Who is not linked to primary care public health facilities for cardiovascular disease prevention, and why-not: A community based follow up study from urban slums in India

Abhijit P Pakhare¹, Ankur Joshi¹, Rasha Anwar², Khushbu Dubey², Sanjeev Kumar¹, Shubham Atal¹, Ishan Raj Tiwari⁴, Vipul Mayank⁴, Neelesh Shrivastava², Rajnish Joshi⁵

Abstract

We designed and conducted a community based longitudinal study in 16 urban slum clusters in context of a community health worker (CHW) led screening and preventive therapy initiation initiative for CVD prevention. Linkage to public health systems primary care facilities was a key outcome indicator for this initiative. In this paper, we have investigated predictors and barriers to non-linkage. CHWs screened all adults aged 30 years through for hypertension as well as diabetes. Referrals were advised and facilitated to nearby Urban Primary Health Centre (PHC) clinic for either treatment initiation or continuation or optimization. CHWs screened a total of 6174 individuals, and physicians identified 1449 participants (23.46%; 95% CI 22.42-24.54) as high-risk who required linkage to public-health facilities for pharmacotherapy. Out of these, 943(65%) attended health facilities with 801(55.2 %) being adherent to pharmacotherapy. Those who were not linked were young men belonging to low socio-economic position, living farther from UPHC, engaged late by CHW and identified to be in denial mode and reported lack of family support. This study highlights importance of early engagement through CHWs after positive screening, necessity to address denial of newly diagnosed and increase male participation in order to reduce detection to treatment initiation gap.

Keywords- hypertension, diabetes, adherence, community health worker, cardio vascular diseases, population-based screening
Introduction

Hypertension, and diabetes mellitus are important risks for future cardiovascular disease (CVD), and their control is the emerging global challenge.[1] In urban India about 30-40% of all adults have hypertension and about 10-15% have diabetes mellitus.[2,3] About half the individuals with hypertension are aware of their elevated blood pressures, and among these half are not on any drug therapy, and of those on drug therapy, only half are controlled.[4] Such diagnosis-to-treatment and treatment-to-optimal control gaps exist for other CVD risk factors as well. In response to the emergent burden of Non-communicable diseases (NCDs), Government of India launched the National Program for Control of Diabetes, Cancer and Stroke (NPCDCS) in 2010 to create awareness about NCD risk factors as well as to conduct opportunistic screening of all adults aged 30 years and above for presence of hypertension and diabetes mellitus, initiate positively screened on drug therapy and lifestyle changes, and follow them up for treatment adherence.[5] First line drug therapies for CVD prevention that were previously available in the private sector but were underutilized due to poor affordability,[6] are now increasingly becoming available in public sector primary care facilities.

There are evidence-practice gaps in CVD prevention, which operate at various levels.[7] Individuals who are screened for hypertension and diabetes mellitus in the community are largely asymptomatic. These individuals have to understand importance of health promotion measures to reduce future CVD risks. Adopting health promotion measures for lifelong requires sustained behaviour change. Also, CVD prevention in such patients requires medicines such as anti-hypertensives and or anti-diabetes therapies. Affordability and availability of such therapies may be a barrier. However, there may be many other barriers other than availability and affordability. Despite a much better availability and affordability of anti-hypertensive medication in high income countries, proportion of individuals with optimal control is only marginally better (36% in high income vs 23% in low-income countries).[6] This implies that additional patient and health-care provider level factors (knowledge, attitude, beliefs and practices), and health-system barriers (infrastructure, access, quality) are equally important.[8] We do not know magnitude of effect of these additional factors on adherence to NCD risk behaviour and drug therapy, when drugs are made available free in public sector primary-care facilities.
We have planned a community based longitudinal study to determine burden of risk factors for CVD, to understand pattern and determinants of healthcare seeking from different types of healthcare facilities among those screened as having risk factors for CVDs. Rationale and design of the community based longitudinal study is published on pre-print server.[9] This manuscript attempts to identify who among the high risk individuals do not get linked (predictors of non-linkage), and reasons for non-linkage.

Methods

Design and Ethics Statement: We designed a community based longitudinal study to identify predictors of non-linkage to public-health primary care facilities. The study design was approved by the institutional human ethics committee (Ref: IHEC-LOP/2017/EF00045) and funded by Indian Council of Medical Research. All participants provided written informed consent prior to initiation of any study procedures. Detailed study protocol is published on pre-print server.[9]

Setting: The study was conducted in 16 urban slum clusters from catchment area of two Urban Primary Health Centres (UPHCs) of Bhopal, a city located in central India. These UPHCs were located at Barkheda Pathani and Saibaba Nagar which are usual places from where study participants sought primary healthcare. In addition to UPHCs, primary care needs in public sector are also met by the district hospital, and government owned medical college hospitals. There are no out-of-pocket costs towards either consultation or available medications at these facilities. Many individuals opt to seek care from private sector, which is larger both in terms of number of providers, as well as individuals who seek care through it. Every primary-care consultation in private sector incurs out-of-pocket expenditure (range 1 to 10 USD), and prescribed medications are available through private pharmacies. Private care providers have longer working hours, and could be located in closer proximity to some urban slum clusters.

Participants: The ASHAs conducted home-based screening of all the eligible and consenting adults aged 30 years or more across 16 urban slum clusters to identify risk factors for CVD. Those who were screened as having hypertension and or diabetes mellitus were included in this study.

Study Tools: Screening consisted of a questionnaire (to identify tobacco or alcohol consumption, previously known hypertension, diabetes or a manifest CVD such as ischemic heart disease or stroke), anthropometry (to measure body mass index (BMI) and waist circumference (WC) (weighing scale -Seca-876, stadiometer-Seca-213 and
measuring tapes Seca-201, Seca, Hamburg, Germany), measurement of blood-pressure (using Omron digital apparatus model 7200, Kyoto, Japan) and a non-fasting blood glucose (RBG) by glucometer (SD diagnostics, Korea). Follow-up tools consisted of a questionnaire for dietary assessment and measurement of blood pressure and random blood glucose. All data was collected on mobile phone based tool- Commcare (Dimagi Inc, USA). All ASHAs were provided with an android based mobile phone with installed Commcare application for data collection. This tool has a facility to track visits and details of the previous visits can be made available. We developed a decision support system for identification of individuals at high risk for future CVD as per the operational definitions (below).

**Operational Definitions:** “High risk for future CVD” included those with a previously known hypertension or diabetes mellitus, newly detected hypertension (Systolic blood pressure (SBP) >140 or diastolic blood pressure (DBP) >90 mm Hg on two or more occasions), or newly detected diabetes mellitus (RBG >200mg/dL). “ASHA engagement” has been classified based on the home-visit to confirmation camp-visit interval. Confirmation visit happening within 7 days has been defined as “early engagers”, between one week and one month were “intermediate” and beyond one month were “late-engagers”. Outcome was classified in terms of the participants being linked to public health public health facilities, or linked to public health facilities but interrupted, or linked to private health facilities, or not linked to any facilities.

**Study Procedures:** Detailed study procedures are described elsewhere.[9] Briefly these involved CHW (ASHA) recruitment and training; ASHA engagement and home-based screening; diagnosis confirmation camps; identification of high-risk individuals; linkage for treatment initiation and continuation and follow-up visits by CHWs.

The “high risk” individuals identified and referred by study supervisors were free to seek care from either the nearest UPHC or any other source of their choice. If they chose to visit the UPHC, they were evaluated by a physician. While UPHC is functional between 12 noon and 5pm on all weekdays, one day in a week was designated as non-communicable disease clinic (Tuesdays for Saibaba nagar, and Wednesday for Barkheda Pathani UPHCs). The physicians were trained to follow simple therapeutic algorithms for treatment initiation, optimization and continuation for hypertension (Based on JNC 8 hypertension guidelines )[10], and diabetes (based on ADA guidelines 2017).[11] Blood pressure of all participants, and blood sugar levels of participants were measured at UPHC for reconfirmation and facilitation of treatment
decisions. The physician advised either treatment initiation (if they were newly detected with hypertension or diabetes mellitus), treatment optimization (if they were previously known to have these risks but were not controlled) or treatment-continuation (if they were well controlled on previous therapies). The physicians could choose from available drugs at UPHC which were Losartan (Angiotensin receptor blocker), Amlodipine (calcium channel blocker), Hydrochlorothiazide (diuretic), Metformin (Biguanide), Glimiperide (sulphonylurea), low-dose Aspirin, and Atorvastatin. These drugs have also been identified by WHO-PEN as essential ingredients for NCD care.[12] Individuals were usually dispensed with 15 days of drug therapy, and advised for a refill thereafter. Those individuals who would not be optimally controlled on maximal permissible dosages of available drugs, despite adequate drug adherence were advised consultation with specialists at secondary or tertiary care hospitals in the public sector. All these treatment decisions (Initiation, escalation, de-escalation of drug therapy) were recorded by the study physician in a NCD register available at UPHC for the research project, which also was a visit-log for high risk participants. Study ID number of high risk participants was recorded against all such treatment decisions. Individuals who were linked to UPHC were identified from the NCD register, which was maintained in hard copy. The data of the NCD register was updated weekly into a designated data collection software by study supervisors. Periodic data quality check was done by study investigators. Those who had three or more visits logged six months from their initial visit at UPHC were classified as “treatment continuers”, and those who had fewer visits were “treatment-interrupters”.

Subsequent to initial screening, ASHAs performed home-visits, once in every two months to reinforce linkages to public health facilities and adherence to drug-treatment. In the six-month home-visit (third visit), ASHA again recorded source of CVD-prevention treatment, and identified individuals who were “not-on treatment”, “on treatment from private care providers”, and “treatment-continuers” or “treatment-interrupters”. Based on this information and treatment records available from UPHC-NCD register all high-risk individuals were classified into four groups: group A, linked to public sector primary care facilities and treatment continuers; group B, linked to private care providers and treatment continuers; group C, linked to public or private sector primary care facilities and treatment interrupters; group D not-linked to any provider. To determine barriers to linkage, we performed a stratified random sampling and listed numerically proportionate individuals from each of the four groups A, B, C,
and D, ensuring a sample size of at least 12 from each group. The barriers were identified by a structured questionnaire consisting of knowledge, attitude, health-system, and social support domains.

**Statistical Analysis:** All data analysis was done using SPSS software (IBM SPSS Statistics for Macintosh, Version 26.0. Armonk, NY: IBM Corp.). Distribution of continuous variables across linkage-groups was compared using ANOVA and dichotomous variables using chi-square test. A p-value of <0.05 was considered as significant for these comparisons. To determine predictors of non-linkage and linkage to private facility, individuals in group A (linked to public health facilities) were considered as reference. Considering more than two categories of outcome variable (Linkage Status) we used multi-nominal logistic regression model to identify variables independently associated with non-linkage, linkage to private facilities and interrupters after linkage with reference to linkage to public health facilities. Odds ratio (OR) was estimated to represent point-estimate and its 95% confidence interval as a measure of precision of the association. We performed a descriptive analysis of the barriers in each of the domains, and for individuals in each of the outcome categories.

**Results**

Between November 2017 and June 2018 a total of 6174 individuals were screened, and 1449 participants (23.46%; 95% CI 22.42-24.54) were identified as high-risk individuals who required linkage for pharmacotherapy. Study flow is depicted in Figure 1. Most of these individuals were middle aged, and women (n=858, 59.2%). Six months after initial screening, 55.2% of all high-risk individuals were linked and treatment-continuers with 544 (37.54%) to public health facilities (Group A), and 259 (17.87%) to private care providers (Group B). Another 142 (9.79%) were treatment-interrupters (Group C), and 506 (34.92%) never got linked to any provider (Group D). Most individuals in Group A (linked to public facilities) were of age more than 45 years (69.3 %), were women (67.8 %) and lived within 3km of UPHC (72.6%), did not use tobacco (60.1%). About half of them (44.9%) were engaged early by ASHAs. Characteristics of individuals in these four groups are presented in Table 1.

As compared to those who were linked to public health facilities, those who never got linked (Group D) were more likely to be young (OR 2.17), men (OR 1.45), in lowest wealth quintile (OR 1.8), consumed alcohol (OR 1.9). These individuals also engaged late with ASHAs (OR 2.61), and lived father away from UPHC (OR 1.37).
Those who were linked to private-care providers (Group B) were less likely to be poor (OR 0.61), or newly detected with hypertension (0.64). This group of individuals engaged late with ASHAs (OR 1.96), and were more likely to be men (OR 1.56). These risk estimates are derived from multi-nominal logistic regression analysis. Goodness of fit was statistically non-significant (p=0.906), likelihood ratio test for model fitting criteria was statistically significant (p<0.001; Cragg-Uhler(Nagelkerke) $R^2=0.623$). This model fitting information indicates that current model can be used to understand predictors of linkage status. (Table 2)

We interviewed 167 of the randomly selected 192 individuals to understand potential barriers and facilitators for non-linkage to public health facilities. The participants had overall poor knowledge about risk factors and unfavourable attitude towards study outcomes across all groups. Individual level, social support, provider level and health system barriers were equally distributed. In comparison to those who were linked (groups A and B), knowledge deficiency was less in individuals who were not-linked (group D). Non-linked individuals rather had unfavourable attitudes and reported poor family and social support. Half of those who were not linked reported that their healthcare provider didn’t suggest any risk reduction measure or a pill, and did not identify much with health-system barriers. Most individuals who were linked to private care providers identified health-system barriers with public sector, and also acknowledged that drugs in private sector are expensive. Individuals who were linked (group A and B) identified more individual level and health-system barriers. (Figure 2)

Discussion

In the current study, where all individuals aged 30 years and above in the community were screened to fill the unawareness gap, six months later only half of all positively screened were on pharmacotherapy. Most of those who were on medication, were obtaining these from the public-sector. Individuals who did not get-linked to a health-care facility were more likely to be young men with poorer economic status living farther from the UPHC. Their engagement level with ASHA workers was also late. Knowledge inadequacy was similar in all groups, though marginally less in non-linked individuals. While those who were on pharmacotherapy identified health-system as a barrier, those not-linked identified more with poor reinforcement by family, peers, and health-care providers. They were also twice more likely to deny presence of risk factor in them, or refuse to modify them, both being components of attitude domain.
Thus, reason of non-linkage in these individuals has a greater contribution of attitude, social support, and provider reinforcement.

Initiation of therapy for hypertension and diabetes is necessary to prevent CVDs. After initial screening of asymptomatic chronic diseases like hypertension or diabetes, elevated biological values need to be confirmed to ensure diagnostic certainty. Subsequently, those detected with a disease-condition need to be initiated on pharmacotherapy. Ensuring initiation of pharmacotherapy in positively screened individuals, who are otherwise asymptomatic, is challenging. We need to overcome both internal (related to awareness and acceptability) and external (related to availability and affordability of medication) barriers to ensure initiation of preventive measures.[8] Attitude of an individual may be thought in the preferential ways of thinking and doing in a context. Here majority of the people have a ‘fear of unknown’ (in absence of objective knowledge) about NCD ‘risk’ and an attitudinal vulnerability may be sensed.

One decade ago, it was reported from UK that 5% of the hypertensive patients fail to initiate treatment after prescribing, and about 50% default within 1 year of treatment initiation.[13] Another study from Canada reported the detection-initiation gap in hypertension to be 18%, and discontinuation rate to be 5% in one year.[14] Medicare beneficiaries in United States were reported to have about 21% annual discontinuation rate for anti-hypertensive drugs.[15] Discontinuation rates for oral hypoglycaemic medication were reported to be as high as 49% at end of one year from another Canadian study, however re-initiation rates in the subsequent year were high.[16] In a hypertension adherence promotion trial from Nigeria, drop-out rates were reported to be about 12%, much lower than many high-income countries.[17] In our study detection-initiation gap was high (more than 30%), and discontinuation rate was modest at about 10% at the end of six months. There is a paucity of estimates from low- and middle-income country settings about such gaps in detection to initiation and characteristics of non-initiators thereon.

In this study, those who were non-initiators were younger men compared to others. This could be explained by the unfavourable attitude towards presence of risk factors, lack of motivation to change the risk state or continue lifelong medication. It may also be related to likelihood of younger men to have occupational priorities, which makes it difficult for them to make multiple visits to the health-facility for their prescription refills. Those who are less-wealthy are also more likely to be engaged in
multiple income generation activities, leading to long working hours, including weekends. Also these men got engaged late by ASHAs which may have various reasons. We argue that young men may have the perception that ASHAs, who are female health-volunteers, cater to health issues of “women” rather than of “men”. Moreover, ASHAs usually visit households during the day-time, when most young men are not at home. Health-promotion activities in urban slums are much restricted in late evenings both due to safety concerns, and as ASHAs have to cater to their own families too. Concurrently, coverage of women has been higher in screening as well as follow-up stages in our study. Measures such as evening and holiday camps, and mop-up campaign involving male volunteers were undertaken for increasing linkage of more men to health-facilities for treatment initiation and continuation, however it had limited success. Skewed distribution of female participation was also reported in a female CHW led trial for blood pressure reduction conducted in Nepal.[18]

The variables favouring or disfavouring linkage in this study may also be thought in reference to Andersen model of total patient delay.[19] This model breaks the delay intervals into dimensional components like appraisal, illness, behavioural, and scheduling delays. Younger individuals also have a comparative shorter duration of diagnosis that may lead to ignorance and consequent treatment-neglect. Asymptomatic nature of diseases also adds to this ignorance. Fear of loss of control, impatience, and competing priorities also force them to develop a selective blindness to self. Early ASHA engagement may give the positive signal to participants about the importance of early diagnosis and treatment and an activist attitude of health system towards the ailment and vice versa. This in turn may prompt the individual to transform from ‘slack deterrent individual’ to ‘tense motivated individual’ who wants to actively seek treatment.

In comparison to those who seek care from public sector, individuals under treatment from private care facilities were more likely to be men, wealthier, and previously known to have hypertension. While knowledge, attitude, and individual level barriers in both these subgroups were comparable, those who sought treatment from private sector identified with greater reinforcement from health-care providers, and family members. Interestingly, privately-linked individuals identified distance and overcrowding in the health-facilities as a greater barrier, rather than questioning the availability or quality of medicines available from public-sector facilities.
Prevention of CVD requires that the public health facilities should have at least three anti-hypertensive drugs (Angiotensin-receptor blocker or an angiotensin converting enzyme inhibitor, Calcium channel inhibitor, and a thiazide diuretic), two oral hypoglycemics (A biguanide and a sulphonylurea), a statin and low dose aspirin. These have also been identified by WHO-PEN as essential ingredients for NCD care.[12] Previous studies have demonstrated that availability of these medications in private pharmacies in India is comparable to high-income-countries, however households are unlikely to afford these due to lower paying capacity.[6] In our study 17.3% of high risk individuals preferred private pharmacies for their drugs, and understandably they were in higher wealth quintiles as compared to those linked to public health facilities.

Various factors influence acceptance and persistence with life-long pharmacotherapy, and its patterns are heterogenous.[20] Detection-to-initiation time interval for anti-hypertensive drug therapy is longer in younger, as compared to older hypertensive individuals.[21] Poor economic status, and poor disease control are strong predictors of discontinuation of pharmacotherapy.[22] Regular medication use in chronic diseases requires a daily, lifelong, repetitive, habit-forming behavior. Behavioral theories suggest that individuals with medication taking habit strength are most likely to exhibit long term adherence.[23] Hence individuals who take their medications regularly when initiated on drug therapy, are most likely to be adherent to their medication over a long-term.[24] To ensure a perpetual habit-forming behavior, a strong early reinforcement needs to be advocated for chronic pharmacotherapy.

We need robust mechanisms to monitor adherence especially when a large number of individuals are likely to be screened and treated in public sector.[25] We also need an efficient health-system that ensures continual access to medication, with minimum disruption of occupational priorities. Recent guidelines for hypertension, and higher CVD risk in South-Asians, advocates a more aggressive management of hypertension and diabetes mellitus.[26] Various systematic reviews have recorded numerous successful interventions, to overcome barriers at individual, family, community, provider, and health-system levels.[27] Interventions that addressed barriers at multiple-levels were more successful than the interventions that focused on a single or fewer barriers.[28] Some of the cost-effective solutions could include improved information and behavior change measures by community health workers,
reinforcements by family and providers, improved drug packaging, accessibility, and monitoring mechanisms at the health-system levels.

**Strengths and Limitations**

Our rationale and design paper details strengths and limitations of this study.[9] Strengths includes implementation through stakeholders of existing public health system who are expected to perform these activities under NPCDCS. CHWs had routine competing priorities from other public health program activities for tasks to be done in this project. Thus project tasks may have been on low priority. This can be considered as strength as it tells us about real field picture as well as limitation (uncertainty about actual performance when such kind of program is scaled up as mainstream program).

**Conclusions**-

CHW led strategy for screening, treatment linkage and follow up of hypertension and diabetes for CVD reduction are feasible. However, a large gap exists between high-risk condition detection to treatment-initiation. This subgroup of newly detected high risk group would need distinct efforts directed to address their state of denial. Also, strategy to decrease treatment initiation to discontinuation trajectory needs to be developed. This can be achieved through improved information and behavior change measures by community health workers, reinforcements by family and providers, improved accessibility, continued drug supply, newer ways of drug packaging and monitoring mechanisms at the health-system levels.

**Conflict of interest** – Authors declare no conflict of interest.

**Funding**- This study was funded by Indian Council of Medical Research, New Delhi as an extramural project grant. Funders have no role in data collection, analysis and writing of the manuscript. (Grant – PI- Dr Rajnish Joshi, IRIS-2014-0976)

**Ethical approval**- The study design was approved by the Institutional Human Ethics Committee of All India Institute of Medical Sciences, Bhopal(Ref: IHEC-LOP/2017/EF00045)

**Informed consent**- Participant Information Sheet in Hindi language was provided to each participant. All participants provided written informed consent prior to initiation of any study procedures.

**Data Statement**- Raw data of this study is not deposited in any public repository. However, anonymized raw data of this study would be available to academicians or researchers on request to corresponding author.
References

1. Olsen MH, Angell SY, Asma S, Boutouyrie P, Burger D, Chirinos JA, Damasceno A, Delles C, Gimenez-Roqueplo A-P, Hering D, López-Jaramillo P, Martinez F, Perkovic V, Rietzschel ER, Schillaci G, Schutte AE, Scuteri A, Sharman JE, Wachtell K, Wang JG. A call to action and a lifecourse strategy to address the global burden of raised blood pressure on current and future generations: the Lancet Commission on hypertension. Lancet Lond Engl. 2016 26;388(10060):2665–712.

2. Gupta R, Gupta VP, Prakash H, Agrawal A, Sharma KK, Deedwania PC. 25-Year trends in hypertension prevalence, awareness, treatment, and control in an Indian urban population: Jaipur Heart Watch. Indian Heart J. 2018 Nov 1;70(6):802–7.

3. Anjana RM, Deepa M, Pradeepa R, Mahanta J, Narain K, Das HK, Adhikari P, Rao PV, Saboo B, Kumar A, Bhansali A, John M, Luaia R, Reang T, Ningombam S, Jampa L, Budnah RO, Elangovan N, Subashini R, Venkatesan U, Unnikrishnan R, Das AK, Madhu SV, Ali MK, Pandey A, Dhaliwal RS, Kaur T, Swaminathan S, Mohan V, Anjana RM, Deepa M, Pradeepa R, Mahanta J, Narain K, Das HK, Adhikari P, Rao PV, Saboo B, Kumar A, Bhansali A, John M, Luaia R, Reang T, Ningombam S, Jampa L, Budnah RO, Elangovan N, Subashini R, Venkatesan U, Unnikrishnan R, Das AK, Madhu SV, Ali MK, Pandey A, Dhaliwal RS, Kaur T, Swaminathan S, Mohan V, Sudha V, Parvathi SJ, Jayashri R, Velmurugan K, Borah PK, Rao SB, Padhiyar JM, Sharma S, Lalramenga P, Das SK, Singh TB, Kaki T, Basaiawmoit MR, Shukla DK, Rao MN, Joshi PP, Dhandania VK, Joshi SR, Yajnik CS. Prevalence of diabetes and prediabetes in 15 states of India: results from the ICMR–INDIAB population-based cross-sectional study. Lancet Diabetes Endocrinol. 2017 Aug 1;5(8):585–96.

4. Chow CK, Teo KK, Rangarajan S, Islam S, Gupta R, Avezum A, Bahonar A, Chifamba J, Dagenais G, Diaz R, Kazmi K, Lanas F, Wei L, Lopez-Jaramillo P, Fanghong L, Ismail NH, Puoane T, Rosengren A, Szuba A, Temizhan A, Wielgosz A, Yusuf R, Yusufali A, McKee M, Liu L, Mony P, Yusuf S, PURE (Prospective Urban Rural Epidemiology) Study investigators. Prevalence, awareness, treatment, and control of hypertension in rural and urban communities in high-, middle-, and low-income countries. JAMA. 2013 Sep 4;310(9):959–68.

5. DGHS M GoI. National Programme for Prevention and Control of Cancer, Diabetes, Cardiovascular Diseases and Stroke (NPCDCS) [Internet]. [cited 2019 Sep 2]. Available from: https://dghs.gov.in/content/1363_3_NationalProgrammePreventionControl.aspx

6. Attaei MW, Khatib R, McKee M, Lear S, Dagenais G, Igumbor EU, AlHabib KF, Kaur M, Kruger L, Teo K, Lanas F, Yusuf K, Oguz A, Gupta R, Yusufali AM, Bahonar A, Kutty R, Rosengren A, Mohan V, Avezum A, Yusuf R, Szuba A, Rangarajan S, Chow C, Yusuf S, PURE study investigators. Availability and affordability of blood pressure-lowering medicines and the effect on blood pressure control in high-income, middle-income, and low-income countries: an analysis of the PURE study data. Lancet Public Health. 2017;2(9):e411–9.
7. Nieuwlaat R, Schwalm J-D, Khatib R, Yusuf S. Why are we failing to implement effective therapies in cardiovascular disease? Eur Heart J. 2013 May;34(17):1262–9.

8. Schwalm JD, McKee M, Huffman MD, Yusuf S. Resource Effective Strategies to Prevent and Treat Cardiovascular Disease. Circulation. 2016 Feb 23;133(8):742–55.

9. Pakhare AP, Joshi A, Khadanga S, Kumar S, Atal S, Ingle V, Sabde Y, Shrivastava N, Lahiri A, Ranjan A, Joshi R. Feasibility of Community Health Worker based cardiovascular risk reduction strategies in urban slums of Bhopal: Rationale and design of community based study. medRxiv. 2020 Sep 18;2020.09.18.20189639.

10. The JNC 8 Hypertension Guidelines: An In-Depth Guide [Internet]. AJMC. [cited 2019 Sep 2]. Available from: https://www.ajmc.com/journals/evidence-based-diabetes-management/2014/january-2014/the-jnc-8-hypertension-guidelines-an-in-depth-guide

11. American Diabetes Association. Standards of Medical Care in Diabetes—2017: Summary of Revisions. Diabetes Care. 2017 Jan 1;40(Supplement 1):S4–5.

12. Package of Essential Noncommunicable (PEN) Disease Interventions for Primary Health Care in Low-resource Settings [Internet]. [cited 2019 Sep 2]. Available from: https://apps.who.int/medicinedocs/en/m/abstract/Js19715en/

13. Vrijens B, Vincze G, Kristanto P, Urquhart J, Burnier M. Adherence to prescribed antihypertensive drug treatments: longitudinal study of electronically compiled dosing histories. BMJ. 2008 May 17;336(7653):1114–7.

14. Gee ME, Campbell NRC, Gwadry-Sridhar F, Nolan RP, Kaczorowski J, Bienek A, Robitaille C, Joffres M, Dai S, Walker RL, Outcomes Research Task Force of the Canadian Hypertension Education Program. Antihypertensive medication use, adherence, stops, and starts in Canadians with hypertension. Can J Cardiol. 2012 May;28(3):383–9.

15. Tajeu GS, Kent ST, Kronish IM, Huang L, Krousel-Wood M, Bress AP, Shimbo D, Muntner P. Trends in Antihypertensive Medication Discontinuation and Low Adherence Among Medicare Beneficiaries Initiating Treatment From 2007 to 2012. Hypertens Dallas Tex 1979. 2016;68(3):565–75.

16. Simard P, Presse N, Roy L, Dorais M, White-Guay B, Räkel A, Perreault S. Persistence and adherence to oral antidiabetics: a population-based cohort study. Acta Diabetol. 2015 Jun;52(3):547–56.

17. Adeyemo A, Tayo BO, Luke A, Ogedegbe O, Durazo-Arvizu R, Cooper RS. The Nigerian antihypertensive adherence trial: a community-based randomized trial. J Hypertens. 2013 Jan;31(1):201–7.

18. Neupane D, McLachlan CS, Mishra SR, Olsen MH, Perry HB, Karki A, Kallestrup P. Effectiveness of a lifestyle intervention led by female community
health volunteers versus usual care in blood pressure reduction (COBIN): an open-label, cluster-randomised trial. Lancet Glob Health. 2018;6(1):e66–73.

19. Andersen BL, Cacioppo JT. Delay in seeking a cancer diagnosis: delay stages and psychophysiological comparison processes. Br J Soc Psychol. 1995 Mar;34 (Pt 1):33–52.

20. Hargrove JL, Pate V, Casteel CH, Golightly YM, Loehr LR, Marshall SW, Stürmer T. Antihypertensive Adherence Trajectories Among Older Adults in the First Year After Initiation of Therapy. Am J Hypertens. 2017 Oct 1;30(10):1015–23.

21. Johnson HM, Thorpe CT, Bartels CM, Schumacher JR, Palta M, Pandhi N, Sheehy AM, Smith MA. Antihypertensive medication initiation among young adults with regular primary care use. J Gen Intern Med. 2014 May;29(5):723–31.

22. Sankar UV, Lipska K, Mini GK, Sarma PS, Thankappan KR. The adherence to medications in diabetic patients in rural Kerala, India. Asia Pac J Public Health. 2015 Mar;27(2):NP513-523.

23. Durand H, Hayes P, Harben B, Conneely A, Finn DP, Casey M, Murphy AW, Molloy GJ. Medication adherence for resistant hypertension: Assessing theoretical predictors of adherence using direct and indirect adherence measures. Br J Health Psychol. 2018;23(4):949–66.

24. Lauffenburger JC, Franklin JM, Krumme AA, Shrank WH, Matlin OS, Spettell CM, Brill G, Choudhry NK. Predicting Adherence to Chronic Disease Medications in Patients with Long-term Initial Medication Fills Using Indicators of Clinical Events and Health Behaviors. J Manag Care Spec Pharm. 2018 May;24(5):469–77.

25. Basu S, Garg S, Sharma N, Singh MM. Improving the assessment of medication adherence: Challenges and considerations with a focus on low-resource settings. Ci Ji Yi Xue Za Zhi Tzu-Chi Med J. 2019 Jun;31(2):73–80.

26. Wander GS, Gupta R, Ram CVS. Western guidelines bring in cardiovascular risk prediction along with blood pressure levels for initiation of antihypertensive drugs: Is the pitch ready for Indians…. J Hum Hypertens. 2019;1–2.

27. Bharti S, Bharti B. Adherence to Antihypertensive Therapy: A Missing Link Between Treatment and Outcomes. Am J Hypertens. 2018 09;31(3):290–2.

28. Conn VS, Ruppar TM, Chase J-AD, Enriquez M, Cooper PS. Interventions to Improve Medication Adherence in Hypertensive Patients: Systematic Review and Meta-analysis. Curr Hypertens Rep. 2015 Dec;17(12):94.
Table 1: Distribution of socio-demographic, risk factors, measurements and classification based on linkage status

| Variables                          | Group A Linked to Public Health Facility N=544 | Group B Linked to Private providers N=259 | Group C Treatment Interrupters N=142 | Group D Not linked N=506 | p-value |
|------------------------------------|-----------------------------------------------|-------------------------------------------|--------------------------------------|--------------------------|---------|
| Age Group                          |                                               |                                           |                                      |                          |         |
| <= 45                              | 167 (30.7)                                    | 88 (34)                                   | 57 (40.1)                            | 250 (49.4)               | <0.001  |
| 46 - 65                            | 286 (52.6)                                    | 129 (49.8)                                | 72 (50.7)                            | 195 (38.5)               |         |
| 66+                                | 91 (16.7)                                     | 42 (16.2)                                 | 13 (9.2)                             | 61 (12.1)                |         |
| Gender                             |                                               |                                           |                                      |                          |         |
| Male                               | 175 (32.2)                                    | 110 (42.5)                                | 61 (43)                              | 247 (48.8)               | <0.001  |
| Female                             | 369 (67.8)                                    | 149 (57.5)                                | 81 (57)                              | 259 (51.2)               |         |
| Formal Education                   |                                               |                                           |                                      |                          |         |
| Yes                                | 283 (52)                                      | 167 (64.5)                                | 80 (56.3)                            | 311 (61.5)               | 0.002   |
| No                                 | 261 (48)                                      | 92 (35.5)                                 | 62 (43.7)                            | 195 (38.5)               |         |
| Marital Status                     |                                               |                                           |                                      |                          |         |
| Other                              | 121 (22.2)                                    | 48 (18.5)                                 | 28 (19.7)                            | 90 (17.8)                | 0.308   |
| Married                            | 423 (77.8)                                    | 211 (81.5)                                | 114 (80.3)                           | 416 (82.2)               |         |
| Distance from PHC                  |                                               |                                           |                                      |                          |         |
| More than 3 km                    | 149 (27.4)                                    | 77 (29.7)                                 | 50 (35.2)                            | 155 (30.6)               | 0.001   |
| 1-3 km                             | 145 (26.7)                                    | 67 (25.9)                                 | 39 (27.5)                            | 181 (35.8)               |         |
| < 1 km                             | 250 (46)                                      | 115 (44.4)                                | 53 (37.3)                            | 170 (33.6)               |         |
| Current Oral Tobacco Use           |                                               |                                           |                                      |                          |         |
| Yes                                | 217 (39.9)                                    | 105 (40.5)                                | 65 (45.8)                            | 247 (48.8)               | 0.020   |
| No                                 | 327 (60.1)                                    | 154 (59.5)                                | 77 (54.2)                            | 259 (51.2)               |         |
| Current Smoking                    |                                               |                                           |                                      |                          |         |
| Yes                                | 35 (6.4)                                      | 22 (8.5)                                  | 14 (9.9)                             | 54 (10.7)                | 0.098   |
| No                                 | 509 (93.6)                                    | 237 (91.5)                                | 128 (90.1)                           | 452 (89.3)               |         |
| Current Alcohol use                |                                               |                                           |                                      |                          |         |
| Yes                                | 69 (12.7)                                     | 33 (12.7)                                 | 28 (19.7)                            | 139 (27.5)               | <0.001  |
| No                                 | 475 (87.3)                                    | 226 (87.3)                                | 114 (80.3)                           | 367 (72.5)               |         |
| BMI                                |                                               |                                           |                                      |                          |         |
| >=25                               | 285 (52.9)                                    | 119 (56.1)                                | 58 (49.6)                            | 175 (48.3)               | 0.283   |
| <25                                | 254 (47.1)                                    | 93 (43.9)                                 | 59 (50.4)                            | 187 (51.7)               |         |
| Abdominal Obesity                  |                                               |                                           |                                      |                          |         |
| Yes                                | 383 (70.4)                                    | 194 (74.9)                                | 87 (61.3)                            | 306 (60.5)               | <0.001  |
| No                                 | 161 (29.6)                                    | 65 (25.1)                                 | 55 (38.7)                            | 200 (39.5)               |         |
| New HTN Diagnosis                  |                                               |                                           |                                      |                          |         |
| Yes                                | 171 (31.4)                                    | 59 (22.8)                                 | 72 (50.7)                            | 207 (40.9)               | <0.001  |
| No                                 | 373 (68.6)                                    | 200 (77.2)                                | 70 (49.3)                            | 299 (59.1)               |         |
| New DM Diagnosis                   |                                               |                                           |                                      |                          |         |
| Yes                                | 51 (9.4)                                      | 14 (5.4)                                  | 13 (9.2)                             | 56 (11.1)                | 0.087   |
| No                                 | 493 (90.6)                                    | 245 (94.6)                                | 129 (90.8)                           | 450 (88.9)               |         |
| Engagement by ASHA (Home visit to camp interval) |                                   |                                           |                                      |                          | <0.001  |
| Late (>1 month)                    | 116 (21.5)                                    | 74 (34.9)                                 | 32 (27.4)                            | 156 (43.1)               |         |
| Intermediate                      | 181 (33.6)                                    | 49 (23.1)                                 | 40 (34.2)                            | 69 (19.1)                |         |
| Early (<7 days)                    | 242 (44.9)                                    | 89 (42)                                  | 45 (38.5)                            | 137 (37.8)               |         |
| Wealth Index Quintile             |                                               |                                           |                                      |                          |         |
| Q1                                 | 67 (13.1)                                     | 21 (8.4)                                  | 23 (17.7)                            | 77 (16.6)                | 0.001   |
| Q2                                 | 79 (15.4)                                     | 32 (12.9)                                 | 21 (16.2)                            | 86 (18.5)                |         |
| Q3                                 | 101 (19.7)                                    | 46 (18.5)                                 | 27 (20.8)                            | 88 (18.9)                |         |
| Q4                                 | 114 (22.3)                                    | 49 (19.7)                                 | 33 (25.4)                            | 101 (21.7)               |         |
| Q5                                 | 151 (29.5)                                    | 101 (40.6)                                | 26 (20)                              | 113 (24.3)               |         |

All numbers indicate frequency (proportion) unless indicated otherwise.
### Table 2: Unadjusted and adjusted multi-nominal regression for predictors of non-linkage

| Variable                                                                 | Group B Linked to Private OR (95%CI) | Group C Treatment interrupters OR (95%CI) | Group D Not linked OR (95%CI) |
|--------------------------------------------------------------------------|--------------------------------------|---------------------------------------------|--------------------------------|
|                                                                          | Unadjusted                           | Adjusted                                   | Unadjusted                     | Adjusted                                      |
| Age                                                                      |                                      |                                             |                               |
| More than 65 years (Elderly)                                             | Ref                                  | Ref                                         | Ref                            |
| Between 30-45 years (Young)                                              | 1.16 (0.85-1.59)                     | 1.51 (1.03-2.22)                           | 2.2 (1.71-2.84)                | 2.17 (1.33-3.53)                             |
| Between 46-65 years (Middle aged)                                       | 0.9 (0.67-1.2)                       | 0.93 (0.64-1.34)                           | 0.57 (0.44-0.72)               | 1.1 (0.69-1.74)                              |
| Gender                                                                   |                                      |                                             |                               |
| Women                                                                    | 1.56 (1.15-2.11)                     | 1.59 (1.09-2.32)                           | 2.01 (1.57-2.58)               | 1.45 (0.96-2.17)                             |
| Men                                                                      | 1.63 (1.04-2.57)                     | 1.38 (0.76-2.51)                           |                                 |                                               |
| Formal schooling (vs no formal schooling)                               | 1.67 (1.23-2.27)                     | 1.19 (0.82-1.73)                           | 0.85 (0.51-1.4)                | 1.47 (1.15-1.88)                             | 1.12 (0.79-1.59) |
| Economic status (Wealth Quintile)                                       |                                      |                                             |                               |
| First Quintile (Lowest)                                                 | 0.6 (0.31-1.15)                      | 1.43 (0.85-2.4)                            | 2.32 (1.09-4.93)               | 1.32 (0.92-1.88)                             | 1.8 (1.1-2.96) |
| Second Quintile                                                         | 0.76 (0.44-1.3)                      | 1.06 (0.62-1.79)                           | 1.66 (0.77-3.59)               | 1.24 (0.89-1.74)                             | 1.57 (0.99-2.49) |
| Third Quintile                                                          | 0.87 (0.54-1.4)                      | 1.07 (0.66-1.72)                           | 2.02 (1.02-4.01)               | 0.95 (0.69-1.31)                             | 0.97 (0.62-1.52) |
| Fourth Quintile                                                         | 0.71 (0.45-1.13)                     | 1.19 (0.76-1.86)                           | 2.19 (1.12-4.28)               | 0.97 (0.72-1.31)                             | 1.08 (0.7-1.66) |
| Fifth Quintile (Highest)                                                | 1.26 (0.83-1.93)                     | 1.86 (1.27-2.74)                           | 2.49 (1.73-3.37)               | 2.61 (1.89-3.59)                             | 1.92 (1.25-2.96) |
| Current Oral Tobacco use (vs Non-use)                                   | 1.03 (0.76-1.39)                     | 1.27 (0.88-1.85)                           | 0.76 (0.46-1.27)               | 1.44 (1.13-1.84)                             | 0.71 (1.41)      |
| Current Smoking (vs Non-smoking)                                        | 1.35 (0.77-2.35)                     | 1.59 (0.83-3.05)                           | 2.06 (0.91-4.66)               | 1.74 (1.11-2.71)                             | 1.15 (0.64-2.06) |
| Current Alcohol use (vs no use)                                         | 1.01 (0.64-1.57)                     | 1.69 (1.04-2.74)                           | 0.77 (0.38-1.55)               | 2.61 (1.89-3.59)                             | 1.92 (1.25-2.96) |
| Engagement by ASHA (Home visit to camp interval)                        |                                      |                                             |                               |
| Early (< 7 days)                                                        | 0.59 (0.41-0.86)                     | 1.03 (0.67-1.57)                           | 0.47 (0.34-0.64)               | 0.66 (0.45-0.96)                             |                   |
| Intermediate (7 days to 1 month)                                        | 0.68 (0.45-1.04)                     | 1.21 (0.73-2.02)                           | 2.76 (2.06-3.7)                | 2.61 (1.84-3.7)                              |                   |
| Late (>1 month)                                                         | 1.96 (1.38-2.77)                     | 1.37 (0.87-2.16)                           | 2.61 (1.84-3.7)                |                                               |                   |
| Distance of cluster from UPHC                                            |                                      |                                             |                               |
| Less than 1 km                                                          | 0.96 (0.69-1.34)                     | 1.04 (0.69-1.58)                           | 1.53 (1.18-1.99)               | 1.7 (1.19-2.42)                              |                   |
| >3 km                                                                    | 1.19 (0.81-1.55)                     | 1.44 (0.97-2.13)                           | 1.37 (0.95-1.93)               |                                               |                   |
| New HTN Diagnosis (vs previously known HTN)                              | 0.64 (0.46-0.91)                     | 2.24 (1.54-3.27)                           | 1.51 (1.17-1.95)               | 1.03 (0.75-1.41)                             |                   |
| New DM Diagnosis (vs previously known DM)                                | 0.55 (0.37-0.82)                     | 2.33 (1.49-3.63)                           | 1.2 (0.81-1.8)                 | 1.38 (0.87-2.19)                             |                   |
| Overweight or Obese (vs Normal) based on BMI                             | 0.55 (0.29-1.06)                     | 1.18 (0.56-2.47)                           | 1.2 (0.81-1.8)                 |                                               |                   |
| Waist Circumference                                                      | 1.14 (0.83-1.57)                     | 0.83 (0.64-1.09)                           | 1.02 (0.71-1.47)               |                                               |                   |
| Those linked to Public health facilities are referent; OR=Odds ratio; ASHA=Accredited social health activist; HTN=Hypertension; DM=Diabetes; BMI=Body mass index; UPHC=Urban Primary health centre. | | | | |
Figure 1: Study Flow

Screening for CVD risk factor
All adults >30 years; Door to door screening
ASHAs accomplished in multiple phases

Community Screening
16 Clusters; N=6174

Confirmation of HTN/DM status
Among pre-screened adults;
Cluster level camps (Supervisor)

Optimization of pharmacotherapy; Dispensing medications; Individuals could choose most convenient facility (Public/Private)

Confirmation for linkage
N=1449

Linked to facility
N=943 (65.07%)

6 month follow-up

Group D
Not Linked
N=506 (34.92%)
No linkage recorded on UPHC register;
Not initiated on therapy at any facility

Group C
Treatment Interrupters
N=142 (9.79%)
Single/Two visits recorded in UPHC; Not continuing any therapy at any facility

Group B
Private-care Facility
N=255 (17.87%)
No linkage recorded on UPHC; Documented adherence from private care provider

Group A
Public-health facility
N=544 (37.54%)
Regular visits recorded in UPHC or documented adherence from another Public-health facility

Treatment Adherent
N=801 (55.2%)
Reported to adherent to pharmacotherapy at 6 months home visit by Supervisor

ASHA Accredited social health activist; UPHC Urban Primary Health Center; CVD Cardiovascular disease; HTN Hypertension; DM Diabetes mellitus;
### Figure 2: Potential barriers for linkages to Public facilities

| Domain and Potential Barriers to effective risk reduction | Group A Public Linked | Group B Private Interrupters | Group C Not Linked | All |
|----------------------------------------------------------|-----------------------|-----------------------------|-------------------|-----|
|                                                          | n=75                  | n=22                        | n=19              | n=51| n=167|
| Knowledge                                                |                       |                             |                   |     |
| Not aware that tobacco intake leads to HTN               | 82.7                  | 86.4                        | 84.2              | 76.5| 81.4 |
| Not aware that Obesity leads to HTN or DM                | 62.7                  | 68.2                        | 42.1              | 47.1| 56.3 |
| Not aware that HTN/DM can lead to heart attack/stroke    | 42.7                  | 59.1                        | 68.4              | 39.2| 46.7 |
| Not aware that Tobacco use can be reduced                | 38.7                  | 36.4                        | 42.1              | 33.3| 37.1 |
| Not aware that Obesity can be reduced                    | 25.3                  | 40.9                        | 15.8              | 23.5| 25.7 |
| Not aware that HTN/DM can be controlled with drugs      | 8.0                   | 4.5                         | 0.0               | 5.9 | 6.0  |
| Attitude                                                 |                       |                             |                   |     |
| Denial of presence of risk factors                       | 9.3                   | 13.6                        | 10.5              | 29.4| 16.2 |
| Acknowledges risk but does not want to reduce            | 5.3                   | 9.1                         | 5.3               | 27.5| 12.6 |
| Feels that risk reduction measures donot work            | 5.3                   | 9.1                         | 0.0               | 19.6| 9.6  |
| Wants to reduce risk but not by a lifelong pill         | 13.3                  | 9.1                         | 21.1              | 35.3| 20.4 |
| Wants to reduce risk but cannot devote time to physical  | 16.0                  | 36.4                        | 10.5              | 27.5| 21.6 |
| Wants to reduce risk but cannot change dietary lifestyle | 4.0                   | 9.1                         | 5.3               | 17.6| 9.0  |
| Health provider                                          |                       |                             |                   |     |
| My 'doctor' says that I donot need any risk reduction    | 45.3                  | 31.8                        | 26.3              | 41.2| 40.1 |
| My 'doctor' says that I donot need any pills or medicines| 18.7                  | 9.1                         | 42.1              | 51.0| 29.9 |
| I have been prescribed alternate therapy                 | 5.3                   | 13.6                        | 10.5              | 3.9 | 6.6  |
| Individual                                               |                       |                             |                   |     |
| I sometimes forget to take drugs                         | 45.3                  | 45.5                        | 31.6              | 23.5| 37.1 |
| I sometimes forget to get a prescription refill          | 24.0                  | 36.4                        | 21.1              | 23.5| 25.1 |
| I donot have the motivation to engage in risk reduction  | 18.7                  | 13.6                        | 26.3              | 29.4| 22.2 |
| I had an adverse drug response due to medicines          | 16.0                  | 18.2                        | 5.3               | 5.9 | 12.0 |
| Health system                                            |                       |                             |                   |     |
| Govt health center is far away                           | 32.0                  | 50.0                        | 15.8              | 15.7| 27.5 |
| Govt health center is crowded                            | 45.3                  | 50.0                        | 26.3              | 21.6| 36.5 |
| Drugs are not available at the health center             | 14.7                  | 18.2                        | 5.3               | 3.9 | 10.8 |
| Drugs are dispensed for short period, multiple visits    | 48.0                  | 45.5                        | 31.6              | 13.7| 36.3 |
| Drugs from govt health center are substandard            | 22.7                  | 9.1                         | 0.0               | 11.8| 15.0 |
| Private drug stores are far away                         | 16.0                  | 18.2                        | 10.5              | 13.7| 15.0 |
| Private drugs are expensive                              | 30.7                  | 50.0                        | 36.8              | 13.7| 28.7 |
| Social support                                           |                       |                             |                   |     |
| Family member does not want me to reduce risk            | 21.3                  | 18.2                        | 21.1              | 33.3| 24.6 |
| Family members not willing to get medicines for me       | 26.7                  | 18.2                        | 47.4              | 54.9| 36.5 |
| Peers believe that risk reduction does not work          | 5.3                   | 4.5                         | 0.0               | 2.0 | 3.6  |

All Numbers indicate proportion of individuals in whom specified barrier is operative. This is also indicated by colour shades: Shades of Red (>60%), shades of orange (40-60%), shades of yellow (20-40%), and shades of green (0-20%). A higher proportion indicates that barrier is identified in larger number of individuals.