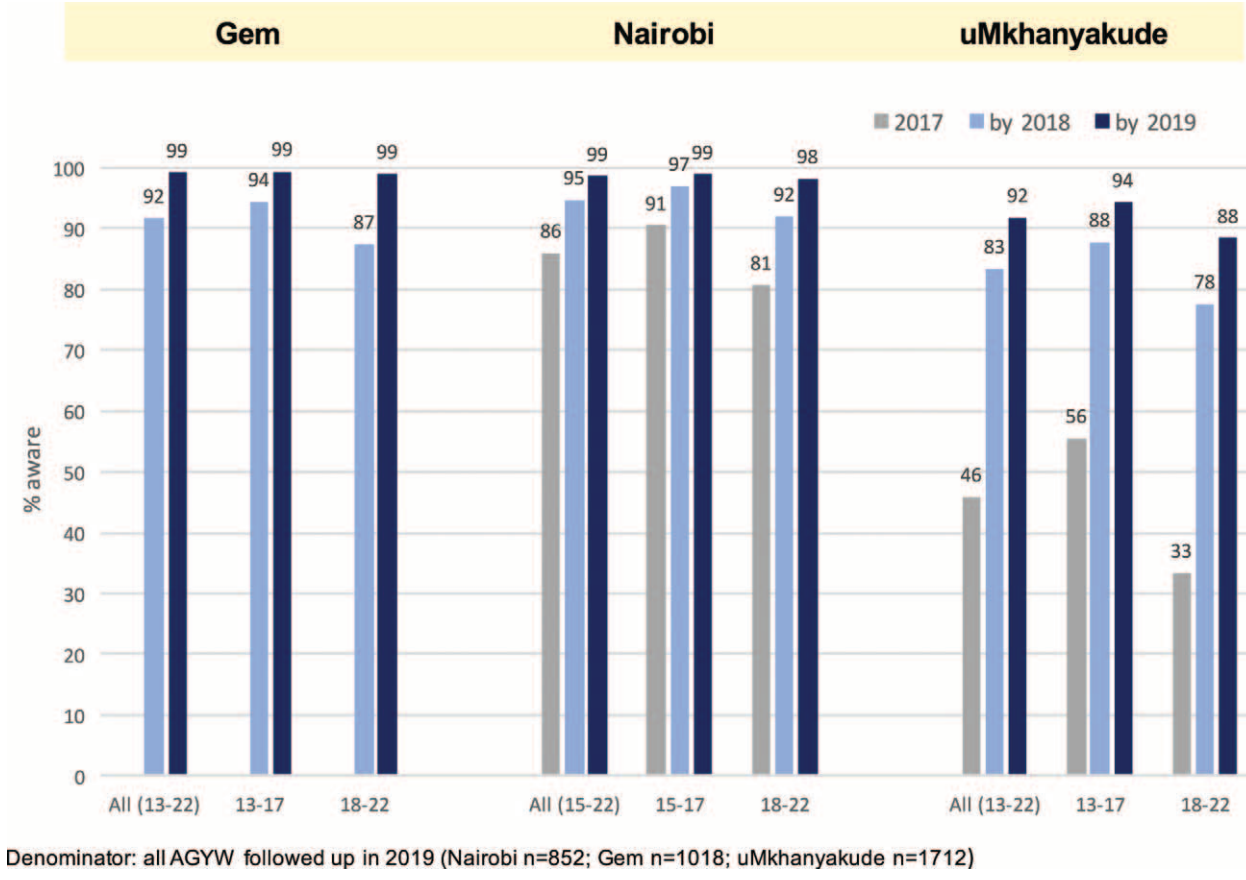

Fig. 1. Cumulative awareness of the Determined, Resilient, Empowered, AIDS-free, Mentored and Safe programme over time, by age group at enrolment and setting.

Uptake of Determined, Resilient, Empowered, AIDS-free, Mentored and Safe core package categories

For all settings, cumulative uptake of all core package categories by 2019 was higher among those invited to participate by 2018 compared with those never invited, with an increasing trend by length of participation in DREAMS (Fig. 2). Differences in uptake between those invited and not invited were greatest for novel DREAMS interventions. For example, in Nairobi, 76% of AGYW reporting invitation in 2017 and 2018 accessed social asset building vs. 9% among those never invited (Fig. 2).

The most accessed core package categories were HIV testing services (>80% in all settings by 2019 among those invited by 2018), social protection (≥65%) and school-based interventions, particularly in younger AGYW (e.g. ≥ 97% in uMkhanyakude, regardless of invitation status) (Fig. 2; Supplemental Digital Content Fig 7a–c, http://links.lww.com/QAD/C386). Usage of HIV testing, contraception and condom interventions (including counselling and product use) was generally higher among AGYW aged ≥ 18 years vs. those < 18 years whereas younger AGYW more frequently accessed social asset building and school-based interventions (Supplemental Digital Content Fig 7a–c, http://links.lww.com/QAD/C386). However, uptake of contraception and condom interventions was fairly low in Gem, even among older AGYW (<50% among those invited; not much higher than for noninvitees). Uptake of parenting and social protection programmes were highest in uMkhanyakude (84 and 96%, respectively among those invited in 2017 and 2018; 39 and 79% among those never invited). Education and provision of PrEP was low in all settings by 2019 (9% among those invited to DREAMS in 2018 in Gem; 26 and < 1% among those invited in 2017 and 2018 in Nairobi and uMkhanyakude, respectively).

Recent usage (previous 12 months) of core package categories reported by all participants, regardless of DREAMS invitation status, generally trended upwards or stayed at similar levels from 2017 to 2019 (Supplemental Digital Content Fig 8a–c, http://links.lww.com/QAD/C387). There were slight falls in social asset building, community mobilization and school-based interventions in uMkhanyakude and Nairobi in 2019, as well as postviolence care in Nairobi, back to or below levels of uptake in 2017.

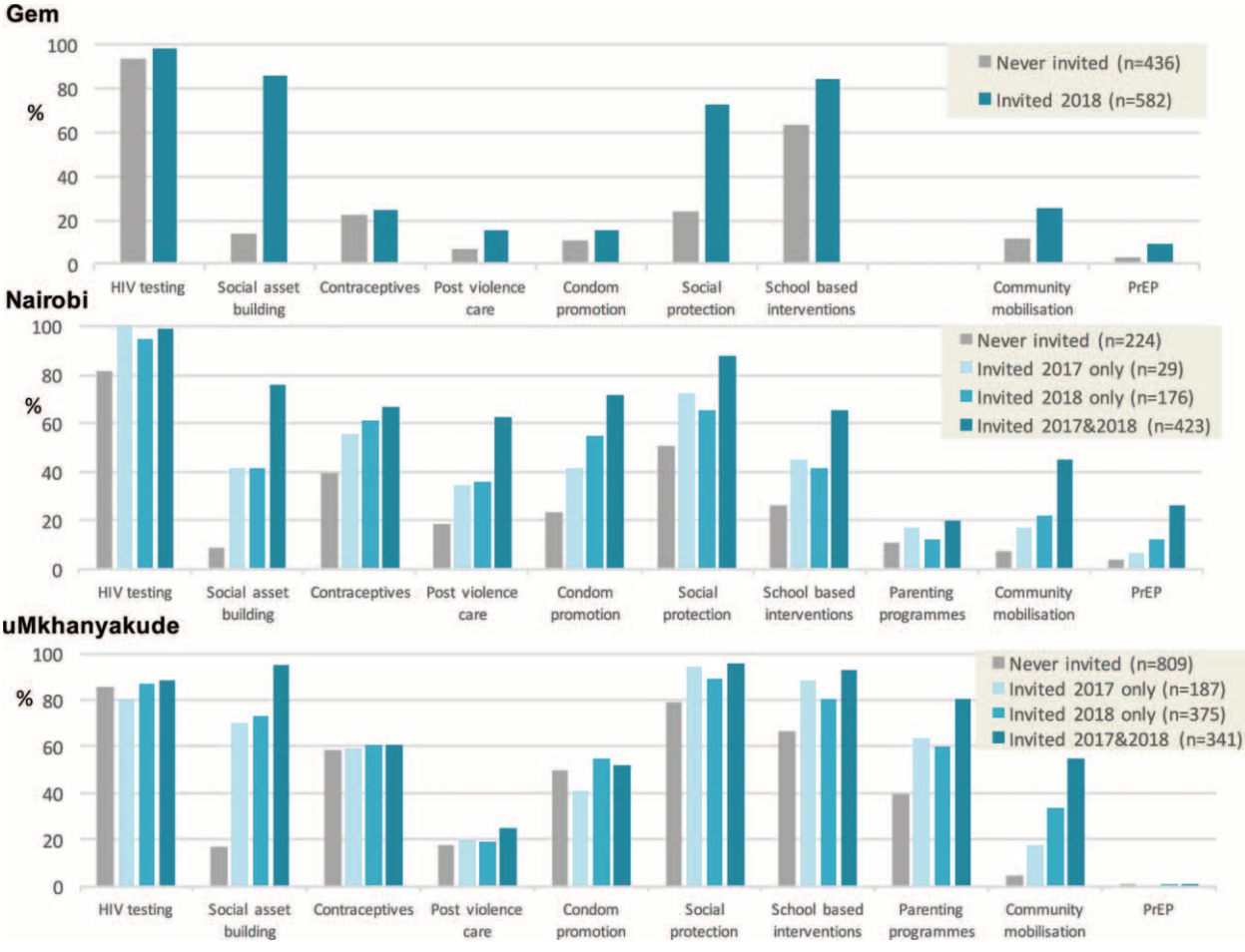

Fig. 2. Cumulative uptake∗ of Determined, Resilient, Empowered, AIDS-free, Mentored and Safe core package categories by 2019, by year of invitation to participate and by setting. *Uptake defined as participation in any intervention in the category reported in 2017 or 2018 or 2019. Postviolence care services are defined as provision of counselling and services after an experience of any kind of violence, such as HIV or sexually transmitted infection screening, or linkages to legal services. Condom, contraceptive and PrEP intervention uptake are defined as counselling/information and/or product use (in uMkhanyakude, PrEP uptake refers to product use and was only intended for sex workers). Parenting programmes were not captured in the surveys in Gem. Refer to Supplemental Digital Content, Fig 1, http://links.lww.com/QAD/C380 for further examples of interventions included in each core package category.

Uptake of combinations of interventions

By 2019, ≥ 98% of AGYW invited to DREAMS by 2018 across all settings had accessed interventions from at least one core package category; 91% or more at least 2 core package categories and 66% or more at least 3 core package categories.

Receipt of combinations of interventions across levels – individual, family and community – increased by year of reported invitation to DREAMS (Fig. 3). For example, among AGYW who accessed at least one intervention in uMkhanyakude in 2018, 71% of those invited into DREAMS in 2017 and 2018 accessed interventions from all three levels (31% ofthose never invited; 50% invited in 2017 only; 57% invited in 2018 only). Usage across levels was higher among AGYW aged 13 of 15–17 years vs. those aged 18–22 years in uMkhanyakude and Nairobi but was similar between age groups in Gem.

A minority of AGYW invited to DREAMS by 2018 accessed all primary interventions designated for their age by 2019 (Fig. 4). In Nairobi, 12% of those aged 15 to 17 years at enrolment and 15% of those aged 18 to 22 years accessed all seven primary interventions; 2 and 5% in Gem, respectively; 24 and 29% in uMkhanyakude, respectively for all five primary interventions. Over 70% of AGYW invited by 2018 had accessed at least three primary interventions in each setting and age-group.

Discussion

A complex, combination HIV prevention intervention delivered through the DREAMS partnership was taken up by high proportions of AGYW living in three diverse settings. Reach was particularly high among younger

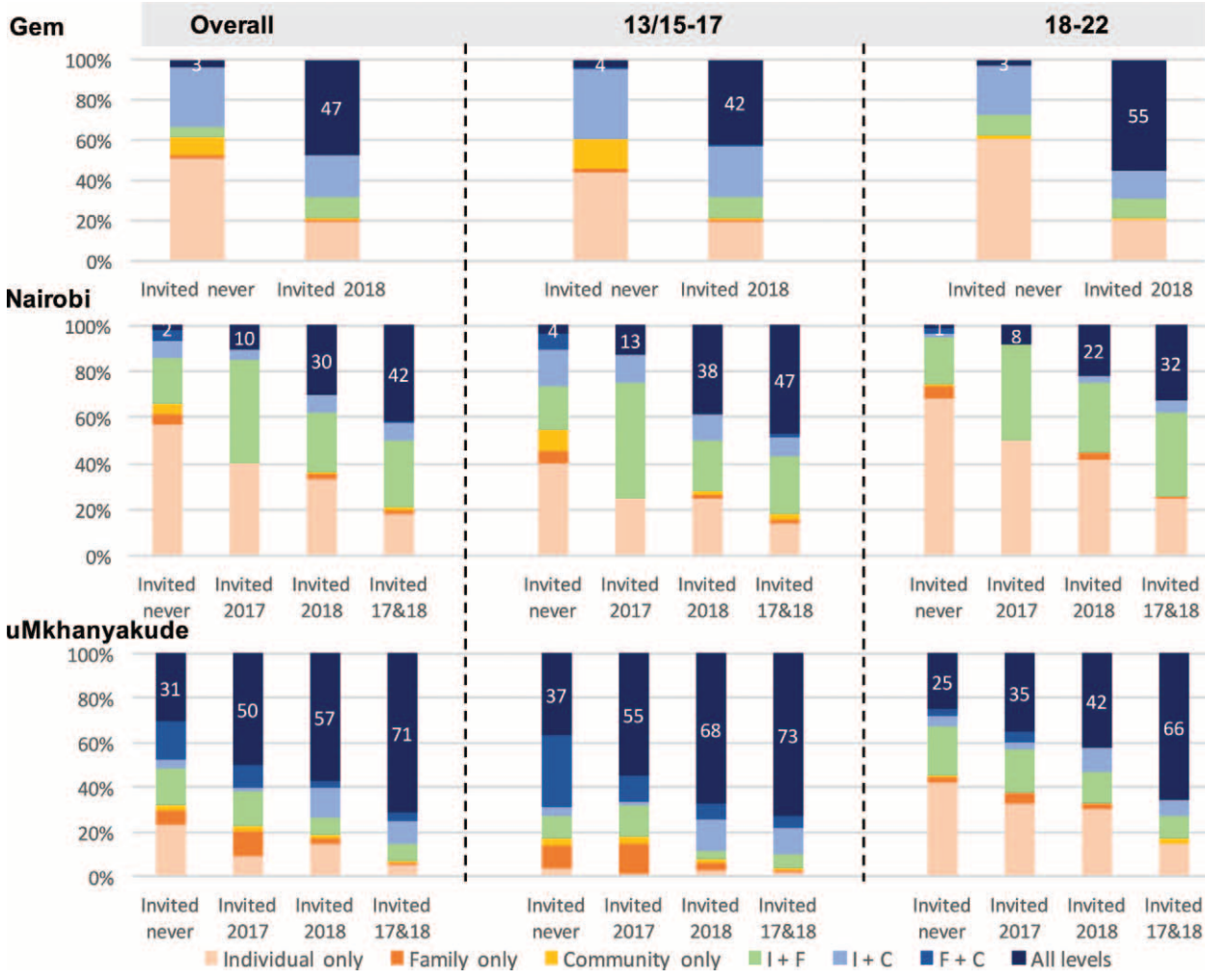

Fig. 3. Uptake∗ of Determined, Resilient, Empowered, AIDS-free, Mentored and Safe core package levels in 2018 by invitation to participate in DREAMS and by setting. *Uptake defined as participation in the last 12 months as reported in 2018. Denominator: AGYW followed up in 2019 who accessed at least one core package category (Nairobi = 649; Gem = 922; uMkhanyakude $N = 1511$).

adolescents, and those from socioeconomically vulnerable backgrounds. Participation in combinations of individual and community-level interventions improved over time, and the majority of DREAMS beneficiaries participated in at least three intervention categories. However, uptake of the complete primary packages prioritized for each age group and setting remained low.

DREAMS rolled out from early 2016, and as of 2018, beneficiaries were more likely to be younger, in school and have more socioeconomic vulnerabilities than nonbeneficiaries, and less likely to be sexually active. Although this profile is consistent with assessments of DREAMS' early implementation [18–21,36], longer term follow-up in this study showed that IPs broadened their reach and recruited more AGYW with HIV/sexual risk characteristics, such as those out-of-school, sexually active, ever pregnant, or married. How to define those at risk and target them with interventions, and the value of targeting vs. promoting broader more equitable approaches, are still debated. Although the greatest and more immediate impacts of DREAMS maybe achieved by reaching those currently at (sexual) risk, reaching those who are socioeconomically vulnerable before their sexual debut may be a valuable longer-term investment. Calls for countries to invest widely in adolescent health initiatives across diverse sectors [37] provide an opportunity to strengthen interventions appropriate for all AGYW (e.g. school-based interventions), and to focus HIV investments on delivery of more intensive intervention packages to AGYW based on individual risk differentiation.

By 2019, most DREAMS beneficiaries had received interventions from ≥3 core package categories, and the majority had accessed ≥3 primary interventions for their setting. High engagement with DREAMS interventions has been reported by other evaluation efforts [36]. Our

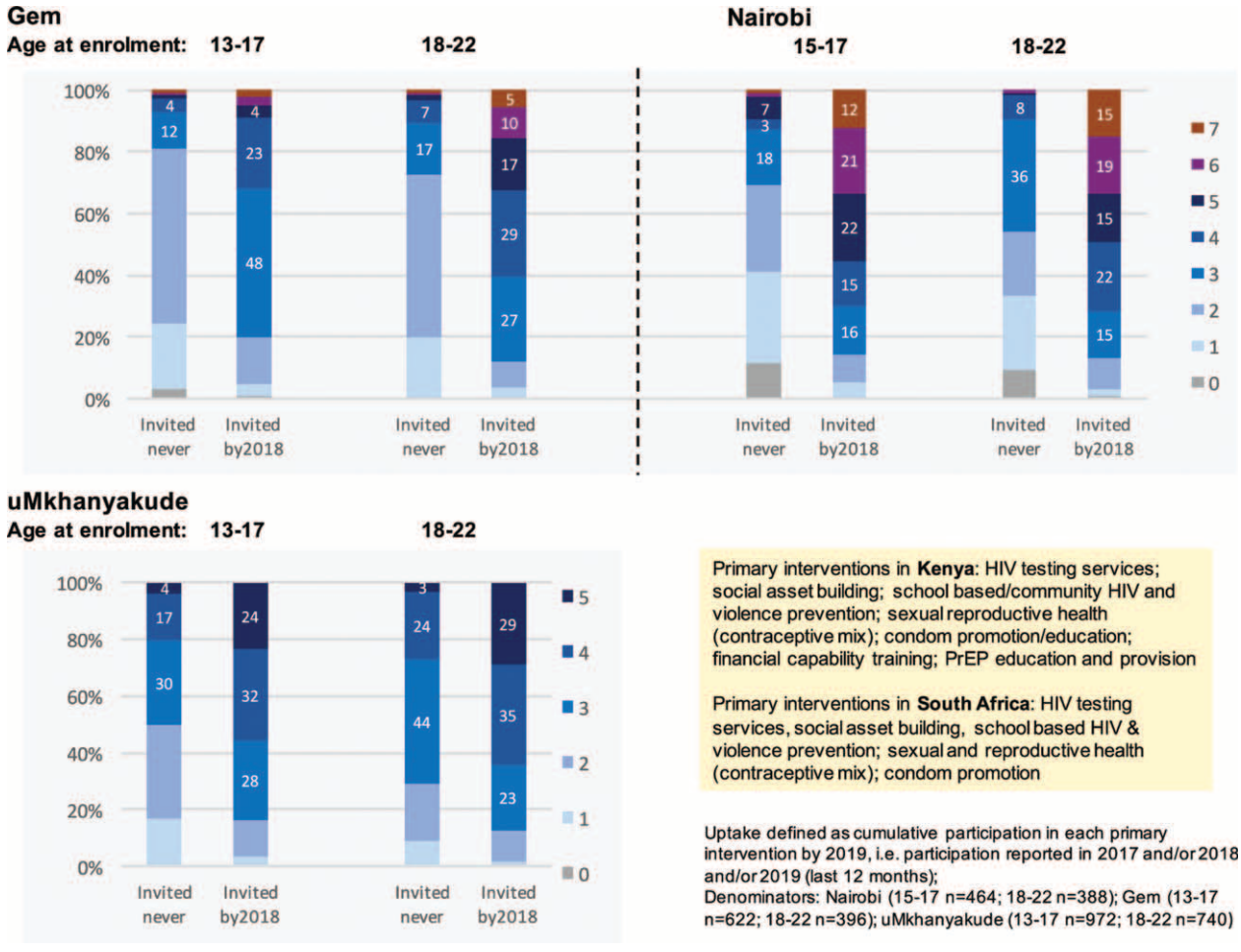

Fig. 4. Number of primary interventions accessed by 2019, by age group at enrolment, invitation to participate in DREAMS, and setting.

analyses further unpacked *how* interventions were combined across *levels* of the core package, revealing high uptake across individual- plus contextual-levels, increasing with duration since DREAMS invitation. Improvements in layering over time are clear when comparing to earlier findings as of 2017 [18]. These improvements likely reflect the staggered roll-out of interventions, and the time it took to scale-up and make adaptations to interventions [22]. Layering was identified as a key challenge by IPs and through early analyses of US Government monitoring and evaluation data, so efforts were subsequently made to strengthen coordination and delivery of multiple interventions. A need was also identified to better engage with older AGYW who had more competing demands on their time, often balancing work and caring for their families; IPs attempted to adapt interventions accordingly, for instance, expanding session hours to evenings or weekends, although engagement with older AGYW has remained a challenge.

Despite strong evidence for layering, over 2–3 years, a minority accessed all intended primary interventions, particularly in Kenya where the package constituted more interventions than in South Africa. Similar findings have emerged in other DREAMS settings [38]. This may reflect the scale of programming efforts and strain on resources to reach high numbers of vulnerable individuals with all primary interventions [22,33,38]. Primary interventions were operationalized later in 2017, evolving over time. Layering with the complete primary package may take more time, and require regular engagement with beneficiaries. A study using DREAMS programme data in western Kenya reported that most 'active' beneficiaries accessed the full primary package over 4 years [39]. There remains an opportunity to strengthen delivery of the DREAMS primary packages through clear guidance and discussion with IPs, and engagement with DREAMS beneficiaries and mentors in the delivery of interventions [33]. Detailed mixed-methods analyses would also enable in-depth exploration of the 'journeys' that AGYW undertook as they participated in DREAMS and navigated the sets of interventions, for a fuller understanding of how layering was implemented in practice, to feed into recommendations for programming.

Access to HIV testing, social protection and school-based interventions was high by 2019, and higher among those invited to DREAMS vs. those never invited. Improvements in uptake of these interventions are almost certainly attributable to DREAMS funding. Scale-up may have been particularly efficient as they built on pre-existing infrastructure and/or capitalized on previous experience of IPs [22,33]. New opportunities to link to interventions including HIV testing were also promoted through DREAMS entry points, such as safe spaces [12]. High 'background' levels of testing, social protection, school-based and condom/contraception interventions among nonbeneficiaries may reflect access through pre-existing, routine programmes (e.g. antenatal care). In Gem, background HIV testing levels may also reflect home-based testing offered as a service through the research platform. Reasons for low and variable uptake of some interventions require further investigation, although low uptake in Gem of contraception/condom promotion and provision interventions may reflect supply issues [40]. Downturns at the population level in participation in some interventions in 2019, including school-based interventions, is likely explained by completion of curricula and cohort ageing, although in uMkhanyakude, termination of DREAMS funding may partially explain the observed trends.

Very high uptake of novel DREAMS interventions, such as safe spaces, demonstrated the feasibility of rapidly scaling-up new services. Uptake of other DREAMS interventions that were new to these settings, including community-based (e.g. Stepping Stones, SASA!) and parenting (e.g. Families Matter Programme) programmes, was generally weaker in Kenya than uMkhanyakude. This may reflect the different models of delivery by setting, with multiple IPs contracted to deliver services, which matched their expertise in South Africa, while in Kenya, one or two IPs delivered the whole package of services [22]. Furthermore, in South Africa, IPs sub-contracted community-based organizations, which had longstanding relationships with the community, and strong links with municipal and traditional community leaders. Delivery of some curriculum-based interventions was also done through schools in South Africa, where secondary school retention is high, offering a feasible way of reaching communities of AGYW in this setting. PrEP was introduced later than other DREAMS interventions, and was intended for AGYW at the highest risk (and was only offered to sex workers in South Africa), partially explaining the low uptake (product use and education). However, lost opportunities to deliver PrEP among hard-to-reach AGYW have also been reported [33,41].

Study strengths were the random selection of population-based cohorts from extensive demographic platforms, high levels of follow-up and detailed data collected on exposure to DREAMS using harmonized tools. Nonetheless, standardization across settings was not always possible because of context-specific differences in DREAMS implementation and data collected. Cohorts in Gem were enrolled in 2018, limiting the cross-setting comparability of cumulative uptake over time. Loss to follow-up was differential by AGYW characteristics, which may have introduced selection bias and over-estimated participation in DREAMS interventions by 2019. However, overall proportions followed-up were high, likely reducing the degree of bias. We relied on self-reported data, and the proportion defined as beneficiaries may be underestimated if AGYW did not self-identify as DREAMS invitees. Overall awareness of DREAMS may be slightly over-estimated in these study cohorts, because of them being recruited specifically for the evaluation of DREAMS, though this would not have influenced the change observed in awareness over time. Although our findings provide useful lessons for other settings, they may not be generalizable to all DREAMS districts.

Our findings strengthen the limited body of evidence for whether complex interventions can be implemented and scaled-up in real-world settings, particularly among young populations. We showed that, over time, high proportions of AGYW were aware of and reached by DREAMS programming. This included AGYW with socioeconomic markers of vulnerability, and although targeting improved, challenges remained in reaching AGYW who would have benefitted from DREAMS interventions based on sexual risk factors. Layering with combinations of interventions improved over time, although opportunities remain to strengthen delivery and ensure all AGYW receive the appropriate set of primary interventions. Lessons continue to be learned about how to improve delivery of, and engagement with, DREAMS and similar programmes, with insights from process evaluation research.

Acknowledgements

We thank Beatrice Maina, Elvis Wambiya, Silvia Njoki, Jaco Dreyer, Thembhlehle Zuma and Sammy Khagayi for their contributions to this research. The African Population and Health Research Center would also like to acknowledge the support and cooperation of the community under the NUHDSS. The Africa Health Research Institute would also like to acknowledge the support and help of the research assistants who collected the data, research administrators, especially A. Jalazi and S. Mbili, for their commitment to the study. We also extend our appreciation to our research community including the community advisory boards in uMkhanyakude district.

I.B. and S.F. led the evaluation study and A.Z., D.K. and M.S. led the study implementation in Nairobi, Gem and uMkhanyakude, respectively. I.B., S.F. and A.G.

conceived the article and designed plans for analysis. A.G. led the execution of analyses with contributions from S. M., N.M., F.M., and M.O.. N.C., J.O. and V.K. oversaw data collection and contributed to interpretation of findings. A.G. wrote the first draft of the manuscript, while I.B., S.F. and S.M. contributed to the second draft. All authors contributed to subsequent drafts and approved the final manuscript.

Sources of funding support: the impact evaluation of DREAMS is funded by the Bill and Melinda Gates Foundation (OPP1136774, http://www.gatesfoundation.org). Foundation staff advised the study team but did not substantively affect the study design, instruments, analysis, data interpretation, decision to publish, or writing of the manuscript. Partner institutions also received funding for their demographic surveillance platforms and associated data collection activities (but their funders did not influence the evaluation study design, analysis, data interpretation, decision to publish or writing of the manuscript): the African Population and Health Research Center acknowledges the generous financial support to the NUHDSS in which the DREAMS Impact Evaluation is nested and which enabled identification of study participants. The NUHDSS is partly funded by SIDA: Grant #54100113. The Africa Health Research Institute acknowledges that this work was supported by the National Institutes of Health under award number 5R01MH114560-03. The Africa Health Research Institute is also supported by a grant from the Wellcome Trust (082384/Z/07/Z).

Conflicts of interest

There are no conflicts of interest.

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