

RESEARCH ARTICLE

Open Access

# Human-centered design as a guide to intervention planning for non-communicable diseases: the BIGPIC study from Western Kenya

Claudia L. Leung<sup>1,2</sup>, Mackenzie Naert<sup>3</sup>, Benjamin Andama<sup>4</sup>, Rae Dong<sup>3</sup>, David Edelman<sup>2</sup>, Carol Horowitz<sup>3</sup>, Peninah Kiptoo<sup>4</sup>, Simon Manyara<sup>4</sup>, Winnie Matelong<sup>4</sup>, Esther Matini<sup>4</sup>, Violet Naanyu<sup>5</sup>, Sarah Nyariki<sup>4</sup>, Sonak Pastakia<sup>6</sup>, Thomas Valente<sup>7</sup>, Valentin Fuster<sup>3</sup>, Gerald S. Bloomfield<sup>3</sup>, Jemima Kamano<sup>5</sup> and Rajesh Vedanthan<sup>8\*</sup>

## Abstract

**Background:** Non-communicable disease (NCD) care in Sub-Saharan Africa is challenging due to barriers including poverty and insufficient health system resources. Local culture and context can impact the success of interventions and should be integrated early in intervention design. Human-centered design (HCD) is a methodology that can be used to engage stakeholders in intervention design and evaluation to tailor-make interventions to meet their specific needs.

**Methods:** We created a Design Team of health professionals, patients, microfinance officers, community health workers, and village leaders. Over 6 weeks, the Design Team utilized a four-step approach of synthesis, idea generation, prototyping, and creation to develop an integrated microfinance-group medical visit model for NCD. We tested the intervention with a 6-month pilot and conducted a feasibility evaluation using focus group discussions with pilot participants and community members.

**Results:** Using human-centered design methodology, we designed a model for NCD delivery that consisted of microfinance coupled with monthly group medical visits led by a community health educator and a rural clinician. Benefits of the intervention included medication availability, financial resources, peer support, and reduced caregiver burden. Critical concerns elicited through iterative feedback informed subsequent modifications that resulted in an intervention model tailored to the local context.

(Continued on next page)

\* Correspondence: [Rajesh.Vedanthan@nyulangone.org](mailto:Rajesh.Vedanthan@nyulangone.org)

<sup>8</sup>New York University Grossman School of Medicine, 180 Madison Avenue, 8th Floor, New York, NY 10016, USA

Full list of author information is available at the end of the article



© The Author(s). 2020 **Open Access** This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by/4.0/>. The Creative Commons Public Domain Dedication waiver (<http://creativecommons.org/publicdomain/zero/1.0/>) applies to the data made available in this article, unless otherwise stated in a credit line to the data.

(Continued from previous page)

**Conclusions:** Contextualized interventions are important in settings with multiple barriers to care. We demonstrate the use of HCD to guide the development and evaluation of an innovative care delivery model for NCDs in rural Kenya. HCD can be used as a framework to engage local stakeholders to optimize intervention design and implementation. This approach can facilitate the development of contextually relevant interventions in other low-resource settings.

**Trial registration:** Clinicaltrials.gov, [NCT02501746](https://clinicaltrials.gov/ct2/show/study/NCT02501746), registration date: July 17, 2015.

**Keywords:** Non-communicable diseases, Kenya, Human-centered design, Delivery of healthcare, Problem-solving, Microfinance

## Background

Globally, non-communicable diseases (NCDs) are the most common cause of premature mortality [1, 2]. Associated with mortality and prolonged disability, NCDs have negative impacts at the individual, community, and societal level due to increased utilization of health services, as well as loss of income and decreased productivity [3, 4]. NCD incidence and outcome are closely linked to social, economic, and environmental factors, disproportionately impacting poor and vulnerable populations [5–7]. In Kenya and other low- and middle-income countries, NCDs are associated with a substantial household financial burden of care, which significantly impacts access to care [8].

In Kenya, multiple studies have demonstrated the positive impact of microfinance on poverty [9, 10], and a small but increasing number of studies have demonstrated the synergistic effect of integrating microfinance and health interventions [11]. Most interventions combined microfinance with health education and did not affect the more complex task of healthcare delivery [12]. The Village Savings and Loans Association (VSLA) model, on which the microfinance model in this paper is derived, has improved food security and strengthened household income indicators in Africa [13, 14]. In this model, participants save money together through buying shares and can access loans by borrowing against their savings. Interest is paid back to the group, and accumulated shares and interest are later shared out to all the group members [15]. Additional informal and formal group-based savings and credit models also exist in Kenya, including microcredit lending through institutions and local moneylenders, savings via investment in livestock, and the Rotating Savings and Credit Associations (ROSCA) model, commonly referred to as merry-go-round, in which members take turns receiving a pot of shared savings over a particular time period [16].

### The need for contextualized interventions

Lack of transport, poverty, and poor quality of care are known barriers to NCD care in western Kenya [17]. Skepticism regarding the health system, fear of stigma,

and socio-economic fragility also contribute to low utilization of available healthcare resources [18, 19]. This complex milieu necessitates targeted solutions that address both the health and economic realities faced by this population. Rather than replicate existing interventions in high-resource settings, development of new interventions must be innovative, striving to provide high-quality care while accounting for resource constraints and contextual factors [5]. Ideally, a replicable intervention design and evaluation process should be used, allowing for the flexibility to develop a contextualized intervention while using a standardized process that can be applied in diverse settings.

Human-centered design (HCD) is a problem-solving approach that utilizes a series of iterative, often non-linear steps to tailor-make solutions for complex problems [20, 21]. While similar to other participatory research frameworks in its inclusion of end-user feedback, HCD differs in its endeavor towards empathy, a deep understanding of the motivations and desires that govern human behavior, as the inspiration and core of intervention development [20, 22]. In this approach, end-users are invited to partner in the design and evaluation process in order to better understand, meet, and even preempt their needs. In a low-resource, complex setting where the phenotypic manifestations of disease drivers may differ significantly from well-resourced settings, these key principles of HCD can be leveraged to optimize intervention development and implementation.

In this paper, we describe how we adapt a four-step HCD approach to guide the development of an integrated model of group care and microfinance for NCD care in rural Kenya. We use this case to describe the potential of utilizing a HCD approach to guide the development of complex interventions in a resource-limited setting.

## Methods

### Setting

The Academic Model Providing Access to Healthcare (AMPATH), initiated in 2001, is a partnership between Moi University College of Health Sciences, Moi

83  
84  
85  
86  
87  
88  
89  
90  
91  
92  
93  
94  
95  
96  
97  
98  
99  
100  
101  
102  
103  
104  
105  
106  
107  
108  
109  
110  
111  
112  
113  
114  
115  
116  
117  
118  
119  
120  
121  
122  
123

Teaching and Referral Hospital, and a consortium of North American academic medical centers [23]. AMPATH established a system of HIV care in western Kenya and has since expanded its clinical scope to include population health and NCDs [24]. At the time that this study was conducted, the Chronic Disease Management program at AMPATH had enrolled over 2000 patients with diabetes and 40,000 patients with hypertension, who were being cared for at nine rural health centers and 30 rural dispensaries. The program dispatches clinicians to rural clinics monthly, which are otherwise staffed by nurses. This study was conducted as part of the Bridging Income Generation and Group Integrated Care (BIGPIC) study which aims to evaluate the combination of microfinance and group medical visits for cardiovascular risk reduction in the AMPATH catchment area across four counties in western Kenya [25].

#### Intervention design

In this project, we adapted a pilot BIGPIC model that consisted of microfinance coupled with monthly group medical care visits with a rural clinician [26]. In this pilot model, participants with diabetes or hypertension are recruited to join the group and consist of at least 50% of group members. Group medical visits with a clinician occur immediately after each microfinance meeting. In order to further refine and adapt this approach to the local context, we utilized a HCD framework consisting of four steps – Discover, Design, Test, and Refine – with an emphasis on community and end-user engagement at each stage (Fig. 1). As HCD is an iterative process, the steps are described in sequence in the Methods and Results sections.

#### Step 1. DISCOVER: understanding the community

The first step in refining the BIGPIC model was to understand the strengths and needs of the local community. We utilized a combination of qualitative research methodologies to explore community and individual perspectives. The primary goals were to identify existing barriers to NCD care, and to identify contextual factors, barriers, and facilitators that could impact intervention design, implementation, and sustainability. We held *mabaraza*, traditional East African community gatherings, to discuss community perspectives in an open format. We also hosted focus group discussions (FGDs) consisting of 10–15 individuals with common characteristics (rural clinicians, community health workers, patients with NCDs, and microfinance group members) to explore individual perspectives. All qualitative studies were led by local team members utilizing a semi-structured guided interview in local languages.

#### Step 2. DESIGN: designing the intervention

**Design team formation** A transdisciplinary team of researchers and community stakeholders led the intervention design, implementation planning, and evaluation process (Fig. 2). The goals of the Design Team were to define the challenges to NCD care based on community input and design an intervention model to meet the needs and challenges of the end-users. Potential participants were identified through snowball sampling and local connections and invited to participate based on personal or professional experiences with NCDs or microfinance. All Design Team members represented end-users, those who may deliver or receive the intervention.

**Design team meetings** Design Team meetings were conducted in a series of weekly three-hour meetings over 6 weeks, following objectives and activities adapted from HCD methodology [21]. An initial agenda was developed, however, timing for each step was flexible.

The specific objectives and activities utilized in the Design Team meetings are described in Fig. 3. The forum and structure of the meetings were intentionally collaborative and interactive to encourage discussion and creativity. In Synthesis meetings, Design Team members reviewed qualitative data gathered in Step 1 and shared their insights, experiences, and questions to help engender a deep understanding of the strengths and barriers related to NCD care in western Kenya. Insights were posted visually and reorganized into broad themes which represented potential intervention barriers, facilitators, or unmet needs (Fig. 6, Table 1). Within each theme, questions were developed to facilitate brainstorming in Ideate meetings. For example, for the theme “Information/Engagement,” we asked, “how might we incorporate health education into patient care?” We learned in Step 1 that microfinance is generally considered a women’s activity which may preclude male participation, so for the theme, “Gender,” we asked, “how might we create a model that is responsive to the needs of men?” Each question was formed to catalyze group discussion to address important and nuanced aspects of the intervention that would ultimately impact intervention acceptability and sustainability.

All ideas were noted and subsequently evaluated in group discussion for pros, cons, and feasibility in Prototype meetings. In the latter example above, we considered gender-specific groups, targeted screening locations when men tend to congregate, and community education, particularly through male leadership involvement.

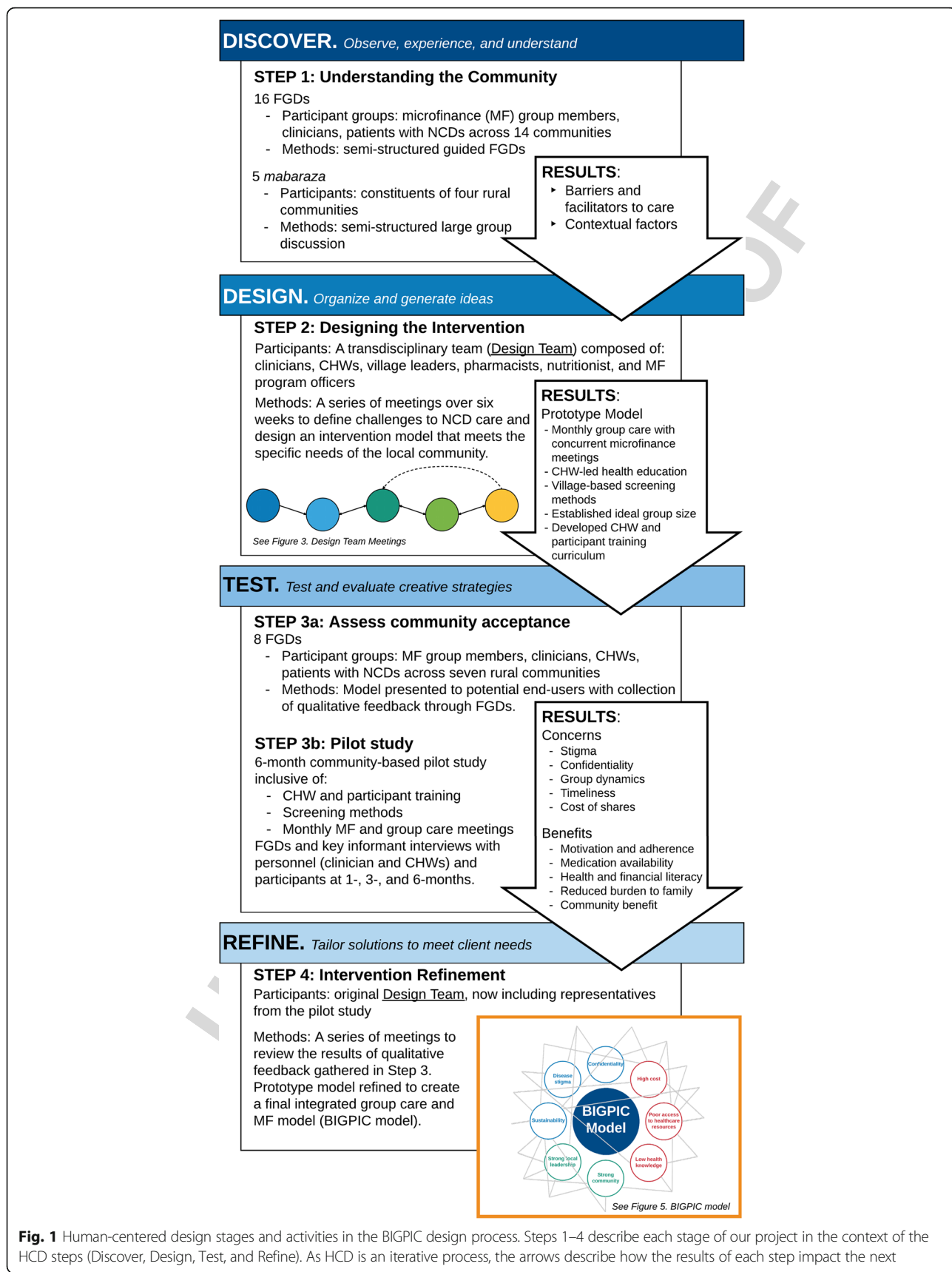
Synthesis, brainstorming, and prototyping were cyclical and iterative steps that raised new questions influencing idea generation. In Create meetings, an initial

F1

F2

F3

T1



f1.1  
f1.2  
f1.3

**Fig. 1** Human-centered design stages and activities in the BIGPIC design process. Steps 1–4 describe each stage of our project in the context of the HCD steps (Discover, Design, Test, and Refine). As HCD is an iterative process, the arrows describe how the results of each step impact the next

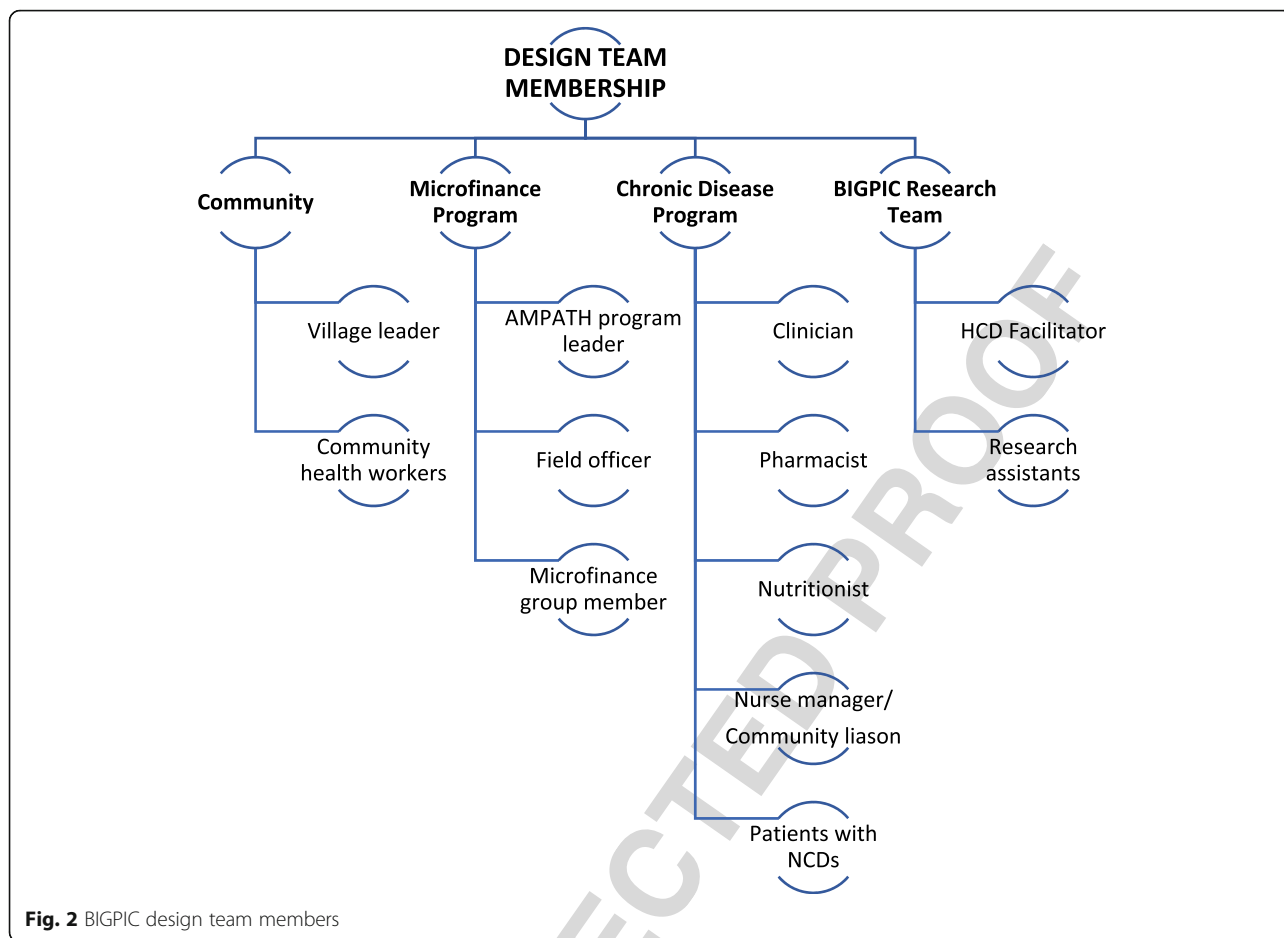


Fig. 2 BIGPIC design team members

226 prototype model was developed that combined group  
 227 medical care and microfinance. Elements crucial to test-  
 228 ing the prototype were developed in this step, including  
 229 participant education materials, healthcare worker train-  
 230 ing curricula, and screening and evaluation protocols.

**Step 3. TEST: assess community acceptance and pilot study** 231

**Acceptability studies** Qualitative feedback was gathered 232  
 to assess community receptiveness to the proposed 233  
 prototype model. FGDs of 10–15 individuals were 234

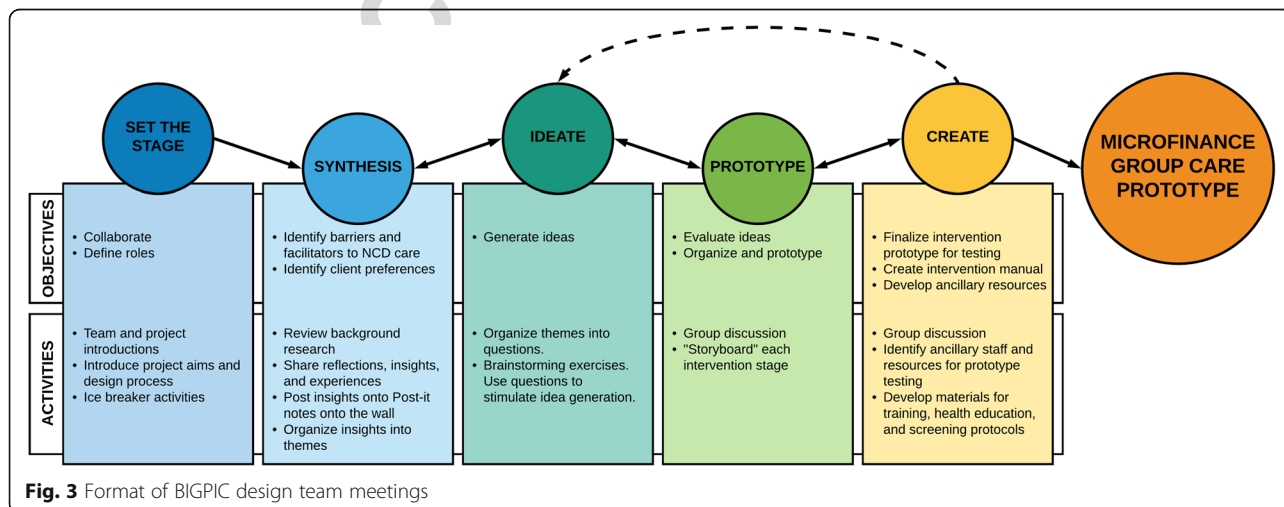


Fig. 3 Format of BIGPIC design team meetings

t1.1 **Table 1** Key themes identified in Step 2, Synthesis meetings

t1.2 Key Themes

---

t1.3 Information/engagement

t1.4 Gender

t1.5 Finance/Cost

t1.6 Attitude/Commitment

t1.7 Time

t1.8 Confidentiality

t1.9 Knowledge

---

t1.10 Preliminary results from Step 1 presented to the Design Team were organized into

t1.11 Themes, along with member contributions of personal insights and experiences

economic fragility, and stigma were significant barriers to accessing and maintaining NCD care [27]. 273 274

**Step 2. DESIGN: designing the intervention** 275  
 Our iterative design process resulted in an initial prototype model combining microfinance with monthly group medical care visits with a rural clinician. Compared to the original BIGPIC pilot model, this prototype engaged community health workers (CHWs) as group liaisons, included a CHW-led health education didactic at every meeting, and emphasized community-based recruitment approaches. 276 277 278 279 280 281 282 283

**Step 3. TEST: assess community acceptance and pilot study** 284 285  
 Approximately 90 individuals in the community were screened, and 31 participants (12 male, 19 female) were enrolled to form the pilot study group. The group included a mix of different ethnic tribes and participants ranged in age from 36 to 75. In total, 17 FGDs and guided interviews were conducted (N = 110) at which point we achieved content saturation. 286 287 288 289 290 291 292

In general, the initial BIGPIC prototype model was found to be acceptable, with multiple perceived and anticipated benefits at the individual, family, and community levels (Fig. 4). Participants reported improved access to medical services by mitigating the need to travel, decreased cost of medications, peer support, and medication reliability as important benefits. Community level feedback provided additional insight to alleviate preexisting concerns regarding the prototype model, highlight persisting concerns, or raised new concerns not previously identified. 293 294 295 296 297 298 299 300 301 302 303

For example, one concern alleviated by the initial prototype regarded gender and group dynamics. In qualitative studies in Step 1 and Step 3, some community members expressed concern that differences in age and gender could affect group participation, given a strong culture of both gender and age-based hierarchy. Unintentionally, our pilot testing group was mixed not only in gender but also age and ethnic tribe. Yet, participants stated they found diversity in age, gender, and background to be a strength of the group, providing a sense of healthy competition between old and young, and allowing the younger members to take leadership roles and provide translation to their local language for the older members. Elected leaders in the group were both male and female, and gender differences did not negatively impact group dynamics. 304 305 306 307 308 309 310 311 312 313 314 315 316 317 318 319

New concerns elicited through this process included maximum group size and concern that this could lead to clinician burn out. Additionally, participants requested increased flexibility in scheduling monthly meetings so as not to interfere with their annual harvest schedule, 320 321 322 323 324

235 conducted with groups of rural clinicians, microfinance  
 236 group members, patients with NCDs, and CHWs. A  
 237 question guide was used to steer the discussion in a  
 238 semi-structured format. We performed a thematic ana-  
 239 lysis of the qualitative feedback utilizing NVivo.

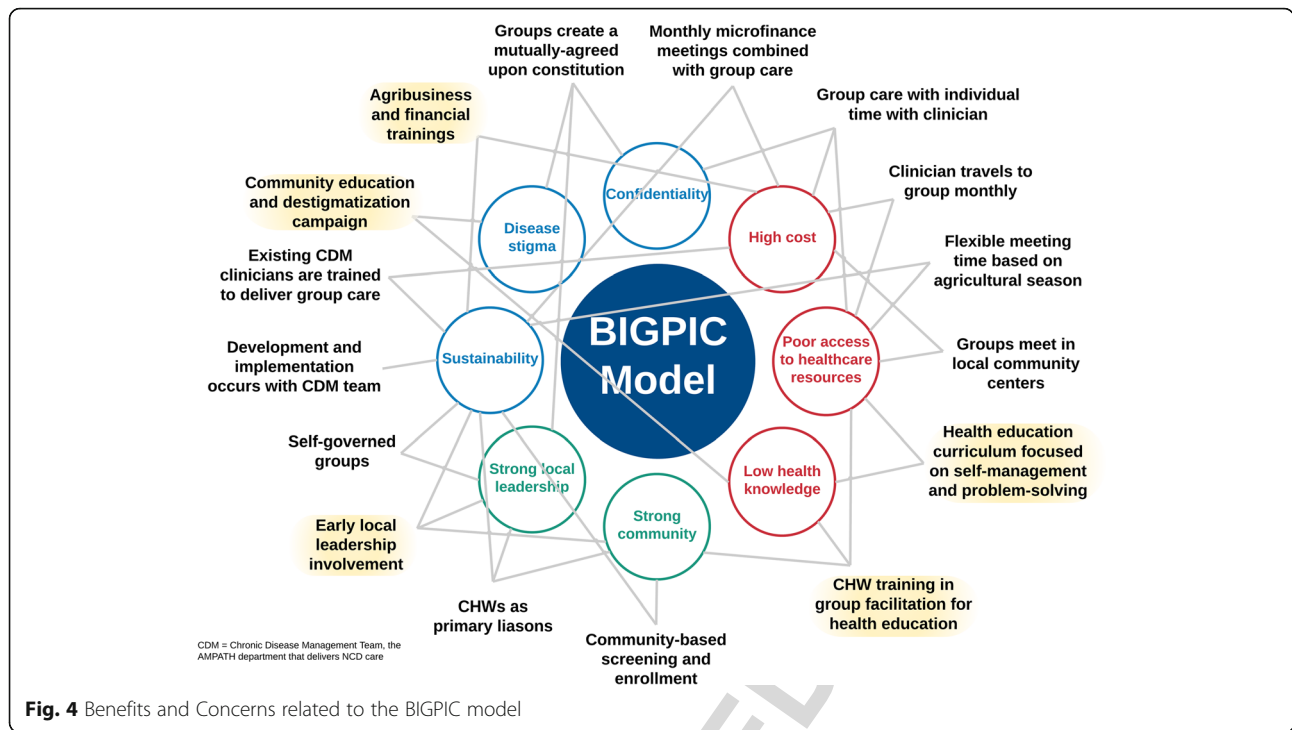
240 **Feasibility pilot study** Implementation strategies and  
 241 the prototype, as defined in Step 2 Results, were piloted  
 242 in one rural community in western Kenya. Adults who  
 243 screened “positive” were those with elevated blood pres-  
 244 sure or elevated fasting blood glucose. Inclusion criteria  
 245 of those who screened positive were newly screened  
 246 adults, previously screened adults who had never linked  
 247 to care, or existing patients who had linked to care in  
 248 the last 6 months. Those with diabetes or hypertension  
 249 who did not meet the inclusion criteria were able to join  
 250 the group as non-study participants to a maximum  
 251 group size of 30 members. Participants and local CHWs  
 252 subsequently received training in microfinance, hyper-  
 253 tension, and diabetes. Qualitative feedback was elicited  
 254 from the participating rural clinician, CHWs, and group  
 255 participants at one, three, and 6 months using guided in-  
 256 terviews and FGDs.

257 **Step 4. REFINE: intervention refinement**  
 258 The Design Team subsequently reconvened to evaluate  
 259 the results of the acceptability studies and feasibility  
 260 pilot study. In addition to the original team, representa-  
 261 tives from among the pilot study participants were  
 262 elected by their peers to take part in the reevaluation  
 263 process. In a series of meetings, the Design Team  
 264 reviewed the feedback and developed a final BIGPIC  
 265 model.

266 **Results**

267 **Step 1. DISCOVER: understanding the community**  
 268 Five *mabaraza* and 16 focus group discussions were  
 269 conducted across 11 sub-counties in western Kenya. Re-  
 270 sults from these qualitative studies indicated that cost,  
 271 lack of medication availability, distance to health facil-  
 272 ities, earned skepticism of the health system, socio-

F4



**Fig. 4** Benefits and Concerns related to the BIGPIC model

f4.1  
f4.2

325 and to expanded availability of commonly used medica- 354  
 326 tions. Researchers and CHWs noted low interest and en- 355  
 327 gagement in the health education didactic sessions 356  
 328 provided by the CHWs. 357

329 Persisting concerns shared by pilot participants in- 358  
 330 cluded apprehension that participation would be limited 359  
 331 by stigma associated with illness such as HIV. Partici- 360  
 332 pants emphasized the importance of anticipatory com- 361  
 333 munity education to enhance community receptiveness, 362  
 334 and suggested strategies to facilitate this. Based on their 363  
 335 prior experiences with brief lifecycles of programs due 364  
 336 to limitations in funding and service delivery, partici- 365  
 337 pants and local leaders also expressed concern regarding 366  
 338 the sustainability of the program, and noted these prior 367  
 339 experiences may discourage some from joining. They 368  
 340 also reported that income generally is low among their 369  
 341 community and requested seed money or incentives to 370  
 342 jump start their savings. 371

343 **Step 4. REFINE: intervention refinement**

344 The final BIGPIC model consists of an integrated group 372  
 345 care and microfinance model, with specific changes to 373  
 346 the prototype model described in Table 3. These include 374  
 347 expanded access to common medications, a reduction in 375  
 348 maximum group size, and clarification of protocols with 376  
 349 CHWs to coordinate changes in meeting times during 377  
 350 the harvest season. 378

351 In response to the low interest in health education di- 380  
 352 dactic sessions, our final model included a redesigned 381  
 353 education curriculum, which shifted the focus from 382

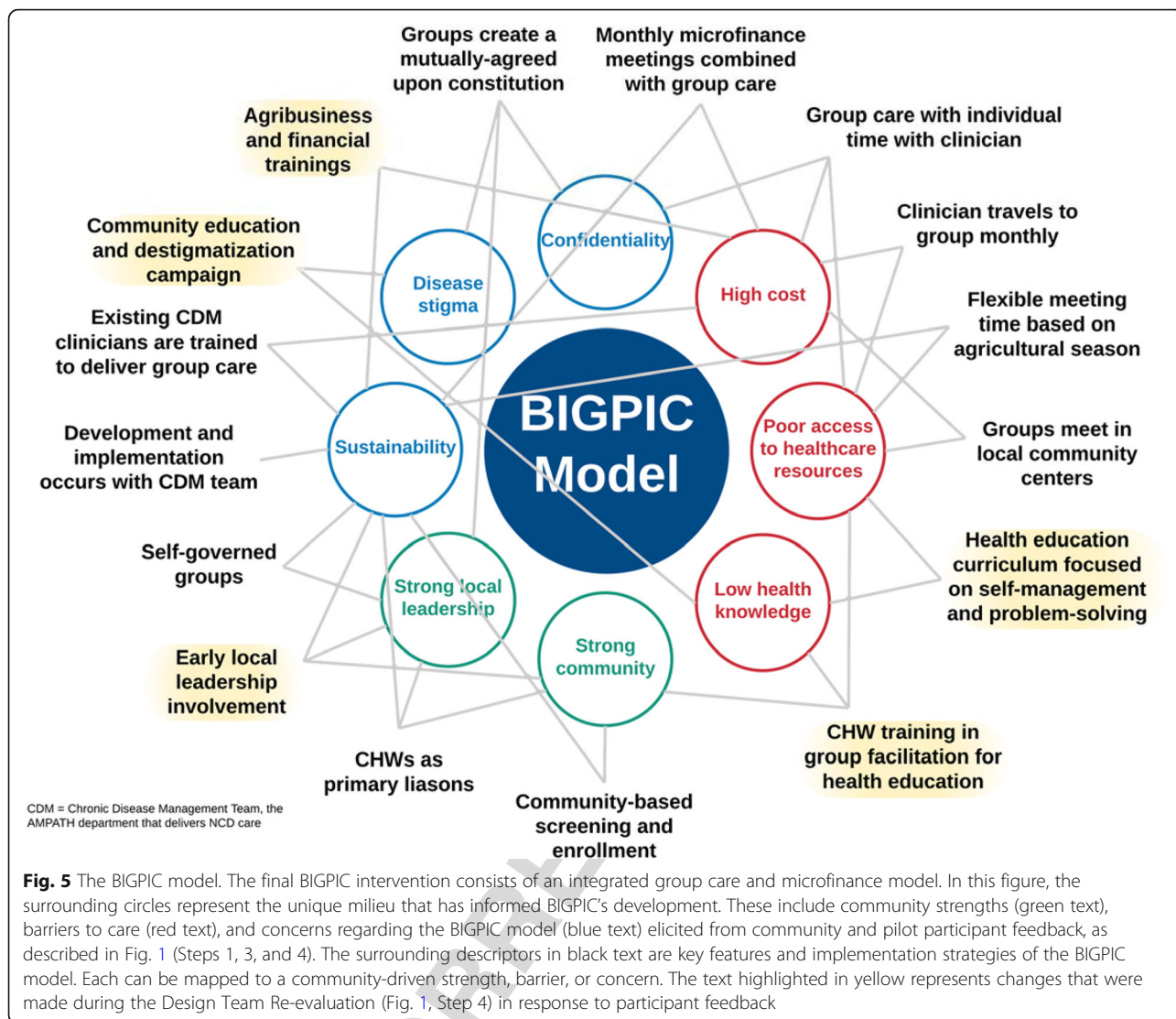
354 didactic sessions on NCD topics to strategies of shared 354  
 355 learning. This included a group facilitation curriculum 355  
 356 to help CHWs facilitate and guide discussions. For ex- 356  
 357 ample, the CHW may choose a topic such as medication 357  
 358 adherence, and guide a discussion of challenges to medi- 358  
 359 cation adherence, encouraging participants to share 359  
 360 potential strategies to improve. Examples of other sug- 360  
 361 gested topics include diet, exercise, oral hygiene, alcohol 361  
 362 use, and stress management. 362

363 As suggested by local leaders and community mem- 363  
 364 bers, our final implementation strategy included in- 364  
 365 creased efforts towards community sensitization of our 365  
 366 intervention and NCDs. We placed an increased em- 366  
 367 phasis on partnership with local community leaders, and 367  
 368 provided reassurance that our BIGPIC model remains 368  
 369 under Chronic Disease Management Team purview, a 369  
 370 known and trusted presence in the community. 370

371 Finally, an extensive discussion took place regarding po- 371  
 372 tential program incentives and seed money. Given com- 372  
 373 munity concerns for sustainability, the Design Team felt 373  
 374 strongly that providing seed money for each newly formed 374  
 375 group would be counterproductive as it would be 375  
 376 dependent on grant funding. An intentional decision was 376  
 377 made not to provide monetary incentives, but to instead 377  
 378 scale up training in money management and agribusiness. 378

379 **Discussion**

380 The refined BIGPIC model was developed using a four- 380  
 381 step HCD framework, resulting in the development of a 381  
 382 health care delivery model targeting health behaviors, 382



**Fig. 5** The BIGPIC model. The final BIGPIC intervention consists of an integrated group care and microfinance model. In this figure, the surrounding circles represent the unique milieu that has informed BIGPIC’s development. These include community strengths (green text), barriers to care (red text), and concerns regarding the BIGPIC model (blue text) elicited from community and pilot participant feedback, as described in Fig. 1 (Steps 1, 3, and 4). The surrounding descriptors in black text are key features and implementation strategies of the BIGPIC model. Each can be mapped to a community-driven strength, barrier, or concern. The text highlighted in yellow represents changes that were made during the Design Team Re-evaluation (Fig. 1, Step 4) in response to participant feedback

383 medication adherence, and financial barriers to accessing  
 384 healthcare in rural Kenya. We gathered insights and opin-  
 385 ions from the community and formed a transdisciplinary  
 386 Design Team of health professionals and community  
 387 members to evaluate our data and create an initial proto-  
 388 type. This prototype was tested over six months and fine-  
 389 tuned through community feedback to enhance accept-  
 390 ability and sustainability. The resulting BIGPIC model  
 391 combines the benefits of microfinance with the peer sup-  
 392 port available through group medical care to enhance  
 393 management of hypertension and diabetes. Key insights  
 394 that developed through the HCD process informed both  
 395 prototype features and implementation strategies and can  
 396 be mapped directly to the strengths, needs, and concerns  
 397 elicited from the community (Fig. 5, Tables 2-3). Cur-  
 398 rently, this product is the primary intervention of a four-  
 399 arm randomized control trial to fully evaluate its impact  
 400 [25]. Pending the final results of the randomized control

401 trial, we are committed to working with stakeholders to  
 402 scale up the model if it is found effective.  
 403 While the potential to leverage HCD for NCD care  
 404 has been previously described [28], our study is one of  
 405 the first to our knowledge to use HCD for a complex  
 406 NCD intervention of this scale [12]. As described by the  
 407 recent Lancet Taskforce on NCDs, poverty stems from  
 408 and is exacerbated by the global burden of NCDs, and  
 409 innovative means are needed to address the household  
 410 economic burden of care in order to alleviate global pov-  
 411 erty, decrease premature deaths, and progress towards  
 412 the United Nations’ Sustainable Develop Goals in Kenya  
 413 and other low- and middle-income countries [3, 29, 30].  
 414 Empathy-driven HCD at its core strives to understand  
 415 the key drivers of human behavior and can be leveraged  
 416 to help bridge the “knowing doing gap” that frequently  
 417 characterizes poor adherence to prescribed lifestyle  
 418 changes for NCD management such as dietary changes,

T2F5  
T3



t2.1 **Table 2** Key insights and BIGPIC prototype features

t2.2	KEY INSIGHTS	PROTOTYPE FEATURES	IMPLEMENTATION STRATEGY
t2.3	<i>Strength:</i> Community, sense of brotherhood	Group-based care model to provide peer support and education Locally-based CHWs facilitate group formation	Community-based health screening to ensure local group formation
t2.4	<i>Strength:</i> Community leadership	Participants elect group leaders and are self-governed by a mutually agreed upon constitution.	
t2.5	<i>Barrier:</i> High cost of care (medications, transport, cost of services, caregiver burden)	Group care is combined with a microfinance program to increase individual access to funds for personal or medical use. Clinician brings basic medication supply box at every visit	Community-based health screening to ensure local group formation. Rural clinician and CHWs travel to group meetings at local community centers.
t2.7	<i>Barrier:</i> Far distance to health facilities and poor quality roads	Community-based groups are linked with a local CHW.	Community-based health screening to ensure local group formation. Rural clinician and CHWs travel to group meetings at local community centers.
t2.9	<i>Barrier:</i> Poor quality of existing physician-patient relationships	Same physicians return to the group as much as possible. Clinicians trained in group care are existing CDM clinicians.	
t2.11	<i>Concern:</i> Variable group dynamics, particularly between age groups and gender	Participants create and sign a mutually agreed upon constitution that emphasizes self-governance and conflict resolution. Groups have a minimum number of study participants, and participants can bring additional friends/family to join the group until the maximum group size is attained.	
t2.13	<i>Concern:</i> Stigma associated with illness or with AMPATH's reputation as an organization for people with HIV.		Increased efforts for community education and destigmatization. Remove AMPATH logo from trucks.
t2.16	<i>Concern:</i> Confidentiality	Group constitution includes a confidentiality clause that is created by the group members. Time is allotted for individual clinician assessment at every group care meeting.	
t2.17	<i>Concern:</i> High cost of participation (share value) may prohibit some from joining	Group members agree upon share value at the start of the group. Limited number of shares can be bought per meeting.	
t2.19	<i>Concern:</i> Sustainability of new programs	No external funding/seed money is required to start a microfinance group. Clinicians trained in group care are existing CDM employees.	Early local and governmental leadership involvement. Implementation occurs with existing CDM teams.
t2.20	<i>Key insights elicited from the design process can be mapped directly to prototype features and implementation strategies. CDM - Chronic disease management</i>		

419 weight management, and tobacco use [28, 31]. In limited  
 420 resource settings, HCD is a process that can comple-  
 421 ment and support existing approaches to shaping NCD  
 422 control such as the World Health Organization STEP-  
 423 wise approach [32]. HCD is one approach to optimize  
 424 stakeholder engagement, and as in the example of BIG-  
 425 PIC, it can propel an understanding of local factors into  
 426 the development of a contextualized intervention. In this  
 427 study, our approach utilizing HCD for complex interven-  
 428 tion design aligns with the Medical Research Council  
 429 guidelines for developing complex interventions, utiliz-  
 430 ing a systematic approach to a development-evaluation-  
 431 implementation process that is tailored to local circum-  
 432 stances [33]. Similar approaches to design-thinking have  
 433 been described with other disease processes in low-  
 434 resource settings [34–36].

Health inequities including those experienced by 435  
 our catchment communities in Kenya are deeply 436  
 rooted in complex social determinants, and increas- 437  
 ingly need to be addressed in cross-sector and trans- 438  
 disciplinary partnerships [37]. Our HCD process 439  
 provided a means to gather data and interact with the 440  
 community to understand strengths and barriers to 441  
 care, while also inviting community members to partic- 442  
 ipate in innovation to enact changes in priority 443  
 areas [38]. Through early involvement of stakeholders, 444  
 we were able to not only address critical concerns 445  
 early in the intervention design process, but also build 446  
 partnerships with local stakeholders that would later 447  
 be critical to the success of intervention implementa- 448  
 tion. Many components of our intervention and imple- 449  
 mentation strategies were illuminated through 450

t3.1 **Table 3** BIGPIC Re-evaluation changes

t3.2	INITIAL PROTOTYPE FEATURE	FEEDBACK/CONCERNS	MODIFICATIONS
t3.3 t3.4	Monthly meeting time determined by clinician availability.	Participant availability may change based on agricultural season.	CHWs function as primary liaison with medical team to coordinate best meeting time before the end of each month.
t3.5 t3.6 t3.7	Group education on NCDs at the time of group formation and before every monthly meeting.	There is low interest in group education.	Health education time is modified from didactic teaching to facilitated group discussions on self-management and problem solving. CHWs receive training in group facilitation.
t3.8	Maximum group size of ~ 30 participants.	Large groups may overburden clinicians.	Maximum group size is decreased to ~ 20 participants.
t3.9 t3.10	Village-based health screenings to recruit intervention participants.	Concern for disease stigma may preclude willingness to join groups	Renew efforts to increase community health and intervention awareness. Remove AMPATH logo from clinician vehicles.
t3.11 t3.12 t3.13	Clinician brings a toolkit of common medications for chronic disease management.	Availability of other commonly used medications (i.e., ibuprofen, antibiotics).	Toolkit of medications needed communicated to AMPATH pharmacy.
t3.14 t3.15	Community entry focused on local leadership.	Concerns regarding program sustainability.	Community entry and scale up includes multiple levels of leadership. Given CDM program is well known, emphasize roll out is in partnership with the existing CDM program. No seed money provided, but increased agribusiness and financial trainings.
t3.16 t3.17 t3.18	Microfinance training during group enrollment, and CHW-led health education didactic sessions every month.	There is low income generation among community members, particularly elderly and those with low education levels.	Agribusiness and financial trainings are incorporated. Health education time is modified as above.
t3.19	<i>Feedback and concerns elicited from pilot participant feedback informed key intervention modifications</i>		

451 critical insights from end users throughout our HCD  
 452 process. For example, multiple community members  
 453 voiced concern for a sustainable intervention that  
 454 would engage with local leaders and not be  
 455 dependent on external funding. The use of an  
 456 economic-based intervention as well as many of the  
 457 features of this microfinance and group care model  
 458 are in response to these lessons learned.

459 **Facilitators of success**

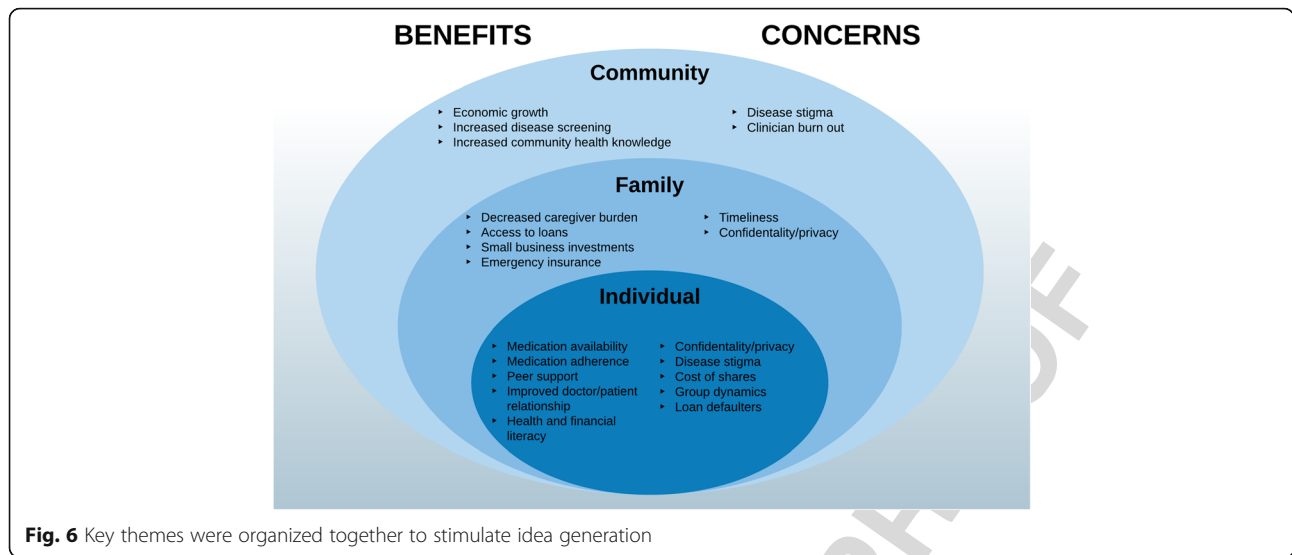
460 Our intervention development operated on the backdrop  
 461 of AMPATH’s existing partnerships with communities  
 462 in its catchment areas. Its existing programs in NCD  
 463 management and microfinance, network, and presence  
 464 in rural communities helped to facilitate participant re-  
 465 cruitment as well as engage with local leadership.  
 466 AMPATH’s existing Chronic Disease Management pro-  
 467 gram and resources including rural clinicians, clinical li-  
 468 aisons, and knowledge of the local communities allowed  
 469 us to scale up our prototype more quickly and effect-  
 470 ively. Increased availability of cellular service in rural  
 471 areas made it possible for us to access patient records  
 472 even in remote areas for continuity of care.

473 Notably, the Kenyan National Hospital Insurance Fund  
 474 (NHIF) has recently extended its benefits to include  
 475 NCD care in its benefits package. Our HCD process can  
 476 provide insight as to the development and type of

intervention that can be successfully incorporated under  
 the benefits offered by NHIF. 477 478

**Limitations** 479

Perhaps one of the greatest strengths of HCD and a vital  
 lesson-learned in our design process is the importance  
 of listening to and collaborating with our participants,  
 which helped us to better understand their challenges  
 and priorities. However, HCD can be a time-consuming  
 process that may not be feasible for all project timelines  
 and resources. Stakeholder buy-in and active engage-  
 ment throughout the HCD cycle is essential, both at the  
 personnel, institutional, and governmental level. This  
 may be difficult to garner in some circumstances  
 whether through lack of availability or lack of familiarity  
 with this specific approach to intervention development.  
 Additionally, as use of HCD is still fairly novel in  
 resource-limited settings, the presence of a facilitator fa-  
 miliar with the HCD process and tools is necessary but  
 may be cost- and time-prohibitive, particularly if inter-  
 vention development takes place over weeks to months.  
 Similarly, while the formation of a multidisciplinary de-  
 sign team is a critical strength of HCD that begets a dee-  
 per understanding of the local context and paves the  
 way for future intervention implementation, coordin-  
 ation of a 10 to 15 person team across diverse educa-  
 tional, language, and geographical backgrounds may be  
 challenging. To combat this, HCD practitioners may 493 494 495 496 497 498 499 500 501 502 503



f6.1  
f6.2

504 consider shorter and faster cycles of prototyping for less  
 505 complex interventions, in order to efficiently evaluate  
 506 ideas and integrate lessons-learned for continuous im-  
 507 provement and sustainability. Beginning with shorter cy-  
 508 cles may also help gain stakeholder support for  
 509 subsequent longer cycles of more complex intervention  
 510 development.

511 We also recognize that HCD is a process that re-  
 512 quires tolerance of ambiguity, pivots, and prototyp-  
 513 ing—factors that can seem to be in opposition to  
 514 traditional hypothesis-driven research methodologies  
 515 [38]. However, we feel that HCD is a process for the  
 516 design and development of interventions and imple-  
 517 mentation strategies that are both desirable and fea-  
 518 sible in the local context, which can then be evaluated  
 519 with traditional hypothesis-driven statistical method-  
 520 ologies. In our study, we have combined HCD with a  
 521 more traditional randomized controlled implementa-  
 522 tion research trial to evaluate the effectiveness of the  
 523 intervention [25].

524 Finally, there is growing enthusiasm in both academic  
 525 medicine and global health spheres for social innovation  
 526 and design thinking as tools that are more capable and re-  
 527 sponsive to the needs of end users [38–40]. However, there  
 528 is still limited evidence regarding the impact of design  
 529 thinking methodologies and related concepts on health out-  
 530 comes [41]. Additional research is needed to evaluate the  
 531 impact of participatory methodologies such as design think-  
 532 ing and social enterprises on health outcomes.

533 **Application to other contexts**

534 The development and implementation of BIGPIC is one  
 535 example of how HCD concepts can be used in resource-  
 536 limited settings. Of particular relevance was the inclusion  
 537 of transdisciplinary community stakeholders on our

Design Team, who represented not only healthcare pro- 538  
 fessionals, but also local community members, leaders, 539  
 and microfinance experts. Our HCD process was inher- 540  
 ently inclusive and collaborative, inviting innovation and 541  
 feedback in every stage of development, and thrived 542  
 through partnership and collaboration [42]. Its applica- 543  
 tions can be imagined broadly in both complex interven- 544  
 tion development such as ours, or in more simple settings 545  
 of adapting a known model or intervention to local con- 546  
 text [38]. While it is unlikely that our exact HCD design 547  
 and group care and microfinance model will be replicated 548  
 wholesale in other contexts, our described process offers 549  
 relevant lessons in low-resource settings both in the 550  
 United States as well as abroad, in line with a scoping re- 551  
 view of design thinking in global settings [38]. 552

Recognizing that there are universal elements to care 553  
 that are common across geopolitical and financial land- 554  
 scapes, we advocate for context-specific interventions 555  
 that can help to optimize care in these settings. How- 556  
 ever, we recognize that potential unintended conse- 557  
 quence is that such specificity may lead to variability and 558  
 inequities in care. For this reason, we urge caution with 559  
 planning for context-specific settings. 560

561 **Conclusions**

562 In this study, we describe how a four-step HCD frame- 562  
 work was used to tailor NCD service delivery to address 563  
 multiple barriers to care for patients with hypertension 564  
 and diabetes in western Kenya. HCD provided a means 565  
 to engage early with local stakeholders, and the process 566  
 of iteration and feedback was critical to address stake- 567  
 holder concerns and optimize intervention design and 568  
 implementation. While this approach to NCD interven- 569  
 tion planning may be time-intensive, it resulted in an 570  
 intervention package that is tailored to the local context 571

572 and well-received by stakeholders. Future initiatives can  
 573 use HCD to partner with local stakeholders to find in-  
 574 novative ways to address complex health problems in  
 575 resource-constrained settings.

576 **Abbreviations**

577 AMPATH: Academic Model Providing Access to Healthcare; BIGPIC: Bridging  
 578 Income Generation with Group Integrated Care; CARE: Cooperative for  
 579 Assistance and Relief Everywhere; CDM: Chronic disease management;  
 580 CHW: Community health worker; FGDS: Focus group discussions;  
 581 HCD: Human-centered design; MF: Microfinance; NCD: Non-communicable  
 582 disease; VSLA: Village Savings and Loan Association; NHIF: National Hospital  
 583 Insurance Fund

584 **Acknowledgements**

585 The authors would like to thank Aileen Li and Julia Dickhaus for editorial  
 586 assistance and the Design Team for their time and participation. We also  
 587 gratefully acknowledge research participants who took their valuable time to  
 588 participate in this study.

589 **Authors' contributions**

590 CL, RV, GSB, SP, TV, VF, JK made substantial contributions to the conception  
 591 and design of the work. CL, RD, BA, PK, SM, WM, EM, SN, and SP contributed  
 592 to the acquisition of data. CL, MN, BA, DE, CH, SM, PK, WM, EM, VN, SN, and  
 593 SP contributed to the analysis of the data and the interpretation of the  
 594 results. CL, RV were major contributors in writing and/or substantially  
 595 revising the manuscript. All authors read and approved the final manuscript.

596 **Funding**

597 Research reported in this publication was supported by the National Heart,  
 598 Lung, and Blood Institute (NHLBI) under grant number 5R01HL125487. The  
 599 content is solely the responsibility of the authors and does not necessarily  
 600 represent the official views of the National Institutes of Health (NIH) and  
 601 NHLBI.

602 **Availability of data and materials**

603 This study complies with the NIH Public Access Policy, which ensures that  
 604 the public has access to the published results of NIH funded research, and  
 605 therefore, all results have been (and will be made) available from final peer-  
 606 reviewed journal manuscripts (including this one) via the digital archive  
 607 PubMed Central upon acceptance for publication.

608 **Ethics approval and consent to participate**

609 This study obtained ethics approval by the NYU School of Medicine  
 610 International Review Board (IRB) in New York, NY (study number i18-01260),  
 611 as well as the Moi University School of Medicine Institutional Research and  
 612 Ethics Committee (IREC) in Eldoret, Kenya (IREC Approval Number 0001368).  
 613 Written informed consent was obtained by each participant at the time of  
 614 enrollment.

615 **Consent for publication**

616 Not applicable.

617 **Competing interests**

618 The authors declare that they have no competing interests.

619 **Author details**

620 <sup>1</sup>Duke University Medical Center, 10 Duke Medicine Circle, Durham, NC  
 621 27710, USA. <sup>2</sup>Division of General Internal Medicine, Duke University School of  
 622 Medicine, 200 Morris St. 3rd floor, Durham, NC 27701, USA. <sup>3</sup>Icahn School of  
 623 Medicine at Mount Sinai, 1 Gustave L. Levy Pl, New York, NY 10029, USA.  
 624 <sup>4</sup>Academic Model Providing Access to Healthcare (AMPATH), P.O. Box 4606,  
 625 Eldoret 30100, Kenya. <sup>5</sup>Department of Behavioral Sciences, School of  
 626 Medicine, College of Health Science, Moi University College of Health  
 627 Sciences, Eldoret, Kenya. <sup>6</sup>Purdue University, Purdue University College of  
 628 Pharmacy, Purdue-Kenya Partnership, West Lafayette, IN, PO Box 5760,  
 629 Eldoret 30100, Kenya. <sup>7</sup>Department of Preventive Medicine, Keck School of  
 630 Medicine, University of Southern California, Los Angeles, CA, USA. <sup>8</sup>New York  
 631 University Grossman School of Medicine, 180 Madison Avenue, 8th Floor,  
 632 New York, NY 10016, USA.

Received: 25 April 2019 Accepted: 7 April 2020

Published online: 12 May 2020

633

634

**References**

635  
 636  
 637  
 638  
 639  
 640  
 641  
 642  
 643  
 644  
 645  
 646  
 647  
 648  
 649  
 650  
 651  
 652  
 653  
 654  
 655  
 656  
 657  
 658  
 659  
 660  
 661  
 662  
 663  
 664  
 665  
 666  
 667  
 668  
 669  
 670  
 671  
 672  
 673  
 674  
 675  
 676  
 677  
 678  
 679  
 680  
 681  
 682  
 683  
 684  
 685  
 686  
 687  
 688  
 689  
 690  
 691  
 692  
 693  
 694  
 695  
 696  
 697  
 698  
 699  
 700  
 701  
 702

1. Roth GA, Johnson C, Abajobir A, Abd-Allah F, Abera SF, Abyu G, et al. Global, regional, and National Burden of cardiovascular diseases for 10 causes, 1990 to 2015. *J Am Coll Cardiol.* 2017;70(1):1–25.
2. World Health Organization. *Global Status Report on Non-Communicable Diseases 2014.* Geneva; 2014. p. 302.
3. Jan S, Laba T-L, Essue BM, Gheorghe A, Muhunthan J, Engelgau M, et al. Action to address the household economic burden of non-communicable diseases. *Lancet.* 2018;391(10134):2047–58.
4. World Health Organization, World Economic Forum. *From Burden to "Best Buys": Reducing the Economic Impact of Non-Communicable Diseases in Low- and Middle-Income Countries.* Geneva; 2011. p. 1–12.
5. Alleyne G, Binagwaho A, Haines A, Jahan S, Nugent R, Rojhani A, et al. Embedding non-communicable diseases in the post-2015 development agenda. *Lancet.* 2013;381(9866):566–74.
6. Joseph P, Leong D, McKee M, Anand SS, Schwalm J-D, Teo K, et al. Reducing the global burden of cardiovascular disease, part 1: the epidemiology and risk factors. *Circ Res.* 2017;121(6):677–94.
7. Leong DP, Joseph PG, McKee M, Anand SS, Teo KK, Schwalm J-D, et al. Reducing the global burden of cardiovascular disease, part 2: prevention and treatment of cardiovascular disease. *Circ Res.* 2017;121(6):695–710.
8. Kankeu HT, Saksena P, Xu K, Evans DB. The financial burden from non-communicable diseases in low- and middle-income countries: a literature review. *Health Res Policy Syst [Internet].* 2013;11(1):31 Available from: <http://health-policy-systems.biomedcentral.com/articles/10.1186/1478-4505-11-31>.
9. Goldberg N. *Measuring the impact of microfinance: taking stock of what we know.* Grameen Foundation USA; 2005.
10. Khandker SR. *Microfinance and Poverty: Evidence Using Panel Data from Bangladesh.* World Bank Econ Rev Oxford University Press. 2005; 19(2):263–86.
11. Leatherman S, Metcalfe M, Geissler K, Dunford C. *Integrating microfinance and health strategies: examining the evidence to inform policy and practice.* Health Policy Plan Oxford University Press. 2012;27(2):85–101.
12. Lorenzetti LMJ, Leatherman S, Flax VL. *Evaluating the effect of integrated microfinance and health interventions: an updated review of the evidence.* Health Policy Plan. 2017;26:czw170–25.
13. Ksoll K, Lilleør HB, Lønborg JH, Rasmussen OD. *Impact of village savings and loan associations: evidence from a cluster randomized trial.* J Dev Econ The Authors. 2016;120(C):70–85.
14. Beaman L, Thuysbaert B. *Saving for a (Not So) Rainy Day: a Randomized Evaluation of Savings Groups in Mali.* National Bureau Econ Res. 2014;7:1–43.
15. Karlan D, Saviotto B, Thuysbaert B, Udry C. *Impact of savings groups on the lives of the poor.* Proc Natl Acad Sci U S A. 2017;114(12):3079–84.
16. Dupas P, Green S, Keats A, Robinson J. *Challenges in Banking the Rural Poor: Evidence from Kenya's Western Province.* NBER Work Paper Series. Cambridge: National Bureau of Economic Research; 2012. p. 1–42. Report No.: NBER Working Paper No. 17851.
17. Naanyu V, Vedanthan R, Kamano JH, Rotich JK, Lagat KK, Kiptoo P, et al. *Barriers influencing linkage to hypertension Care in Kenya: qualitative analysis from the LARK hypertension study.* J Gen Intern Med. 2016;31(3): 304–14.
18. Dong R, Leung C, Naert M, Naanyu V, Kiptoo P, Matelong W, et al. *Abstract 15036: Chronic Disease Stigma, Skepticism of the Health System, and Socio-Economic Fragility: Factors Impacting Receptiveness to a Non-Communicable Disease Intervention in Rural Kenya.* Circulation American Heart Association. 2018;138(Suppl\_1):A15036.
19. Naert M, Leung C, Andama B, Dong R, Edelman D, Horowitz C, et al. *Addressing perceived corruption, transparency, and stigma: increasing community receptiveness to a non-communicable disease intervention involving microfinance in rural Kenya.* Atlanta: American Public Health Association; 2017.
20. Brest P, Roumani N, Bade J. *Problem solving, human-centered design, and strategic processes.* Stanford: Stanford PACS; 2015. p. 1–32.
21. IDEO.org. *The Field Guide to Human-Centered Design.* 2015. 192 p.
22. Hoover C. *Human-Centered Design vs. Design-Thinking: How They're Different and How to Use Them Together to Create Lasting Change [Internet];* 2018. p. 1–7. [cited 2019 Nov 24]. [Movingworlds.org.](https://blog.movingworlds.org/human-centered-design-vs-design-) Available from: <https://blog.movingworlds.org/human-centered-design-vs-design->

- 703 [thinking-how-theyre-different-and-how-to-use-them-together-to-create-](#)  
704 [lasting-change/](#).
- 705 23. Einterz RM, Kimaiyo S, Mengech HNK, Khwa-Otsyula BO, Esamai F, Quigley F,  
706 et al. Responding to the HIV pandemic: the power of an academic medical  
707 partnership. *Acad Med*. 2007;82(8):812–8.
- 708 24. Mercer T, Gardner A, Andama B, Chesoli C, Christoffersen-Deb A, Dick J,  
709 et al. Leveraging the power of partnerships: spreading the vision for a  
710 population health care delivery model in western Kenya. *Glob Health*. 2018;  
711 5:1–11.
- 712 25. Vedanthan R, Kamano JH, Lee H, Andama B, Bloomfield GS, Delong AK,  
713 et al. Bridging income generation with group integrated care for  
714 cardiovascular risk reduction: rationale and design of the BIGPIC study. *Am*  
715 *Heart J*. 2017;188:175–85.
- 716 26. Pastakia SD, Manyara SM, Vedanthan R, Kamano JH, Menya D, Andama B,  
717 et al. Impact of bridging income generation with group integrated care  
718 (BIGPIC) on hypertension and diabetes in rural Western Kenya. *J Gen Intern*  
719 *Med*. 2017;32(5):540–8.
- 720 27. Dong R, Leung C, Naert M, Naanyu V, Kiptoo P, Matelong W, et al. Chronic  
721 disease stigma, skepticism of the Health system, and socio-economic  
722 fragility: factors impacting receptiveness to a non-communicable disease  
723 intervention in rural Kenya. *Am Heart Assoc*. 2018.
- 724 28. Matheson GO, Pacione C, Shultz RK, Klügl M. Leveraging human-centered  
725 Design in Chronic Disease Prevention. *Am J Prev Med Elsevier*. 2015;48(4):  
726 472–9.
- 727 29. Nugent R, Bertram MY, Jan S, Niessen LW, Sassi F, Jamison DT, et al.  
728 Investing in non-communicable disease prevention and management to  
729 advance the sustainable development goals. *Lancet*. 2018;391(10134):2029–  
730 35.
- 731 30. Niessen LW, Mohan D, Akuoku JK, Mirelman AJ, Ahmed S, Koehlmoos TP,  
732 et al. Tackling socioeconomic inequalities and non-communicable diseases  
733 in low-income and middle-income countries under the sustainable  
734 development agenda. *Lancet*. 2018;391(10134):2036–46.
- 735 31. Pfeffer J, Sutton RI. *The Knowing Doing Gap*. Boston: Harvard Business  
736 School Press; 2004. p. 1–8.
- 737 32. Riley L, Guthold R, Cowan M, Savin S, Bhatti L, Armstrong T, et al. The World  
738 Health Organization STEPwise approach to noncommunicable disease risk-  
739 factor surveillance: methods, challenges, and opportunities. *Am J Public*  
740 *Health*. 2016;106(1):74–8.
- 741 33. Craig P, Dieppe P, Macintyre S, Michie S, Nazareth I, Petticrew M.  
742 Developing and evaluating complex interventions: the new Medical  
743 Research Council guidance. *BMJ*. 2008;29:a1655–6.
- 744 34. Lunze K. Innovative approaches for improving maternal and newborn  
745 health - A landscape analysis. *BMC Pregnancy Childbirth*. 2015;16:1–19.
- 746 35. Hirschhorn LR. Learning before leaping: integration of an adaptive study  
747 design process prior to initiation of BetterBirth, a large-scale randomized  
748 controlled trial in Uttar Pradesh, India. *Implement Sci*. 2015;12:1–9.
- 749 36. Mohr DC, Lyon AR, Lattie EG, Reddy M, Schueller SM. Accelerating digital  
750 mental Health Research from early design and creation to successful  
751 implementation and sustainment. *J Med Internet Res*. 2017;19(5):e153–16.
- 752 37. Marmot M, Friel S, Bell R, Houweling TA, Taylor S, Health OBOTCOSDO.  
753 Closing the gap in a generation: health equity through action on the social  
754 determinants of health. *Lancet Elsevier Ltd*. 2008;372(9650):1661–9.
- 755 38. Bazzano AN, Martin J, Hicks E, Faughnan M, Murphy L. Human-centred  
756 design in global health: a scoping review of applications and contexts.  
757 Virgili G, editor. *PLoS One*. 2017;12(11):e0186744–24.
- 758 39. McLaughlin JE, Wolcott MD, Hubbard D, Umstead K, Rider TR. A qualitative  
759 review of the design thinking framework in health professions education.  
760 *BMC Med Educ*. 2019;3:1–8.
- 761 40. Deitte LA, Omary RA. The power of design thinking in medical education.  
762 *Acad Radiol*. 2019 Oct;26(10):1417–20.
- 763 41. Roy MJ, Donaldson C, Baker R, Kerr S. The potential of social enterprise to  
764 enhance health and well-being: a model and systematic review. *Soc Sci*  
765 *Med Elsevier Ltd*. 2014;123(C):182–93.
- 766 42. Nastasi BK, Varjas K, Schensul SL, Silva KT, Schensul JJ, Ratnayake P. The  
767 participatory intervention model: a framework for conceptualizing and  
768 promoting intervention acceptability. *Sch Psychol Q*. 2000;15(2):207–32.

## 769 Publisher's Note

770 Springer Nature remains neutral with regard to jurisdictional claims in  
771 published maps and institutional affiliations.

**Ready to submit your research? Choose BMC and benefit from:**

- fast, convenient online submission
- thorough peer review by experienced researchers in your field
- rapid publication on acceptance
- support for research data, including large and complex data types
- gold Open Access which fosters wider collaboration and increased citations
- maximum visibility for your research: over 100M website views per year

**At BMC, research is always in progress.**

Learn more [biomedcentral.com/submissions](https://biomedcentral.com/submissions)

