EVALUATING THE EVIDENCE FOR HISTORICAL INTERVENTIONS HAVING REDUCED HIV INCIDENCE:

A RETROSPECTIVE PROGRAMMATIC MAPPING MODELLING ANALYSIS

SYNOPSIS REPORT 2016

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ABBREVIATIONS

AIDS	Acquired immune deficiency syndrome
ANC	Antenatal clinic/s
ARV	Antretroviral
ART	Antiretroviral Therapy
BSS	Behaviour Surveillance Surveys
CONAVIHSIDA	Consejo Nacional para el VIH y el SIDA
COPRESIDA	Consejo Presidencial de SIDA
DHS	Demographic and Health Survey
DIGECITSS	Dirección General de Control de Infecciones de Transmisión Sexual SIDA
FSW	Female Sex Worker
HIV	Human immunodeficiency syndrome
MICS	Multiple Indicator Cluster Survey
MSM	Men who have sex with men
RCT	Randomised Clinical Trial
UNAIDS	Joint United Nations Programme on HIV and AIDS
UNFPA	United Nations Population Fund
VMMC	Voluntary medical male circumcision
WHO	World Health Organisation

1. INTRODUCTION

Between 2001 and 2011, HIV incidence was reported to have declined by >50% across 25 countries (13 of which are in sub-Saharan Africa).[1] Since 2001, the sharpest declines in HIV incidence have been observed across sub-Saharan African (25%) and the Caribbean (42%).[1]

A comprehensive review of empirical and modelled HIV incidence trends across 20 countries in Sub-Saharan Africa between 1990 and 2012 found that the decline in incidence commenced prior to the introduction of ART programmes from 2004.[2]

Prior to the availability of antiretroviral therapy (ART), changing an individual's sexual risk behaviour was the focus of many intervention programmes and determining whether these have resulted in reduced HIV transmission is essential if lessons are to be learnt and successful programmes identified.

However, variation in prevalence trends observed in surveillance data can occur as a consequence of changes in natural transmission dynamics over time. During epidemic maturation, HIV transmission saturates among those with high rates of partner change and the average incidence subsequently decreases. A decline in prevalence observed in surveillance data can therefore occur as a consequence of natural epidemiological dynamics in the absence of changes in sexual risk behaviour and cannot be automatically attributed to a successful intervention programme.

Under natural epidemic dynamics, transmission during the early phase of the epidemic occurs rapidly within a small group of people with an increased rate of change in sexual partners, which places them at higher risk of HIV acquisition. As the epidemic matures, transmission within this small group of people with an increased risk of HIV acquisition saturates and incidence begins to stabilise. Transmission continues to occur within a larger group of people with a lower risk of HIV acquisition (who constitute the majority of the general population), but at a much slower rate due to their lower rate of change in sexual partners. People with a higher risk of HIV acquisition are selectively removed from the population as a consequence of experiencing AIDS-related mortality at a greater rate than people with a lower risk of HIV acquisition. However, clinical progression and the associated decline in immune function can span a decade[3] and AIDS-related mortality is therefore significantly delayed after initial infection. This creates a time lag between any change in incidence and its associated change in AIDS-related mortality. Heterogeneity in the risk of HIV acquisition therefore influences the trajectory of the HIV epidemic in two ways; people with a higher risk of HIV acquisition cause an early peak in prevalence resulting from rapid transmission and increased incident infections and as the epidemic matures, a delayed reduction in prevalence as a result of subsequent AIDS-related mortality. Following this peak in AIDS-related mortality and in the absence of any other influences, prevalence can plateau as incident infections and AIDS-related mortality reach equilibrium. This is conditional on the reproduction number, defined as the average number of secondary cases that a typical case of an infection generates over the course of their infectious period, being greater than one.

However, there are many complex forces that interact simultaneously to produce the prevalence trends observed in surveillance data and in order to explore the impact of each, the availability of accurate epidemiological data is essential.

Uganda presents early and compelling evidence for changes in sexual risk behaviour having contributed to substantial declines in national prevalence.[4] Prevalence declines were

consistently observed across different geographic and demographic sections of the population in addition to a number of population-based surveys reporting changes in sexual risk behaviour indicators.[4] Between 1989 and 1995, sexual risk behaviour indicators showed an increase in the age of sexual debut, a decrease in casual or non-regular partners and an increase in condom use.[5] A comparative analysis of these trends within neighbouring countries (Kenya, Malawi and Zambia) that had similar epidemic dynamics but lacked HIV prevalence declines on the same scale as Uganda showed that only a reduction in sexual partners and abstinence distinguished Uganda from comparison countries.[5] Stoneburner *et al.*[5] subsequently demonstrated that a 70% reduction on HIV incidence was associated with a 60% reduction in casual sex. It has been proposed that this resulted from high level political support facilitating a multi-sectorial response that in turn utilised a decentralised approach to plan and implement a successful behavioural change communication programme.[4]

An individual's sexual risk behaviour is greatly affected by social and cultural norms, therefore programmes aimed at raising awareness about HIV prevention are often delivered at the group-level e.g., mass media campaigns.[6]

Randomised clinical trials (RCTs) that randomise at the individual-level can therefore be a less informative means by which to evaluate such interventions.[6] Changes in social and cultural norms also require time to accumulate and subsequently diffuse across different risk groups prior to exerting an impact on incidence. Detecting such changes therefore requires an extended follow up period and while RCTs are considered the gold standard for providing evidence of efficacy, restrictions in terms of their scale, duration and selective study population can limit their ability to detect the impact of an intervention aimed at changing sexual risk behaviour.[6,7] Although observational studies are considered to provide a weaker source of evidence,[7] their scale, duration and study population are broader than that of RCTs, which can be advantageous when evaluating the population-level effectiveness of HIV prevention programmes.[6]

Combining observational data with epidemiological models has previously been used to evaluate the impact of HIV prevention programmes aimed at changing sexual risk behaviour.[8–11] Epidemiological models are able to account for the natural epidemic dynamics in the absence of interventions and subsequently deduce what impact on prevalence these interventional programmes have achieved. This approach was able to provide strong evidence for changes in sexual risk behaviour affecting the course of the epidemic in Uganda, Zimbabwe and urban areas of Kenya and Haiti.[11] For Zimbabwe, extensive historical mapping of prevention programmes and key informant interviews were conducted; an increased awareness of AIDS-related mortality and severe economic decline were concluded to have stimulated reductions in multiple concurrent sexual partnerships.[10,12]

1.1 Aims

The aim of this multi country study was to evaluate whether ART scale-up and changes in sexual risk behaviour, as identified through self-reported Demographic and Health Survey (DHS) data and other data sources as available, have contributed to the trends in HIV prevalence observed through national surveillance data.

1.2 Objectives

In selected countries, to what extent are estimated HIV incidence declines robust and to what extent have such incidence declines contributed to declines in prevalence.

a) If declines in HIV incidence have been experienced in the selected countries, what caused changes in incidence? Determine if there is evidence that changes in sexual behavior change (number of sexual partners and/or condom use) and/or increased uptake of biomedical interventions (ART and/or voluntary medical male circumcision) have contributed to changes in HIV incidence in different populations and age groups, and at what moment in time this might have occurred.

b) Determine which specific HIV prevention programmes in each selected country have contributed to changes in (a) and (b).

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2. METHODOLOGY

2.1 Country selection

A steering committee was convened by the World Bank and included representatives from UNAIDS, UNFPA, WHO and the Global Fund, with Imperial College London as the technical partner. The following inclusion criteria were agreed by the steering committee and used to identify countries with an appropriate epidemiological context for participation in this study:

- Evidence of reductions in modelled HIV incidence, either among the general population or among key populations.
- Evidence of self-reported changes in sexual risk behaviours, measured over at least three population-based surveys.
- Evidence of rapid increases in ART coverage.
- Evidence of available data on other HIV prevention programmes.

The five countries that subsequently engaged in this study were Botswana, Dominican Republic, Kenya, Malawi and Zambia.

2.2 Epidemiological modelling

The framework within which this work was conducted has been described previously[11] and used the modelling approach outlined by Hallett *et al*.[10] However, owing to the different patterns of risk of HIV exposure within each country, the model used and its associated pattern of analysis varied accordingly. Further details can be found within each specific country report.

For each country, a deterministic mathematical model of heterosexual HIV transmission was developed in order to replicate natural epidemic dynamics in the absence of interventions or changes in sexual risk behaviour. This was termed the constrained model. By producing counterfactual projections in this way, we were able to remove the effect of factors such as ART scale-up and simulate a control scenario of how we believe prevalence trends naturally evolve in HIV epidemics. If model projections fit poorly to observational data, this indicates that characteristics which influence the course of the epidemic are missing from the model. In a stepwise approach, interventions that might have influenced the epidemic were built into the model and its fit to data re-evaluated.

If the fit of model projections to surveillance data were not improved through the incorporation of an intervention, the data were considered to provide little evidence to support its effect on the course of the epidemic. However, if the model incorporating interventions provided a better fit, then the nature, timing and magnitude of their effect on prevalence trends were explored. The number of infections averted as a consequence of changes in sexual risk behaviour was a parameter of particular interest and was calculated by comparing epidemic trajectories from two simulations of the same model; one with the effects of changes in sexual risk behaviour removed and one with them in place. Comparing nested models in this way enabled a systematic assessment as to which most accurately replicated observed prevalence trends.

2.3 Data

Observed prevalence trends were determined from HIV sentinel surveillance data from pregnant women and key populations. For all countries, population-based surveys were used to make adjustments to sentinel surveillance data in order to address the overestimation resulting from sampling bias (see limitations for further details).

Data were disaggregated according to the different patterns of risk of HIV exposure within each country. For Malawi and Botswana, data were disaggregated according to urban and rural location. For Zambia and Kenya, data were disaggregated according to subnational regions. For Dominican Republic, data were disaggregated according to key populations of interest that included men who have sex with men (MSM), female sex workers (FSW) and rural communities of Haitian sugar cane workers called “Bateyes”.

Temporal trends in sexual risk behaviour were determined from knowledge and sexual risk behaviour indicators reported at more than one time point through Demographic and Health Surveys (DHS), Multiple Indicator Cluster Surveys (MICS) and similar national surveys as available.

2.4 Historical mapping

Historical mapping of HIV programmes, conducted for Botswana and Malawi, provided a retrospective analysis of political, economic, social, cultural and demographic factors that may have influenced the course of the epidemic. A review of HIV prevention policies, campaigns, interventions, studies and evaluations conducted between 1985 and 2012 was performed alongside key informant interviews, which included people involved in research, implementation and management of HIV programmes over the same time period.

A comparison of the temporal relationship between the modelled change in incidence, trends in sexual risk and behavioural indicators and historical mapping of HIV prevention programmes enabled an assessment to be made as to whether there was any likely association.

3. RESULTS

3.1 Botswana

Strong evidence was found for the combined influence of changes in sexual risk behaviour and ART on the course of the epidemic, with the impact of averting approximately 210,000 infections in urban areas and 120,000 infections in rural areas between 1975 and 2012. In addition, there was evidence for ART exerting an independent effect on incidence in both urban and rural areas and some evidence for the independent influence of behavioural change on incidence in urban areas.

The discrepancy between urban and rural results could be due to geographical heterogeneity in HIV epidemiology or a lack of power in the available data to detect this more subtle signal in rural areas. As 43%[13] of Botswana's population resides in rural areas, this highlights the need for further investigation into factors driving epidemiology at a subnational level.

Findings from the historical mapping of HIV prevention programmes were consistent with the total combined activities having contributed to changes in sexual risk behaviour. However, this exercise was limited by a lack of available data during 1985-2000 and therefore heavily relied on key informant interviews.

While condom use increased between 2008 and 2013, the percentage of people with more than one partner in a 12-month period increased.

Knowledge and sexual risk behaviour indicators reported at more than one time point through the Botswana AIDS Indicator Surveys[14–17] indicated that temporal trends in sexual risk behaviour varied according to indicator. Of those with more than one partner in a 12-month period, the percentage that used a condom remained stable over the same time period. Quantifying the extent to which these two factors may counteract each other remains challenging and separating the relative impact of each on incidence declines was not possible.

3.2 Dominican Republic

There was strong evidence for the combined influence of changes in sexual risk behaviour and, to a lesser extent, ART on the course of the epidemic, with the impact of averting approximately 460,000 cumulative infections over the course of the epidemic (between 1982 and 2015). Among FSW, approximately 44,000 cumulative infections were averted. Among Bateyes, approximately 33,000 cumulative infections were averted and approximately 28,000 cumulative infections were averted among MSM.

There was reasonable evidence to support the influence of ART on prevalence. However, ART alone was found to be insufficient to explain the observed epidemic trend. Evidence for the influence of changes in sexual risk behaviour on prevalence was also promising and supported by trends in knowledge and sexual risk behaviour indicators.

Knowledge and sexual risk behaviour indicators[18] reported at more than one time point indicated that temporal trends in sexual risk behaviour among the general population varied according to indicator. While all indicators for condom use were found to increase between 1996 and 2013, the percentage of people engaging in higher risk sex also increased over the same time period. This trend was also observed in younger respondents aged 15-24. Of the respondents who reported engagement in higher risk sex, as defined by sex with a non-marital,

non-cohabitating partner, condom use was found to increase. Of those respondents who reported engagement in higher risk sex, as defined by sex with more than one partner within a 12-month period, the percentage who reported condom use remained stable. Quantifying the extent to which these two factors may counteract each other remains challenging and separating the relative impact of each on incidence declines was therefore not possible.

When asked to describe a method of HIV prevention, >90% of FSW and >90% of MSM reported condom use across all five provinces and this was consistently reported within the 2008 and 2012 behaviour surveillance surveys (BSS).[19,20] Reported condom use among FSW varied according to the type of sexual partner; more than 60% of respondents reported condom use with the last client whereas less than 10% of respondents reported condom use with their husband.[19,20] The proportion of FSW who mentioned having one faithful partner as a means of HIV prevention was >69% across all five provinces in 2008 but this reduced to >58% in 2012.[19,20] The prevalence of commercial sex among MSM was <40% across all five provinces in 2008 however this increased to >65% in 2012.[19,20] Reported condom use among those engaging in commercial sex was > 18% across all five provinces in 2008 and increased to >40% in 2012.[19,20]

3.3 Kenya

Results provided evidence for the influence of changes in sexual risk behaviour, and to a much lesser extent ART, on the course of the epidemic, with their combined impact averting approximately 4,107,000 infections between 1980 and 2015. This was mostly attributed to changes in sexual risk behaviour.

There was evidence for a change in sexual risk behaviour exerting an independent effect on prevalence when evaluated on a national and subnational (county) scale. Changes in sexual risk behaviour alone were predicted to have averted approximately 4,000,000 cumulative infections nationally over the course of the epidemic. This is consistent with earlier findings by Hallett *et al.*[11] which found that observed declines in prevalence could only be reproduced by the model if it assumed a reduction in sexual risk behaviour. Encouragingly, temporal trends in knowledge and sexual risk behaviour indicators[21] suggested increased condom use and decreased engagement in higher risk sex over the same time period and are therefore supportive of this finding.

There was reasonable evidence to support the independent influence of ART on prevalence nationally, especially as a coinciding trend in ART scale up was observed. While this study has shown ART to have some impact on prevalence trends, this has yet to be fully optimised and the magnitude of impact exerted through ART is considerably smaller than the magnitude of impact exerted through changes in sexual risk behaviour.

The observed variation in effect size across counties highlights the need for further investigation at this spatial resolution. Expanding data availability at the subnational level will enable this analysis to be refined and the distribution of risk factors driving local epidemiology to be explored.

3.4 Malawi

Some national counterparts raised concerns about the validity of early Antenatal Clinic (ANC) prevalence data in Malawi. As the conclusions drawn from this method rely strongly on those data, conclusions should be interpreted with care.

Strong evidence for the combined influence of changes in sexual risk behaviour and ART on the course of the epidemic was found in urban areas, with the impact of averting approximately 340,000 infections between 1975 and 2012. When evaluating the influence from each of these interventions independently, changes in the epidemic trajectory were more strongly associated with changes in sexual risk behaviour than ART. In rural areas, there was some indication of the combined influence of changes in sexual risk behaviour and ART on the course of the epidemic but this did not reach a high level of evidence.

The discrepancy between urban and rural results could be due to geographical heterogeneity in HIV epidemiology or a lack of power in the available data could have prevented detection of a more subtle signal in rural areas. As 84%[13] of Malawi's population resides in rural areas, this highlights the need for further investigation into factors driving epidemiology at a subnational level.

Findings from the historical mapping of HIV prevention programmes were consistent with the total combined activities having contributed to changes in sexual risk behaviour. However, this exercise was limited by a lack of available data during 1985-2002 and therefore heavily relied on key informant interviews.

However, temporal trends in knowledge and sexual risk behaviour indicators provide some insight. When asked to describe a method of HIV prevention, the proportion of both men and women mentioning condom use increased between 1992 and 2000.[22] Equally the proportion of both men and women mentioning abstinence as a method of HIV prevention increased during the same period.[22] Although the proportion of women who mentioned having only one partner as a method of HIV prevention was stable over this period, the proportion of men mentioning this method reduced.[22]

Encouragingly all indicators for condom use were found to increase between 1992 and 2010. Engagement in higher risk sex, as defined by sex with a non-marital, non-cohabitating partner, decreased for male respondents and remained stable for female respondents between 2000 and 2010. The percentage of respondents reporting sex with multiple partners remained stable between 2004 and 2010. The percentage of male respondents reporting commercial sex within the last year decreased between 2000 and 2010.

3.5 Zambia

Results provided some evidence for the combined influence of changes in sexual risk behaviour and antiretroviral therapy (ART) on the course of the epidemic, with the impact of averting approximately 909,000 infections between 1975 and 2015.

In addition, there was evidence for a change in sexual risk behaviour exerting an independent effect on prevalence when evaluated on a national and subnational (provincial) scale. Temporal trends in knowledge and sexual risk behaviour indicators demonstrated an increase in the proportion of both men and women mentioning condom use and abstinence as a method of HIV prevention.[23] Engagement in higher risk sex, as defined by sex with multiple partners, decreased between 1992 and 2014. Between 1996 and 2014, condom use increased among those respondents reporting sex with a non-marital, non-cohabitating partner. The percentage of respondents who reported condom use the last time they had sex with a spouse or cohabitating partner also increased between 1996 and 2014. The percentage of male respondents reporting commercial sex within the last year decreased between 1996 and 2014 in addition to condom use increasing among such respondents between 2001 and 2014.

There was reasonable evidence to support the independent influence of ART on prevalence nationally, especially as data showed a coinciding trend in ART scale up. The observed variation in prevalence trends across subnational regions highlights the need for further investigation at this spatial resolution. Expanding data availability at the subnational level would enable this analysis to be refined and the distribution of risk factors driving local epidemiology to be explored.

Table 1: Summary of impact evaluation results

Country:	Impact evaluation		
	Cumulative Infections averted (n)	**Reduction in Cumulative Incidence (%)**	**Year in which decline in incidence commenced.**
Botswana			
Urban areas:	210,000	47	2001
Rural areas:	120,000	35	2001
Dominican Republic	460,000	21	1997
Kenya	4,107,000	63	1995
Malawi*	340,000	48	2001
Zambia	909,000	23	1990

Source: Authors

*Note: * = Impact evaluation for urban areas only - insufficient evidence of impact in rural areas.*

4. DISCUSSION

Findings from this study are consistent with those of Awad *et al.*[8], who used epidemiological modelling to demonstrate the plausibility of declines in HIV prevalence occurring as a consequence of declines in sexual risk behaviour across 18 countries in sub-Saharan Africa. This study has extended such work by incorporating ART scale-up within the epidemiological models and additionally triangulating data from multiple sources in order to explore different programmatic contributions that may have instigated observed changes in sexual risk behaviour.

Evidence was found for the combined impact of changes in sexual risk behaviour and ART on the course of the epidemic. ART was shown to possibly have some effect on the epidemic but alone, was insufficient to explain the observed epidemic trend owing to the fact that incidence declines predate the availability of ART. Equally, this study evaluates incidence declines that predate the introduction of voluntary medical male circumcision (VMMC) into HIV prevention programmes, which therefore limits its ability to evaluate the impact of such biomedical interventions.

Triangulation of data from different sources has provided a compelling narrative for a decline in sexual risk behaviour. Such temporal changes in sexual risk behaviour indicators provide plausible proximate determinants along the causal pathway. In order to determine whether changes in sexual risk behaviour were motivated by targeted prevention programmes or by more informal means of inter-personal communication, stronger evidence of appropriate coverage and timing of prevention programmes to ensure sufficient exposure to their target populations are required before conclusive statements can progress from association to causation.

While observing an increase in AIDS-related mortality during epidemic maturation may motivate an individual to alter their risk of HIV acquisition, HIV prevention programmes provide the knowledge and resources to enable that same individual to take active steps in doing so. However, distinguishing the relative contribution of each mechanism and determining the extent to which they interact is challenging.

4.1 Limitations

Findings from this work are encouraging but require a note of caution. Conclusions are largely drawn against observational data from sentinel surveillance sites, which provide a valuable insight into temporal prevalence trends. However, the technology for HIV testing has undergone continuous improvement over the course of the epidemic, resulting in changes to test specificity over time; these changes could confound the results substantially. Furthermore, in all epidemics, as the epidemic matures, AIDS-related sub-fertility and a shifting age distribution of women presenting to these clinics could also account for the observed decline in prevalence and cannot be ruled out at this stage.

Findings from the historical mapping of HIV prevention programmes were consistent with the total combined activities having contributed to changes in sexual risk behaviour. However, this qualitative exercise relied on subjective recollections 15 years after the event or exposure to factors of interest, which may engender recall bias. Furthermore, the reliability of self-reported sexual risk behaviour is challenged by social desirability bias. These sources of bias, combined with limited data availability for early interventions, therefore limit the weight given to such evidence.

While results showed an association between intervention programmes and reduced HIV transmission, evaluating whether there was evidence for a causal relationship with specific programmes was beyond the scope of the available data. Future studies may or may not be able to better determine whether changes in sexual risk behaviour were motivated by targeted prevention programmes or by more informal means, such as inter-personal communication giving rise to greater HIV awareness, which occurred concurrently as the epidemic matured.

4.2 Future impact evaluations

This analysis largely focused on exploring the drivers behind incidence declines that were observed prior to the scale-up of ART and VMMC, and therefore focused largely on the impact of programmes aimed at changing sexual risk behaviour. While the impact of ART or VMMC would therefore not be strongly 'visible' at this time, with the benefit of several years of additional data, future evaluations may be able to detect evidence of their impact on the epidemic.

Owing to an increase in the number of interventions aimed at providing education and information on HIV/AIDS, social desirability bias is likely to have changed over time. Accurately quantifying the extent to which a population is exposed to any mass media behavioural change campaign is challenging and for HIV/AIDS, this is compounded by the fact that certain sexual behaviours are often highly stigmatised. Receiving AIDS information through more informal channels of communication, such as friends, churches and other social networks, has been shown to be hugely influential,[12] however remains even more challenging to accurately quantify.

While social desirability bias pertains to any self-reported data, greater opportunities exist to interrogate treatment data with quantifiable biomarkers. This could facilitate methods to adjust for such bias and thus improve the reliability of such data.

As epidemiological trends continue to be monitored during the current period of ART programme expansion and broadening eligibility criteria, prospectively collected data outlining key indicators, such as coverage, uptake, adherence and viral suppression, will be imperative for future monitoring and evaluation analyses. In contrast to quantifying the number of people exposed to a behavioural change communication campaign disseminated through radio, television, community and personal networks, ART programmes intrinsically lend themselves to quantitative data collection (for example, through enumerating the number of patients receiving ART).

Measures of the coverage and uptake of public health interventions are essential for any impact evaluation. Incorporating such indicators as an integral part of future treatment and prevention programmes would greatly facilitate *prospective* collection of such data, thereby reducing the influence of recall bias and greatly increasing the robustness of findings. Accurate prospective monitoring of current interventions, at both national and subnational levels, will therefore be imperative to better inform future monitoring and evaluation efforts.

In the era of ART scale-up, longitudinal prevalence trends alone can be misleading owing to the fact that ART extends survival of the HIV population in receipt of treatment.[24] This will result in increased prevalence, which in turn can obscure a decline in incident infections. Mathematical modelling of the HIV epidemic will therefore have a role in evaluating the impact of ART programmes by providing a means by which to take account of confounding factors, such as the extended survival experienced by those in receipt of ART, when generating the counterfactual scenario.

5. CONCLUSIONS

In conclusion, declines in sexual risk behaviour have shown a consistent association with concomitant declines in HIV incidence and have been estimated to result in hundreds of thousands of new infections being averted in the five countries included in this study (Table 1). Ultimately, primary prevention through changes in sexual risk behaviour must remain central to the AIDS response; expansions in ART programmes need to be matched by commensurate progress in HIV prevention programmes or they risk becoming unsustainable.[12] Conclusions from this study propose that no single prevention programme has been responsible for the decline in incidence, rather the combined exposure to public and interpersonal communication explaining the increased AIDS-related mortality in addition to a range of HIV prevention programmes has served to motivate and enable individuals to alter their risk of HIV acquisition.

Attributing changes in sexual risk behaviour to specific interventions requires data quantifying exposure to such interventions and plausible mechanisms linking the proposed intervention to changes in sexual behaviour. However, changes in sexual risk behaviour are most likely the product of cumulative exposure to a wide range or prevention programmes and owing to multiple interventions and societal changes occurring simultaneously, such attribution remains challenging.[6]

As the HIV epidemic continues to mature alongside the increasing scope and coverage of treatment and prevention programmes, inferring trends in incidence from available prevalence data and subsequently identifying drivers behind epidemic trends will become increasingly complex.[25] The availability of prospectively collected programmatic and epidemic surveillance data at a greater sub-national spatial resolution will greatly improve the robustness of future impact evaluations.

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