BMJ Open

Cross-sectional analysis of factors associated with medication adherence in western Kenya

Pooja Gala ,[1] Jemima H Kamano,[2] Manuel Vazquez Sanchez,[3] Richard Mugo,[4] Vitalis Orango ,[2,4] Sonak Pastakia,[5] Carol Horowitz,[6] Joseph W Hogan,[7] Rajesh Vedanthan [8]

To cite: Gala P, Kamano JH, Vazquez Sanchez M, *et al*. Cross-sectional analysis of factors associated with medication adherence in western Kenya. *BMJ Open* 2023;**13**:e072358. doi:10.1136/bmjopen-2023-072358

► Prepublication history and additional supplemental material for this paper are available online. To view these files, please visit the journal online (http://dx.doi.org/10.1136/bmjopen-2023-072358).

Received 28 February 2023
Accepted 14 August 2023

For numbered affiliations see end of article.

Correspondence to
Dr Pooja Gala;
Pooja.Gala@nyulangone.org

ABSTRACT

Objectives Poor medication adherence in low-income and middle-income countries is a major cause of suboptimal hypertension and diabetes control. We aimed to identify key factors associated with medication adherence in western Kenya, with a focus on cost-related and economic wealth factors.

Setting We conducted a cross-sectional analysis of baseline data of participants enrolled in the Bridging Income Generation with Group Integrated Care study in western Kenya.

Participants All participants were ≥35 years old with either diabetes or hypertension who had been prescribed medications in the past 3 months.

Primary and secondary outcome measures Baseline data included sociodemographic characteristics, wealth and economic status and medication adherence information. Predictors of medication adherence were separated into the five WHO dimensions of medication adherence: condition-related factors (comorbidities), patient-related factors (psychological factors, alcohol use), therapy-related factors (number of prescription medications), economic-related factors (monthly income, cost of transportation, monthly cost of medications) and health system-related factors (health insurance, time to travel to the health facility). A multivariable analysis, controlling for age and sex, was conducted to determine drivers of suboptimal medication adherence in each overarching category.

Results The analysis included 1496 participants (73.7% women) with a mean age of 60 years (range 35–97). The majority of participants had hypertension (69.2%), 8.8% had diabetes and 22.1% had both hypertension and diabetes. Suboptimal medication adherence was reported by 71.2% of participants. Economic factors were associated with medication adherence. In multivariable analysis that investigated specific subtypes of costs, transportation costs were found to be associated with worse medication adherence. In contrast, we found no evidence of association between monthly medication costs and medication adherence.

Conclusion Suboptimal medication adherence is highly prevalent in Kenya, and primary-associated factors include costs, particularly indirect costs of transportation. Addressing all economic factors associated with medication adherence will be important to improve outcomes for non-communicable diseases.

Trial registration number NCT02501746.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ The WHO five dimensions of factors affecting medication adherence allows for a comprehensive understanding of medication adherence.
⇒ Multiple economic factors related to procurement of healthcare that could affect medication adherence were studied, including income, wealth, medication costs and transportation costs.
⇒ To illustrate the association of specific cost-related factors and medication adherence, we used the multivariable regression model to generate predicted values of medication adherence at different combinations of medication costs and transportation costs.
⇒ Data were unavailable to evaluate the impact of the doctor–patient relationship or healthcare system trust on medication adherence.
⇒ As a cross-sectional study, the factors that affect longitudinal medication adherence were not studied.

INTRODUCTION

Low-income and middle-income countries (LMICs) are facing an increasing burden of hypertension, diabetes and cardiovascular disease (CVD).[1–4] Pharmacological treatment for hypertension and diabetes is well known to reduce morbidity and mortality.[5] Medication adherence, defined as taking medications as prescribed, is critical to successful pharmacotherapy and the control of hypertension, diabetes and CVD.[6] However, suboptimal medication adherence among patients with hypertension is quite prevalent in LMICs,[7] particularly in Africa.[8]

Prior studies in LMICs have identified several factors that contribute to suboptimal medication adherence including male gender, number of prescription medications, comorbidities, smoking/alcohol use, psychosocial stressors, lack of family support and poor provider–patient communication.[7 9 10] Additionally, social and economic factors resulting in lack of access are major

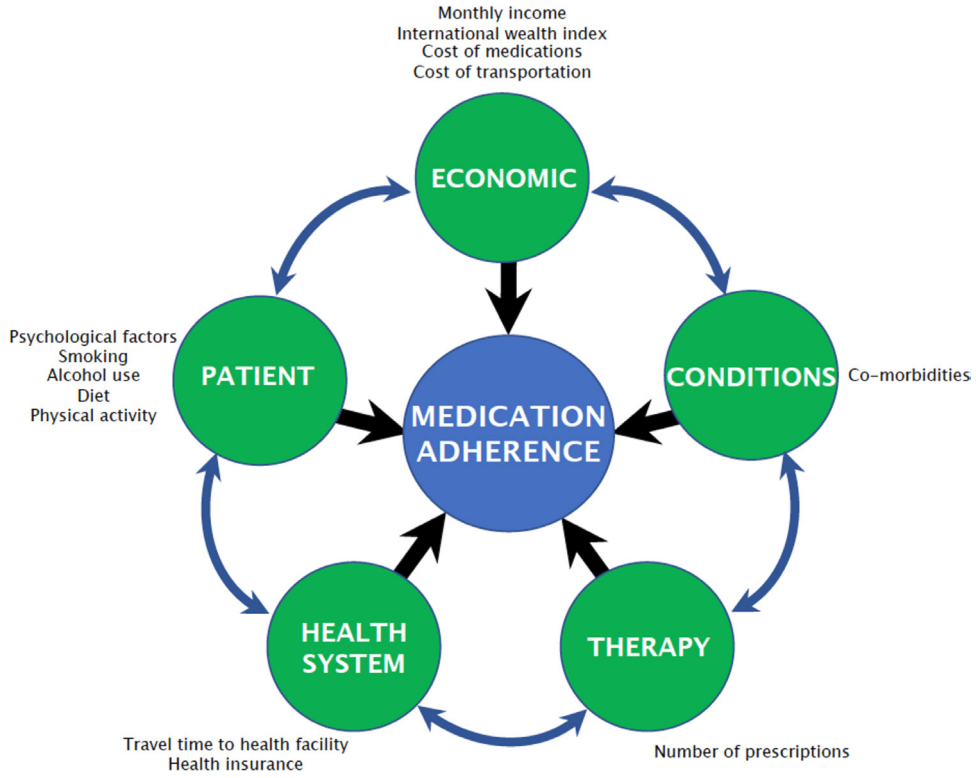

Figure 1 Determinants of medication adherence, adapted from the WHO dimensions of medication adherence, illustrating the study variables used in the analyses.

contributors to suboptimal medication adherence, particularly among individuals with lower wealth and socioeconomic status.[8 11] Cost-related medication non-adherence—when individuals skip medication doses, take less medicine or delay filling their prescriptions due to cost and financial pressures—has been well documented in high-income countries.[12–14] There is a growing amount of evidence of cost-related medication non-adherence in LMICs, particularly in the HIV population taking antiretroviral therapy.[7 8] In Ethiopia, out-of-pocket medication costs and lower monthly income contributed to suboptimal medication adherence.[15] Overall, more data are needed to better understand cost-related medication non-adherence in Africa.[11 16 17] Few studies in Africa have examined the relative contribution of specific economic costs, such as transportation costs to health facilities, in addition to medication costs.[8 18]

The Bridging Income Generation with Group Integrated Care (BIGPIC) trial investigated the effectiveness of group medical visits integrated into microfinance groups in reducing blood pressure among individuals with hypertension or diabetes in rural Kenya.[19 20] Using baseline data from the BIGPIC trial, we aimed to evaluate factors associated with medication adherence, with particular attention to cost-related factors that may contribute to medication adherence in a rural population in Kenya. We hope to highlight key factors that can be targeted for intervention in western Kenya and other low-resource settings worldwide.

METHODS

Setting and participants

The BIGPIC trial was a four-arm, cluster randomised trial that evaluated the impact of combining microfinance and group medical visits on blood pressure reduction among individuals with hypertension or diabetes in western Kenya.[19 20] Inclusion criteria for the BIGPIC study were adults 35 years or older[21] enrolled in the Academic Model Providing Access to Healthcare Partnership's (AMPATH's) chronic disease management programme who had diabetes (fasting glucose≥7 mmol/L), impaired fasting glucose (fasting glucose 5.6–6.9 mmol/L) or increased risk of developing diabetes (Leicester Risk Assessment Score≥7).[19 22] All participants in both the BIGPIC study and this secondary analysis had either diabetes or hypertension (systolic blood pressure≥140 mm Hg or diastolic blood pressure≥90 mm Hg). Full details of the trial methods and procedures have been previously described.[19 20] Of the 2890 individuals enrolled in the BIGPIC trial, 1496 participants reported having been prescribed hypertension or diabetes medications in the 3 months prior to the baseline questionnaire.[19] Our present analysis is restricted to these individuals.

Independent and dependent variables

The WHO defines five dimensions of factors affecting medication adherence, which were included as independent variables in the analysis: 'economic factors' including monthly income, cost of transportation to health facility, monthly medication costs and International Wealth

Table 1 Factors affecting medication adherence and mean adherence score

	Total (n=1496)	Mean medication adherence score (SD)
Sociodemographics		
Age	Median 60 (IQR 52–70)	
Male sex (vs female sex)	393 (26.3%)	Female: 2.6 (1.4) Male: 2.5 (1.4)
Number of comorbidities	Mean 1.2 (0.4)	
Comorbidities		
Diabetes only	131 (8.8%)	2.5 (1.5)
Hypertension only	1035 (69.2%)	2.7 (1.4)
Hypertension and diabetes	330 (22.1%)	2.4 (1.4)
Number of prescription medications*	Median: 2 (IQR 2–3)	
PSS-4 Score	Mean score: 1.8 (SD 0.6)	
Smoking	17 (1.1%)	Yes: 2.4 (1.7) No: 2.6 (1.4)
Alcohol		
No alcohol use	1426 (95.3%)	2.6 (1.4)
≤5 drinks per week	49 (3.3%)	2.8 (1.7)
>5 drinks per week	21 (1.4%)	2.9 (1.3)
Health Insurance (vs no insurance)	315 (21.1%)	Yes: 2.6 (1.5) No: 2.6 (1.4)
International Wealth Index		
IWI Category 4.00–14.99	207 (13.8%)	3.0 (1.5)
IWI Category 15–24.99	368 (24.6%)	2.6 (1.4)
IWI Category 25–39.99	459 (30.7%)	2.5 (1.4)
IWI Category≥40+	462 (30.9%)	2.4 (1.4)
Monthly income		
No job	931 (63.0%)	2.8 (1.4)
<1000 KSH	176 (11.9%)	2.2 (1.4)
1000–4999 KSH	236 (16.0%)	2.3 (1.4)
≥5000	135 (9.1%)	2.2 (1.3)
Time to travel to health facility (one way) (n=1161)		
0–30 min	844 (72.7%)	2.6 (1.5)
31–60 min	227 (19.6%)	2.5 (1.4)
>60 min	90 (7.8%)	2.5 (1.4)
Cost of transportation to health facility (one way)† (n=1026)	Median 50 KSH (IQR 40–70 KSH)	
0 KSH	105 (10.2%)	2.3 (1.4)
1–99 KSH	676 (65.9%)	2.5 (1.3)
100+ KSH	245 (23.9%)	2.5 (1.5)
Monthly medication costs‡ (n=1070)	Median 200 KSH (IQR 100–400 KSH)	
0–100 KSH	303 (28.3%)	2.6 (1.5)
101–400 KSH	538 (50.3%)	2.5 (1.3)
>400 KSH	229 (21.4%)	2.3 (1.4)
Not filled prescription or missed clinic appointments due to healthcare costs	934 (62.4%)	Yes: 3.0 (1.4) No: 1.9 (1.2)
Running out of medications waiting for next clinic appointment	950 (63.5%)	Yes: 3.0 (1.4) No: 1.8 (1.2)

US$1 is ~140 KSH.
*529 participants did not report number of prescription medications taken in the past 3 months.
†470 participants did not report transportation costs (one way) to clinic.
‡426 participants did not report monthly medication costs.
KSH, Kenyan Shillings; PSS-4, Perceived Stress Scale 4.

Table 2 Percentage of participants not filling a prescription or skipping medical visits due to cost by monthly income and international wealth (IWI) categories

Not filling a prescription or skipping medical visits due to healthcare procurement costs	
Monthly income (p=0.004)	
No job	614 (66.0%)
<1000 KSH	105 (59.7%)
1000–4999 KSH	138 (58.5%)
≥5000 KSH	70 (51.9%)
Total	927 (62.7%)
IWI Category (p<0.001)	
4.00–14.99	150 (72.5%)
15.0–24.99	234 (63.6%)
25–39.99	299 (65.1%)
≥40+	251 (54.3%)
Total	934 (62.4%)

IWI, International Wealth Index; KSH, Kenyan Shillings.

Index (IWI); 'condition-related factors' including comorbidities; 'patient-related factors' including psychologic factors (Perceived Stress Scale (PSS-4)),[23] smoking, alcohol use, diet and physical activity; 'therapy-related factors' including number of prescription medications; and 'healthcare team and system-related factors' including time to travel to the health facility and health insurance (figure 1).[6] The data for these independent variables were collected as part of the baseline assessment of the BIGPIC trial.[19]

Within the category of economic factors, healthcare procurement costs were defined as any cost related to accessing healthcare services and procuring medications, including but not limited to: cost of clinic services, transportation costs to clinic and pharmacy, and medication costs. We examined two types of costs: medication costs and transportation costs. Medication costs were self-reported monthly costs of medications for diabetes and/or hypertension. Transportation costs were defined as the self-reported cost of transportation to the participant's health facility. In addition, participants were asked if they had ever failed to fill a prescription or skipped a medical visit due to healthcare procurement costs, and whether they had ever run out of medications waiting for their next clinic appointment. Economic status was measured using both self-reported monthly income and the IWI, an asset-based wealth index.[24] For IWI, monthly income, monthly medication costs and transportation costs, categories were determined after assessment of the frequency distributions.

Medication adherence, the dependent variable, was evaluated using the Voils Medication Adherence Scale, which is a validated self-report scale of three medication adherence statements to which participants respond on a scale from 1 (strongly disagree) to 5 (strongly agree).[25] Numerical scores from the Voils Medication Adherence Scale were summed and averaged for each participant. This average score was treated as a continuous variable for medication adherence, with one being optimal medication adherence and five being very poor medication adherence. Consistent with prior use of the Voils adherence score, suboptimal medical adherence was defined as an average score of >1.[26 27]

Statistical analysis

Descriptive statistics were used to summarised economic, patient-related, therapy-related, system-related and condition-related factors of interest. Multivariable linear regression models were used to evaluate factors potentially associated with medication adherence. Factors included in the analysis were chosen based on prior studies suggesting potential associations between each factor and medication adherence. Controlling for age and sex, we combined all factors into a unified multivariable regression to determine independent predictors of suboptimal medication adherence. For illustrative purposes, we used the multivariable regression model to generate estimated predicted values of medication adherence at different combinations of transportation and medication costs. Finally, we ran subanalyses separately among participants with hypertension, diabetes and comorbid hypertension and diabetes, in order to assess whether the relationship between costs and medication adherence differed by the specific disease condition. For all regression analyses described above, 95% CIs were reported.[28 29] Statistical analysis was performed using R software (V.4.0.3; R Foundation for Statistical Computing, Vienna, Austria).

Patient and public involvement

This study is a secondary data analysis of the BIGPIC study, a collaboration between AMPATH Kenya and New York University (NYU) Grossman School of Medicine. AMPATH Kenya is a partnership among Moi University, Moi Teaching and Referral Hospital and a consortium of North American universities, including NYU Grossman School of Medicine.[30–32] The AMPATH Kenya programme has developed a comprehensive chronic disease management programme, with a focus on hypertension and diabetes.[30] The BIGPIC project was developed together with local partners using a human-centred design approach that included input from health professionals, patients, microfinance officers, community health workers and village leaders.[33]

RESULTS

Sociodemographics and self-reported clinical data

Of the 1496 participants, 73.7% (approximately 1096) were women and the median age was 60 years (range 35–97). The majority of participants had hypertension (69.2%), 8.8% had diabetes and 22.1% had comorbid hypertension and diabetes. Only 21.1% of participants were enrolled in Kenya's National Hospital Insurance

Table 3 Adherence factors and association with medication adherence, results from the multivariable linear model

Variable	Change in medication adherence score	95% CIs
Age	0.0	(–0.0 to 0.0)
Male sex	0.1	(–0.2 to 0.3)
WHO patient-related factors		
Any alcohol use	0.1	(–0.7 to 0.5)
PSS-4 Score	**0.2**	**(0.1 to 0.4)**
WHO condition-related factors		
Hypertension	**0.3**	**(0.0 to 0.6)**
Diabetes	0.2	(–0.3 to 0.7)
WHO therapy-related factor		
Number of prescriptions	0.0	(–0.1 to 0.1)
WHO economic-related factors		
IWI Category 4–14.99	Reference	Reference
IWI Category 15–24.99	0.2	(–0.7 to 0.2)
IWI Category 25–39.99	0.2	(–0.6 to 0.2)
IWI Category≥40+	0.3	(–0.7 to 0.2)
Monthly income<1000	0.3	(–0.6 to 0.1)
1000–4999	0.2	(–0.5 to 0.1)
≥5000	0.3	(–0.7 to 0.1)
Monthly costs of medications 0–100 KSH	Reference	Reference
Monthly cost of medications 101–400 KSH	0.00	(–0.3 to 0.3)
Monthly cost of medications 400+	0.2	(–0.6 to 0.2)
Transportation costs 0 KSH	Reference	Reference
Transportation costs 1–99 KSH	**0.7**	**(0.4 to 1.1)**
Transportation costs 100+ KSH	**0.5**	**(0.1 to 0.9)**
Running out of medications waiting for next clinic appointment	**0.3**	**(0.0 to 0.6)**
Not filled prescriptions or not attended clinic visits due to healthcare costs	**1.1**	**(0.9 to 1.4)**
WHO health system-related factor		
Health insurance coverage	0.3	(–0.1 to 0.6)

US$1 is ~140 KSH.
Significant factors are bolded
KSH, Kenyan Shillings; PSS-4, Perceived Stress Scale 4.

Fund and 69.1% of participants were living below the poverty level (IWI Category <40). The majority of participants, 63.0%, reported no monthly formal employment income (table 1).

Medication adherence

Suboptimal adherence (mean Voils adherence score>1) was reported by 71.2% of participants. The mean adherence score was 2.6 (SD: 1.4). Higher mean adherence scores were observed for certain economic factors (low IWI, no formal employment income, not filling prescriptions or attending clinic due to healthcare procurement costs, running out of medications waiting for the next clinic appointment); patient factors (higher PSS-4 and any alcohol use); and condition-related factors (hypertension) (table 1).

Self-reported healthcare procurement costs (which included both the cost of medications and transportation) were reported by 62.4% of participants as a reason for not filling prescriptions or attending clinic visits. The percentage of participants who reported not filling prescriptions or attending clinic visits due to healthcare procurement costs increased as monthly income and wealth decreased (table 2). Notably, the negative impact of healthcare procurement costs on clinic attendance and filling medications was reported even by individuals in the highest income and wealth strata (51.9% and 54.3% of participants, respectively) (table 2).

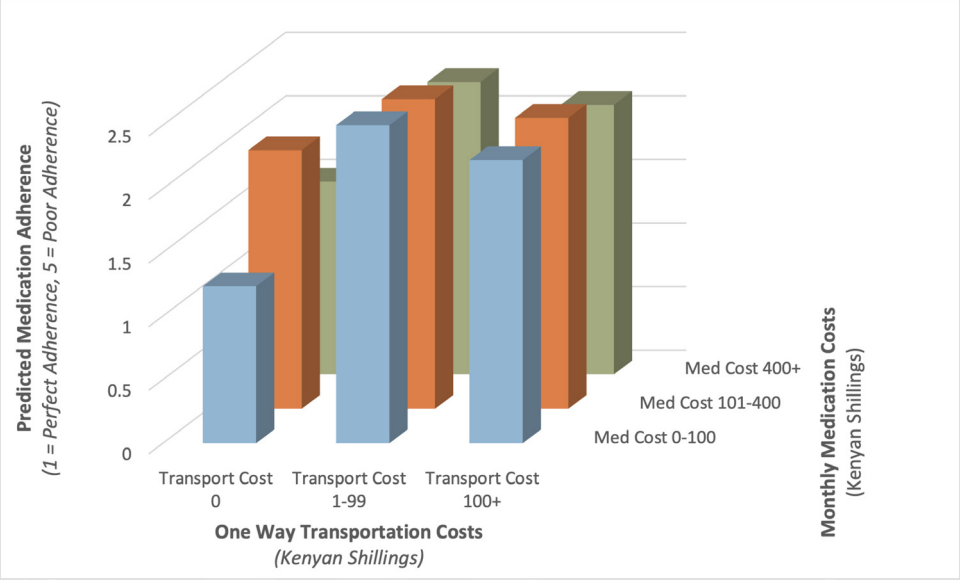

Figure 2 Estimated predicted values of medication adherence at different combinations of transportation and medication costs, generated from the multivariable regression model, illustrating that greater transportation costs were associated with higher (worse) adherence scores, while medication costs were not associated with adherence scores. Full results with CIs are provided in online supplemental table 1.

In the adjusted multivariable analysis, not filling prescriptions or attending clinic visits due to healthcare procurement costs was associated with worse medication adherence (1.1 point greater adherence score, 95% CI: 0.9 to 1.4) (table 3). Higher monthly medication costs were not associated with medication adherence. However, transportation costs greater than zero were associated with worse medication adherence (figure 2, online supplemental table 1). Other measures of economic status, including monthly income and IWI, were also considered in the multivariable model and were not associated with medication adherence. Higher PSS-4 Score (increased perceived stress) was associated with worse medication adherence. There was no evidence in multivariable analysis of an association between medication adherence and any alcohol use.

Economic factors

The majority of participants (71.7%) paid over 100 Kenyan Shillings (KSH) a month for medications, with 50.3% paying between 101 and 400 KSH and 21.4% paying over 400 KSH. On average, those in the highest IWI (≥40) and income categories (≥5000 KSH) reported paying more with respect to monthly medication costs compared with those in lower IWI and income categories (online supplemental figure 1A, B).

The majority of participants (65.9%) reported paying 1–99 KSH for transportation to the health facility, with 23.9% paying 100 or more KSH. On average, those in the highest IWI (≥40) and income categories (≥5000 KSH) reported paying higher transportation costs to the health facility than those in lower IWI and income categories (online supplemental figure 2A, B).

Comorbidity-specific relationships between adherence and economic-related factors

Medication costs were higher for participants with diabetes. Median monthly medication costs were 150 KSH for participants with hypertension, 360 KSH for those with diabetes and 350 KSH for comorbid hypertension and diabetes. However, transportation costs did not appreciably differ by reported medications prescribed (online supplemental table 2). The separate analyses for participants with hypertension, diabetes and comorbid hypertension and diabetes revealed that, while the point estimate for each separate regression approximated the primary analysis, the association between transportation costs and medication adherence was statistically significant only for individuals with hypertension (0.7 greater adherence score, 95% CI: 0.2 to 1.1, for KSH 1–99; and 0.6 greater adherence score 95% CI: 0.1 to 1.1, for KSH 100+) (online supplemental table 3).

DISCUSSION

Suboptimal medication adherence is highly prevalent in rural Kenya, with nearly three-quarters of our study population with diabetes or hypertension reporting suboptimal medication adherence. Among factors known to affect medication adherence in our study population economic factors were most significantly associated with suboptimal medication adherence. Among potential healthcare procurement costs, transportation costs were associated with suboptimal medication adherence. Monthly medication costs were not significantly associated with medication adherence.

The prevalence of suboptimal medication adherence reported in our study is consistent with other studies conducted in Kenya.[34] In a growing number of studies, financial status and healthcare procurement costs were prominent factors associated with suboptimal medication adherence.[8 15 18 35] When evaluating procurement costs affecting medication adherence, many studies focus on the cost of medications.[11 35 36] In our study, in contrast, transportation costs were independently and significantly associated with suboptimal medication adherence. To the best of our knowledge, ours is one of few studies to report this specific adherence barrier for patients with hypertension or diabetes in Africa.[18 37 38] The 'indirect cost' of transportation necessary to access healthcare has been previously highlighted in HIV medication adherence studies.[39–41] This is also consistent with data from low-resource settings in high-income countries[42–44] and LMICs outside of Africa.[45] Transportation costs have been shown in prior studies to lead to missed clinic appointments and less access to pharmacies.[39 46] An additional indirect cost includes the opportunity cost of lost wages associated with time spent at a clinic appointment or travelling to the clinic or pharmacy.[47 48]

Our results also highlighted the relationship between income, wealth and a participant's ability to attend clinic or fill their medications. Even in the highest income and wealth categories, the percentages of those who reported not filling prescriptions or skipping medical visits due to healthcare procurement costs were striking and higher than noted in data from the Kenya household health expenditure survey.[49] Multiple factors may be contributing to this finding, including lack of insurance coverage for outpatient non-communicable disease medications, varying demand for healthcare services[50] and the rural population included in this analysis.

The financial burden of transportation, especially among the most economically and socially disadvantaged, appears to be prohibitive and needs to be addressed in order to truly achieve accessible chronic disease care. Innovative approaches to reducing patient costs, such as community delivery of medications,[51] need to be formally evaluated and scaled up.

Future studies can also help to further explore other direct and indirect cost-related factors that might prevent individuals from adhering to their medications, such as the opportunity cost of lost wages when missing work related to the time required for both the clinic appointment and travel to and from the clinic or pharmacy. In addition, individuals under financial strain may make decisions to prioritise certain expenditures for essential goods and services over others (eg, choosing to pay for food rather than medications or vice versa).[47 49] Different medical conditions exert different cost burdens on patients. In our study, we found that individuals with diabetes had higher monthly medication costs, consistent with other studies conducted in LMICs.[52 53] Our comorbidity-specific results signal that the association between economic factors and medication adherence might also be different for individuals with different disease conditions. These results highlight the need for further studies on cost-related factors impacting medication adherence in Africa and other LMICs.

The primary patient-related factor associated with suboptimal medication adherence was perceived stress. Few prior studies in Africa have identified stress and depression as significant causes of suboptimal medication adherence for participants with hypertension and diabetes.[54 55] Consistent with our results, a cross-sectional study in Ghana reported that stress among hypertensive participants was associated with worse medication adherence.[54] In our study, monthly income was associated with perceived stress (analyses not shown), thus linking socioeconomic determinants with psychological factors and ultimately with poor medication adherence.

We acknowledge the following limitations of our study. First, the study was not designed to be a comprehensive analysis of every major factor associated with medication adherence. Thus, we did not have the data to be able to evaluate the impact of the doctor–patient relationship or healthcare literacy. Second, our cross-sectional study also did not explore the factors associated with longitudinal medication adherence, including self-efficacy and evolving patient beliefs regarding medication necessity. Third, we did note missing data for monthly medication costs and transportation costs, and only complete (non-missing) observations were used in our final multivariable model. We recognise that this reduced our analytical sample size and statistical power to detect associations. Fourth, social desirability and recall bias inherent to all self-reported adherence scales are also a limitation. In addition, this study was not designed to collect more in-depth data regarding prescription filling practices. It is known that patients under financial stress partially fill medications, skip doses to save money or delay filling prescriptions to save money in high-income countries.[56] More research can be done in the future to determine the extent of partial filling of medications in LMICs. Finally, generalisability might be an issue, given that the participant population might have a different level of financial insecurity than the general population. However, our results still highlight important challenges that are confronted by patients worldwide who are navigating poverty and illness.[45]

CONCLUSION

Our study demonstrated a strong association between cost, particularly transportation costs and suboptimal medication adherence in a resource-limited setting. We identified key intervenable factors, particularly transportation costs. Accessibility and affordability of the entire process of procuring medications are paramount to achieve medication adherence. Addressing the full spectrum of cost-related factors affecting medication adherence in Africa and other LMICs will be imperative to improve medication adherence worldwide.

Author affiliations
[1]Medicine, NYU Grossman School of Medicine, New York, New York, USA
[2]Medicine, Moi University, Eldoret, Kenya
[3]Population Health, New York University Grossman School of Medicine, New York, New York, USA
[4]Academic Model Providing Access to Healthcare (AMPATH), Eldoret, Kenya
[5]Center for Health Equity and Innovation, Purdue University College of Pharmacy Nursing and Health Sciences, West Lafayette, Indiana, USA
[6]Medicine and Population Health Science, Icahn School of Medicine at Mount Sinai, New York, New York, USA
[7]Biostatistics, Brown University, Providence, Rhode Island, USA
[8]Medicine and Population Health, New York University Grossman School of Medicine, New York, New York, USA

Twitter Rajesh Vedanthan @rvedanthan

Acknowledgements The authors would like to thank Kun Qian for input into the statistical analysis. We would also like to thank the AMPATH Kenya community for their input into the BIGPIC trial as this study a secondary analysis of the data collected in the main trial.

Contributors PG, JHK, MVS, JWH and RV designed the study. RM and VO acquired and maintained the data. MVS, JWH, PG and RV analysed and interpreted the data. PG, MVS and RV wrote the manuscript. JHK, RM, VO, SP, CH, JWH and RV revised the manuscript. All authors approved the final manuscript. PG is responsible for the full content of the work as the guarantor.

Funding The BIGPIC trial was supported by the National Heart, Lung, and Blood Institute of the National Institutes of Health under award number 5R01HL125487. The content of this study is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health.

Competing interests None declared.

Patient and public involvement Patients and/or the public were involved in the design, or conduct, or reporting, or dissemination plans of this research. Refer to the Methods section for further details.

Patient consent for publication Consent obtained directly from patient(s).

Ethics approval This study involves human participants. The protocol for the BIGPIC study was approved by the Moi University School of Medicine Institutional Research and Ethics Committee and the NYU Grossman School of Medicine Institutional Review Board (ethics approval number i18-01260_CR5). All participants provided written informed consent. This report is a secondary analysis of baseline data collected by the BIGPIC study. Participants gave informed consent to participate in the study before taking part.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available upon reasonable request. This study is in compliance with the NIH Public Access Policy, which ensures that the public has access to the published results of NIH-funded research. All results have been (and will be made) available from final peer-reviewed journal manuscripts (including this one) via the digital archive PubMed Central upon acceptance for publication.

Author note This study is a secondary data analysis of the BIGPIC Study, a collaboration between AMPATH Kenya and New York University Grossman School of Medicine. AMPATH Kenya is a partnership among Moi University, Moi Teaching and Referral Hospital and a consortium of North American universities, including NYU Grossman School of Medicine. AMPATH Kenya program has developed a comprehensive chronic disease management program, with a focus on hypertension and diabetes. The BIGPIC project was developed together with local partners using a human-centred design approach that included input from health professionals, patients, microfinance officers, community health workers and village leaders. This secondary analysis was aimed at identifying the factors affecting medication adherence that can be further explored through the existing care delivery program and research infrastructure of AMPATH Kenya. Both US-based biostatisticians (JWH and MVS) and Kenya-based AMPATH data managers and biostatisticians (RM and VO) helped maintain, analyse and interpret the data. This study is one of multiple studies planned with the goals of shared lead authorship and promoting the development of research skills among local researchers.

ORCID iDs
Pooja Gala http://orcid.org/0000-0002-7505-9352
Vitalis Orango http://orcid.org/0000-0001-6145-1823
Rajesh Vedanthan http://orcid.org/0000-0001-7138-2382

REFERENCES

1 Zhou B, Carrillo-Larco RM, Danaei G. Worldwide trends in hypertension prevalence and progress in treatment and control from 1990 to 2019: a pooled analysis of 1201 population-representative studies with 104 million participants. *Lancet* 2021;398:957–80.
2 Schutte AE, Srinivasapura Venkateshmurthy N, Mohan S, *et al*. Hypertension in low- and middle-income countries. *Circ Res* 2021;128:808–26.
3 Bowry ADK, Lewey J, Dugani SB, *et al*. The burden of cardiovascular disease in Low- and middle-income countries: epidemiology and management. *Can J Cardiol* 2015;31:1151–9.
4 Flood D, Seiglie JA, Dunn M, *et al*. The state of diabetes treatment coverage in 55 low-income and middle-income countries: a cross-sectional study of nationally representative, individual-level data in 680 102 adults. *Lancet Healthy Longev* 2021;2:e340–51.
5 Turnbull F, Blood Pressure Lowering Treatment Trialists C. Effects of different blood-pressure-lowering regimens on major cardiovascular events: results of prospectively-designed overviews of randomised trials. *Lancet* 2003;362:1527–35.
6 World Health Organization. Adherence to long-term therapies: evidence for action; 2003.
7 Nielsen JØ, Shrestha AD, Neupane D, *et al*. Non-adherence to anti-hypertensive medication in low- and middle-income countries: a systematic review and meta-analysis of 92443 subjects. *J Hum Hypertens* 2017;31:14–21.
8 Macquart de Terline D, Kane A, Kramoh KE, *et al*. Factors associated with poor adherence to medication among hypertensive patients in twelve low and middle income sub-saharan countries. *PLoS One* 2019;14:e0219266.
9 Peh KQE, Kwan YH, Goh H, *et al*. An adaptable framework for factors contributing to medication adherence: results from a systematic review of 102 conceptual frameworks. *J Gen Intern Med* 2021;36:2784–95.
10 Xu J, Zhao M, Vrosgou A, *et al*. Barriers to medication adherence in a rural-urban dual economy: a multi-stakeholder qualitative study. *BMC Health Serv Res* 2021;21:799.
11 Sarfo FS, Mobula LM, Burnham G, *et al*. Factors associated with uncontrolled blood pressure among Ghanaians: evidence from a multicenter hospital-based study. *PLoS ONE* 2018;13:e0193494.
12 Morgan SG, Lee A. Cost-related non-adherence to prescribed medicines among older adults: a cross-sectional analysis of a survey in 11 developed countries. *BMJ Open* 2017;7:e014287.
13 Piette JD, Heisler M, Wagner TH. Cost-related medication underuse among chronically ill adults: the treatments people forgo, how often, and who is at risk. *Am J Public Health* 2004;94:1782–7.
14 De Avila JL, Meltzer DO, Zhang JX. Prevalence and persistence of cost-related medication nonadherence among medicare beneficiaries at high risk of hospitalization. *JAMA Netw Open* 2021;4:e210498.
15 Sendekie AK, Netere AK, Kasahun AE, *et al*. Medication adherence and its impact on glycemic control in type 2 diabetes mellitus patients with comorbidity: a multicenter cross-sectional study in northwest Ethiopia. *PLoS ONE* 2022;17:e0274971.
16 Aminde LN, Tindong M, Ngwasiri CA, *et al*. Adherence to antidiabetic medication and factors associated with non-adherence among patients with type-2 diabetes mellitus in two regional hospitals in Cameroon. *BMC Endocr Disord* 2019;19:35.
17 Agbor VN, Takah NF, Aminde LN. Prevalence and factors associated with medication adherence among patients with hypertension in sub-

Saharan Africa: protocol for a systematic review and meta-analysis. *BMJ Open* 2018;8:e020715.
18 Mebrahtu G, M Moleki M, Okoth Achila O, *et al*. Antihypertensive medication adherence and associated factors: a cross-sectional analysis of patients attending a national referral hospital in Asmara, Eritrea. *Patient Prefer Adherence* 2021;15:2619–32.
19 Vedanthan R, Kamano JH, Chrysanthopoulou SA, *et al*. Group medical visit and microfinance intervention for patients with diabetes or hypertension in Kenya. *J Am Coll Cardiol* 2021;77:2007–18.
20 Vedanthan R, Kamano JH, Lee H, *et al*. Bridging income generation with group integrated care for cardiovascular risk reduction: rationale and design of the BIGPIC study. *Am Heart J* 2017;188:175–85.
21 Jonas DE, Crotty K, Yun JDY, *et al*. Screening for prediabetes and type 2 diabetes: updated evidence report and systematic review for the US preventive services task force. *JAMA* 2021;326:744–60.
22 Gray LJ, Taub NA, Khunti K, *et al*. The Leicester risk assessment score for detecting undiagnosed type 2 diabetes and impaired glucose regulation for use in a multiethnic UK setting. *Diabet Med* 2010;27:887–95.
23 Cohen S, Kamarck T, Mermelstein R. A global measure of perceived stress. *J Health Soc Behav* 1983;24:385–96.
24 Smits J, Steendijk R. The international wealth index (IWI). *Soc Indic Res* 2015;122:65–85.
25 Voils CI, Maciejewski ML, Hoyle RH, *et al*. Initial validation of a self-report measure of the extent of and reasons for medication nonadherence. *Med Care* 2012;50:1013–9.
26 Blalock DV, Zullig LL, Bosworth HB, *et al*. Self-reported medication nonadherence predicts cholesterol levels over time. *J Psychosom Res* 2019;118:49–55.
27 Voils CI, King HA, Neelon B, *et al*. Characterizing weekly self-reported antihypertensive medication nonadherence across repeated occasions. *Patient Prefer Adherence* 2014;8:643–50.
28 Doll H. Statistical approaches to uncertainty: P values and confidence intervals unpacked. *Evidence-Based Medicine* 2005;10:133–4.
29 Greenland S, Senn SJ, Rothman KJ, *et al*. Statistical tests, P values, confidence intervals, and power: a guide to misinterpretations. *Eur J Epidemiol* 2016;31:337–50.
30 Bloomfield GS, Kimaiyo S, Carter EJ, *et al*. Chronic noncommunicable cardiovascular and pulmonary disease in sub-Saharan Africa: an academic model for countering the epidemic. *Am Heart J* 2011;161:842–7.
31 Mercer T, Gardner A, Andama B, *et al*. Leveraging the power of partnerships: spreading the vision for a population health care delivery model in Western Kenya. *Global Health* 2018;14:44.
32 Prabhakaran D, Anand S, Gaziano TA, *et al*. *Quality improvement in cardiovascular disease care. Cardiovascular, respiratory, and related disorders*. Washington (DC): The International Bank for Reconstruction and Development, The World Bank, 2017.
33 Leung CL, Naert M, Andama B, *et al*. Correction to: human-centered design as a guide to intervention planning for non-communicable diseases: the BIGPIC study from Western Kenya. *BMC Health Serv Res* 2020;20:738.
34 Waari G, Mutai J, Gikunju J. Medication adherence and factors associated with poor adherence among type 2 diabetes mellitus patients on follow-up at Kenyatta national hospital, Kenya. *Pan Afr Med J* 2018;29:82.
35 Wirtz VJ, Kaplan WA, Kwan GF, *et al*. Access to medications for cardiovascular diseases in low- and middle-income countries. *Circulation* 2016;133:2076–85.
36 Okello S, Nasasira B, Muiru ANW, *et al*. Validity and reliability of a self-reported measure of antihypertensive medication adherence in Uganda. *PLoS One* 2016;11:e0158499.
37 Wariva E, January J, Maradzika J. Medication adherence among elderly patients with high blood pressure in Gweru, Zimbabwe. *J Public Health Afr* 2014;5:304.
38 Kisigo GA, Mcharo OC, Robert JL, *et al*. Understanding barriers and facilitators to clinic attendance and medication adherence among adults with hypertensive urgency in Tanzania. *PLOS Glob Public Health* 2022;2:e0000919.
39 Tuller DM, Bangsberg DR, Senkungu J, *et al*. Transportation costs impede sustained adherence and access to HAART in a clinic population in Southwestern Uganda: a qualitative study. *AIDS Behav* 2010;14:778–84.
40 Becker N, Cordeiro LS, Poudel KC, *et al*. Individual, household, and community level barriers to ART adherence among women in rural eswatini. *PLoS One* 2020;15:e0231952.
41 Wasti SP, Simkhada P, Randall J, *et al*. Factors influencing adherence to antiretroviral treatment in Nepal: a mixed-methods study. *PLoS One* 2012;7:e35547.
42 Feehan M, Morrison MA, Tak C, *et al*. Factors predicting self-reported medication low adherence in a large sample of adults in the US general population: a cross-sectional study. *BMJ Open* 2017;7:e014435.
43 Byhoff E, Guardado R, Xiao N, *et al*. Association of unmet social needs with chronic illness: a cross-sectional study. *Popul Health Manag* 2022;25:157–63.
44 Xu S, Goodrich GK, Moore KR, *et al*. Identifying relative changes in social risk factors: an analytic approach. *Med Care* 2021;59:e9–15.
45 Gupta S, Dhamija JP, Mohan I, *et al*. Qualitative study of barriers to adherence to antihypertensive medication among rural women in India. *Int J Hypertens* 2019;2019:5749648.
46 Syed ST, Gerber BS, Sharp LK. Traveling towards disease: transportation barriers to health care access. *J Community Health* 2013;38:976–93.
47 NHJ H. Opportunity cost: the hidden toll of seeking health care. Health Affairs; 2019.
48 Ray KN, Chari AV, Engberg J, *et al*. Opportunity costs of ambulatory medical care in the United States. *Am J Manag Care* 2015;21:567–74.
49 Njagi P, Arsenijevic J, Groot W. Cost-related unmet need for healthcare services in Kenya. *BMC Health Serv Res* 2020;20:322.
50 Mwenda N, Nduati R, Kosgei M, *et al*. What drives outpatient care costs in Kenya? An analysis with generalized estimating equations. *Front Public Health* 2021;9:648465.
51 Tran DN, Kangogo K, Amisi JA, *et al*. Community-based medication delivery program for antihypertensive medications improves adherence and reduces blood pressure. *PLoS One* 2022;17:e0273655.
52 Ewen M, Joosse HJ, Beran D, *et al*. Insulin prices, availability and affordability in 13 low-income and middle-income countries. *BMJ Glob Health* 2019;4:e001410.
53 Zhang P, Zhang X, Brown J, *et al*. Global healthcare expenditure on diabetes for 2010 and 2030. *Diabetes Res Clin Pract* 2010;87:293–301.
54 Kretchy IA, Owusu-Daaku FT, Danquah SA. Mental health in hypertension: assessing symptoms of anxiety, depression and stress on anti-hypertensive medication adherence. *Int J Ment Health Syst* 2014;8:25.
55 Jayanna K, Swaroop N, Kar A, *et al*. Designing a comprehensive non-communicable diseases (NCD) programme for hypertension and diabetes at primary health care level: evidence and experience from urban Karnataka, South India. *BMC Public Health* 2019;19:409.
56 Khera R, Valero-Elizondo J, Das SR, *et al*. Cost-related medication nonadherence in adults with atherosclerotic cardiovascular disease in the United States, 2013 to 2017. *Circulation* 2019;140:2067–75.