Is Achieving Carbon Neutrality Possible in Healthcare? Comparing the Environmental Costs of Differentiated Service Delivery of Antiretroviral Therapy for People Living with HIV in Rural South Africa

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Background:

- People living with HIV require reliable access to antiretroviral therapy (ART) to maintain viral suppression
- Standard-of-care for people living with HIV in South Africa to refill ART is going in-person to clinics
- Retention in HIV care is a complex public health problem
- Differentiated service delivery: client-centered approach that adapts HIV services across the health care cascade to reflect the preferences, expectations, and needs of people living with HIV while reducing unnecessary burdens on the health system
- The Deliver Health Study (2019-20): Adults living with HIV in rural KwaZulu-Natal, South Africa were enrolled and randomized to receive standard clinic-based care or 3-month ART refills and monitoring at home
- Proportion of clients who were virally suppressed in the Deliver Health Study was **significantly higher among those who received home-delivered ART refills** vs. clinic-based care (88% vs. 74%; RR=1.21, 95% CI: 1.02-1.42)
- Home delivery of ART and monitoring is **effective** for achieving viral suppression and retention in HIV care, but what is the environmental impact of scaling up home-delivered ART in high HIV prevalence settings such as rural South Africa? **Could scaling up home delivery support a carbon-neutral approach by reducing overall greenhouse gas emissions from individual commuters to clinics?**

Objective: To analyze carbon dioxide (CO_2) emissions data to compare environmental costs of different ART refill methods for people living with HIV.

Methods:

- Compared cumulative CO_2 emissions for quarterly visits over 12 months for participants receiving home-delivered vs. clinic-based refills
- Six- and 12-month refill scenarios were evaluated
- Per person living with HIV, delivery log data was used to:
    - Calculate total distance travelled (km)
    - Estimate cumulative CO_2 emissions ($kgCO_2$)

Table 1. Estimated CO_2 emissions per km travelled by transport method to ART refill visits

Refill Method	**Transport Method**	**Estimated CO_2 Emissions ($kgCO_2$/km)**
Clinic	Walking	0
	Bicycling	0
	Driving (personal vehicle)	0.148
	Public Transit/Taxi (Toyota Quantum Sesfikile bus)	0.339
Home delivery	Delivery vehicle (2016 Ford Ranger 2.2L Diesel Double Cab 4x4)	0.185

Two outcomes:

1) Incremental cost-effectiveness ratio (ICER):

$$\frac{\left(\text{Avg. total } CO_2 \text{ emissions}_{\text{home delivery group}}\right) - \left(\text{Avg. total } CO_2 \text{ emissions}_{\text{clinic group}}\right)}{\left(\frac{n_{\text{virally suppressed in home delivery group}}}{n_{\text{home delivery group}}}\right) - \left(\frac{n_{\text{virally suppressed in clinic group}}}{n_{\text{clinic group}}}\right)}$$

2) Comparative cost-effectiveness (CCE):

$$\left(\frac{Avg.\ total\ CO_2\ emissions_{home\ delivery\ group} * n_{\text{home delivery group}}}{n_{virally\ suppressed\ in\ \text{home delivery}\ group}}\right) - \left(\frac{Avg.\ total\ CO_2\ emissions_{clinic\ group} * n_{\text{clinic group}}}{n_{\text{virally suppressed in clinic group}}}\right)$$

Results

- Of those who knew their HIV status at baseline (n=103), 3% had taken ART in the past and stopped taking them and 10% took a break from taking ART at some point
    - Reasons for discontinued ART use included long clinic waiting times and clinics being located too far away
- Walking was the most common (64%) mode of transportation to ART refill visits for participants the clinic group, followed by minibus (33%), then driving (3%)
- **ICER**: Incremental carbon-cost was 50 kg of CO_2 per person virally suppressed through home delivery, equivalent to driving 271 extra km in the delivery vehicle

    - If 6- or 12-month refills were provided instead, incremental emissions for home-delivered ART would be 25 and 13 kg of CO_2, equivalent to 136 and 68 km driven, respectively
- **CCE**: Compared to the clinic group, home delivery cost an extra 7.8 kg of CO_2 emissions per person virally suppressed

Table 2. Characteristics of people living with HIV in the Deliver Health Study

Characteristic	**Clinic (N=73)**	**Home Delivery (N=80)**	**Total (N=153)**
	mean (SD) or n (%)		
Age (years)	35.6 (8.5)	38.8 (9.3)	37.3 (9.1)
Men	38 (52.1)	44 (55.0)	82 (53.6)
Marital status			
Single	38 (52.1)	40 (50.0)	78 (51.0)
Member of an unmarried couple	31 (42.5)	29 (36.3)	60 (39.2)
Married	0 (0)	6 (7.5)	6 (3.9)
Divorced or widowed	4 (5.5)	5 (6.3)	9 (5.9)
Educational attainment			
Primary	23 (31.5)	15 (18.8)	38 (24.8)
Secondary	40 (54.8)	57 (71.3)	97 (63.4)
Tertiary and above	10 (13.7)	8 (10.0)	18 (11.8)
Employed	26 (35.6)	33 (41.3)	59 (38.6)
Individuals known to be living with HIV	51 (69.9)	52 (65.0)	103 (67.3)
Past ART use (among individuals known to be living with HIV, n=103)			
Currently on ART	48 (65.8)	50 (62.5)	98 (64.1)
Taken ART in the past	2 (2.7)	1 (1.3)	3 (2.0)
Never taken ART	23 (31.5)	29 (36.3)	52 (34.0)
Virally suppressed (<20 copies per mL) at month 12	54 (74.0)	70 (87.5)	124 (81.0)
Total distance travelled to refill visit per participant (km)	7.3 (13.3)	6.3 (5.1)	6.8 (9.8)
Cumulative CO_2 emissions across all refill visits over study follow-up per participant ($kgCO_2$)	0.4 (0.6)	7.3 (8.2)	0.4 (0.7)

Conclusions

In rural South Africa, incremental CO_2 emissions were higher for participants receiving home-delivered vs. clinic-based ART refills but could be offset by 6- or 12-month refills and/or changing number of deliveries or vehicle type. Other research studies should consider quantifying environmental impacts of their work alongside the public health impacts.

What's next?

We are collecting data in an ongoing randomized controlled trial, the SMART ART Study, in KwaZulu-Natal, South Africa. We will analyze CO_2 data from the SMART ART Study along with the Deliver Health Study.

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