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Fuelling policy: The Role of Public Health Policy-Support Tools in Reducing Household Air Pollution as a Risk-Factor for Non-Communicable Diseases in LMICs

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Abstract

Reducing Household Air Pollution (HAP) is currently the responsibility of energy sectors, which has inhibited potential significant health advancements for many LMICs. Public health policy-support tools have recently incorporated HAP as a risk-factor for non-communicable diseases (NCDs), yet the functionality of these tools has not previously been explored. Using the epidemiological and economic modelling offered by the tools, this dissertation demonstrated how the tools can help to promote HAP reduction through an illustrative example of India. More broadly, this dissertation explored how mechanisms within the tools foster intersectoral coherence necessary to achieve NCD-related development goals. Findings showed that policy-support tools have the foundations to assist intersectoral planning, yet adjustments can be made.

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List of Abbreviations

AIM	AIDS Impact Module (Spectrum)
ALRI	Acute Lower Respiratory Infection
BAR-HAP	Benefits of Actions to Reduce Household Air Pollution (Tool)
BCC	Behaviour Change Campaign
BCR	Benefit-cost ratio
CHEST	Clean Household Energy Solutions Toolkit
COI	Cost of Illness
COPD	Chronic Obstructive Pulmonary Disease
GBD	Global Burden of Disease
GoI	Government of India
HAP	Household Air Pollution
ICA	Institutional and context analysis
IHD	Ischaemic Heart Disease
LiST	Lives Saved Tool
LMIC	Low- and Middle- Income Countries
LPG	Liquid Petroleum Gas
MoH	Ministry of Health
MoPNG	Ministry of Petroleum and Natural Gas
NCD	Non-communicable disease
NDC	Nationally Declared Contributions (to the Paris Agreement)
NPV	Net present value
NSB	Net social benefit
OHT	One Health Tool
PMUY	Pradhan Mantri Ujjwala Yojna (LPG connection scheme)
PNG	Piped Natural Gas
RCT	Randomised control trial
ROI	Return on Investment
SDG	Sustainable Development Goals
TFR	Total Fertility Rate
UNDP	United Nations Development Programme
WHO	World Health Organisation
WHO-IAQ	World Health Organisation Indoor Air Quality Guidelines

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1. Introduction

Public health policy-support tools, namely computer-based excel built models compiled using demographic, epidemiological and economic modelling, provide support for policymakers during their decision-making process (Bollinger and Ross 2021). These tools project future needs of populations, providing guidance on the resources needed for intervention scale-up (ibid). With a broader increase in reliance on datafication, policy-support tools are increasing in popularity and expanding their scope. The aim of this dissertation is to demonstrate and explore two cutting-edge tools for a holistic approach to health planning in low- and middle-income countries (LMICs).

Recently public health policy-support tools have incorporated non-communicable disease (NCD) risk-factors alongside their modules for infectious disease control planning. This addition aids resource planning in locations facing protracted epidemiological transitions, with increasing NCD burdens alongside persistent infectious diseases (Byass, de Savigny and Lopez 2014). In places also suffering from scarce resources, this situation overstretches public health systems (Bigdeli et al. 2018). 77% of all NCD deaths occur in LMICs, the majority occurring prematurely among the 30-69 age-group (WHO 2021). The global health agenda has promoted a holistic approach to NCD reduction, conceptualising health as "the collective effect of social, economic and physical living conditions", necessitating health-enhancing actions from non-health sectors (Gama e Colombo 2010). One structural NCD risk-factor in LMICs, which demands intersectoral action, is Household Air Pollution (HAP) caused by the combustion of unclean cooking fuels. Over the past year (2021), public health policy-support tools have expanded to project the impact of HAP on NCDs.

Solid fuel combustion (wood, coal, and agriculture residue) is currently used by over 3 billion people for cooking (Jindal and Aggarwal 2020), while most high-income populations have transitioned to 'clean' fuels such as electricity (IEA 2015). This situation led to the inclusion of 7.1 into the Sustainable Development Goals (SDGs), to "ensure access to clean energy in all homes by 2030" (UN 2015). Recent empirical studies confirm the relationship between combustion of unclean fuels and NCDs, with HAP estimated to account for 2.31 million global deaths in 2019 (Bennitt et al. 2021). Therefore, there is a motivation to reduce HAP to contribute to SDG 3.4, "to reduce one third premature mortality from NCDs by 2030" (WHO 2015). HAP is also a significant contributor to ambient air pollution (Smith and Pillarisetti 2017), relevant to SDG 13, "take action to combat climate change" (UN 2015). Furthermore, as women remain confined to the domestic sphere in many LMICs, they bear the greatest burden of hours spent collecting traditional fuels (Austin and Mejia 2017). Reducing HAP is therefore significant for SDG 5.1 "to empower all women" (UN 2015). Due to these multifaceted motivations, the World Health Organisation (WHO) has dubbed reducing HAP (2016) as a "burning opportunity". However, in LMICs where HAP reduction is driven by energy and technology sectors, while SDG 7.1 may be met, clean fuels are not used routinely enough to substantially reduce HAP exposure, inhibiting the potential health and social opportunities from being realised.

To date, no study has explored the cutting-edge policy-support tools created by WHO for HAP reduction. The Benefits of Action to Reduce Household Air Pollution (BAR-HAP) and the Spectrum-based OneHealth Tool (OHT) are the focus of this research. No study has demonstrated the functionality of these tools to project the health and costing outcomes of HAP policy scenarios. Beyond this, minimal studies have considered mechanisms behind such tools for cultivating intersectoral planning necessary to achieve NCD reduction. This research has been framed around the primary question: **How can public health policy-support tools help to promote a reduction of HAP in LMICs?** To answer the question, this dissertation will provide illustrative examples of the tools to demonstrate their use, before exploring how the mechanisms within the tools can foster the intersectoral collaboration necessary for holistic NCD prevention. India was chosen as test-case to present these findings. Two sub-questions are included to guide analysis:

- How many NCDs can be prevented in India through HAP reduction by 2030, and what are the estimated needed resources?
- How can public health policy-support tools foster intersectoral collaboration for holistic NCD control?

This dissertation is structured as follows. Chapter 2 reviews literature on the mechanisms within policy-support tools for policy-planning in LMICs, and empirical evidence on the health effects of HAP. An overview of HAP reduction in India is presented here. Chapter 3 outlines the methodology used, assumptions inputted into the tools, and study limitations. Chapter 4 presents Results of the epidemiological and economic modelling, alongside demonstrating the functionalities of the tools. Chapter 5 discusses the implications of the results for holistic NCD planning. The final chapter presents conclusions and offers policy implications both for HAP reduction in India and suggested adjustments to the policy-support tools.

2. Literature Review

2.1 Policy-support tools for public health in LMICs

Public health policy-support tools aid health intervention planning, projecting the future needs of populations and examining the effect of policy options (Bollinger and Ross 2021). Avenir Health's Spectrum is the most comprehensive system of public health policy-support modules. Demproj, the demographic module, provides the backbone to all Spectrum modules, projecting the impact that changing fertility, mortality, and migration patterns have on the demographic composition of future populations. Modules have been used by scholars and policymakers alone or in conjunction to build projections offering public health implications. For example, USAID analysed family planning needs for Nigeria using the FamPlan module (Goliber and Sanders 2009). Stover et al. (2016) used AIM, the AIDS Impact Module, to model future trends in HIV and estimate resources needed to achieve the 90-90-90 initiative. Michalow et al. (2015) applied both LiST, the Lives Saved Tool projecting changes in maternal and child survival, and FamPlan to compare the impact of interventions to prevent stillbirths and reduce maternal and infant mortality in South Africa.

The Spectrum-based OHT supports sector-wide strategic health-system planning for LMICs. The Spectrum suite of impact modules provide the population calculations used in OHT costing package (Stegmuller et al. 2017). The costing templates include programme costs such as human resources, infrastructure, and logistics (Bollinger and Ross 2021). OHT was used, for example, to outline costing for Indonesia's mid-term development plan (Ali et al. 2020), resource needs for Kenya's health sector strategic plan (Perales, Dutta, and Maina 2015), and to calculate resources needed to strengthen health-systems towards the fulfilment of SDG 3 (universal health coverage) in 67 LMICs (Stenberg et al. 2017).

While this dissertation projects the prevented NCDs from HAP-reduction and estimates the resources needed, this illustration is primarily to demonstrate *how* these tools can promote HAP reduction. From this lens, it is useful to understand what mechanisms operate within the tools for public health policy-planning. Literature from this perspective has been sparse, however this study has synthesised five mechanisms: demographic forecasting, monetizing health, contestability, projections based on good and appropriate evidence, and 'transparent datafication'.

Demographic forecasting

The demographic forecasting (projections of the future composition of populations based on assumptions of fertility, mortality, and migration) embedded in the policy-support tools is one mechanism used for policy planning. Leone (2010) stresses how vital population dynamics are for health planning, due to the impact of ageing populations and population growth in developing countries on healthcare provisions. By accounting for future population structures, tools can foster mid-term strategic plans which are necessary to ensure ministries can align their sector visions with other government priorities (Bollinger et al. 2017; Stegmuller et al. 2017). Furthermore, demographic forecasting (alongside epidemiological modelling) can show policy options against an estimated future counterfactual, identifying potential 'missed opportunities' with foresight which entices policymakers to act (Todorova 2015).

Monetizing health

Policy-support tools present ill-health in terms of economic loss. Hutchinson et al. (2019) contend that using OHT to build "investment cases" for health provides a mechanism to bring multiple sectors together around a common theme. Wong et al. (2018) reference the cost-effective framing presented by the tools, which Norheim, Emanual and Millum (2019) contend currently dominates global health decision-making. Many studies used OHT to present the economic cost of HIV/AIDS to build motivation across stakeholders to invest in antiretroviral treatment (Kumaranyake 2008; Canning 2006; Bruno et al. 2008). More recently, studies have utilised the same mechanism within OHT to promote an investment case for NCDs (Hutchinson et al. 2019; Farrington et al. 2019; Bertram et al. 2018). By monetizing health, public health policy-support tools can motivate health-enhancing action among non-health actors.

Contestability

Contestability is another mechanism behind policy-support tools for policy-planning. The tools present data visualisations for the non-technical user (Wong et al. 2018; Stegmuller et al. 2017). Raineri and Molinari (2021:47) explore how data visualisation tools for policymaking "preserve the human brain's centrality in a decision-making environment that is increasingly dominated by artificial intelligence". The goal of artificial intelligence is to prevent beneficiaries from interacting directly with the data. Yet Raineri and Molinari (2021) propose that visualisations should be presented based on constraints that the user previously set on the data, for the user to then infer a decision from the visual outputs. Through the process, policy-actors "inject human bias" (ibid). Kluttz, Kohli, and Mulligan (2020) explain that the user can 'contest' the tools, exploring how changes in the datasets influence the tool outputs against counterfactuals. Rather than being presented with what an algorithm believes to be the most cost-effective intervention, potentially resulting with invisible biases, public health policy-support tools encourage actors to engage with, critique, and correct the tools.

Projections based on good and appropriate evidence

Bollinger et al. (2017) and Wong et al. (2018) highlight that policy-support tools offer sound evidence for policymakers to base their decisions on. Stegmuller et al. (2017:146) cites an NGO program coordinator who states that LiST can help show empirically what intervention can save the most lives preventing "ad hoc decision making". This mechanism complements calls to increase evidence-based policy, resting on assumptions that increased evidence utilisation will be a more efficient means of achieving social goals (Cookson 2005; Birbeck et al. 2013). For clinical interventions, 'good evidence' refers to randomised control trials (RCTs) which establish causality most confidently by controlling for extraneous variables (Chalmers et al 1981). Notably, Parkhurst and Abeysinghe (2016) argue that RCTs are not always useful for public policy, where social-structural factors (controlled for in RCTs) are fundamental in intervention success. They frame 'good' evidence for health policy in terms of 'appropriateness', advocating for insights based on field-experiments which account for social realities (ibid). Policy-support tools for public health interventions compile both good and appropriate evidence for projections. For example, LiST uses both RCTs and quasi-experimental studies to determine the effect of measles vaccination on child survival (Sudfeld, Navar, and Halsey 2010). The policy-support tools therefore offer certainty on effectiveness and appropriate efficiency.

'Transparent Datafication'

Scholars may argue that the previous two mechanisms (good evidence and contestability) have the potential to negatively skew agenda setting. Argyrous (2012) argues that evidence-based policy has been subject to critique, often swayed by the distorting influences of powerful interests (Hawkins and Parkhurst 2016) which may be provided a platform through the contestability mechanism. Indeed, Ergas (2009) contends that poor decisions can be made on good evidence.

To hold policymakers to account and prevent this situation, there is a mechanism within the tools conceptualised here as 'transparent datafication'. As the data used is visible and the analytical choices are explicit (Argyrous 2012), the choices made by the user and tool are transparent. This transparency combines with the "logic of datafication", which Hoeyer, Bauer, and Pickersgill (2019) explain works as a tool for accountability. Metrics make human suffering visible, and it is through these metrics that governments can be held accountable (ibid). Crucially, it is the policy-support tools which "mobilise and perform accountability metrics" through transparent data and assumptions (ibid:470; Callon and Munisea 2005). Through 'transparent datafication', policymakers are held accountable to prioritise resources effectively.

In sum, public health tools offer support for policymakers through these five mechanisms. Throughout this dissertation, these mechanisms provide an analytical lens to demonstrate the tools functions in practice, and to explore how they can foster intersectoral planning for holistic NCD reduction.

2.2 Public health policy-support tools for reducing HAP

This dissertation explores how public health policy-support tools can help to promote a reduction of HAP. HAP, caused by cooking with solid fuels, is now considered the greatest environmental health-risk factor globally, responsible for almost 5% of the global burden of disease (GBD) (Ahmed et al. 2019). HAP is also emitted through heating and lighting (Muyanja et al. 2017), though most literature and robust data focuses on cooking fuels. The WHO's indoor air quality (WHO-IAQ 2010) guidelines contend that HAP levels below $PM_{2.5}$ 25mg/m^3 annual average are recommended for a fuel to be "clean", such as liquid petroleum gas (LPG) and electricity. Empirical evidence establishes strong links between high HAP exposure and NCD onset (Smith et al. 2014), causing 11% of all deaths due to ischemic heart disease (IHD), 12% of all strokes, 25% of all chronic obstructive pulmonary disease (COPD), 17% of all lung cancer, 45% of pneumonia deaths in children under-5, and 28% of adult deaths due to acute lower respiratory infections (ALRI) (WHO 2018). As air pollution is controllable, these adverse health outcomes are preventable (Schraufnagel et al. 2019). There is anecdotal evidence that HAP exposure occurring *in utero* can increase risk for low birth weight, still birth, and gestational hypertension (Amegah, Quanshah, and Jakkola 2014). This dissertation focuses on NCDs rather than adverse birth outcomes, due to the current lack of robust evidence for the latter.

Sufficient evidence to make a systematic case for NCDs caused by HAP has only recently been firmly established (Smith and Pillarisetti 2017). This explains why public health policy-support tools have only now extended to account for this risk-factor. In 2018, WHO developed its Clean Household Energy Solutions Toolkit (CHEST), containing six modules for countries to develop evidence-based HAP reduction policies that reduce health risks. This includes the standalone HAP module, BAR-HAP, and the HAP model integrated into the suite of NCD risk-factors on the Spectrum-based OHT, both released in 2021. Prior to CHEST, attempts to project the impact of HAP on NCDs, or the resources needed to scale-up HAP reduction for NCD aversion, involved complex statistical and epidemiological modelling from the ground-up, lacking many of the mechanisms listed above (for example, see Smith and Pillarisetti 2017). No study has yet demonstrated the useability of the HAP model on OHT, and BAR-HAP has not been explored beyond those who created the tool (Das et al. 2021). In addition, HAP initiatives are currently underway in some developing countries, providing a timely opportunity to explore how public health policy-support tools can help to promote a reduction of HAP in LMICs**.** The purpose of this dissertation is to illustrate how these tools, BAR-HAP and OHT, work to promote a reduction of HAP for NCD prevention.

Scholars argue that intersectoral cooperation is necessary to achieve NCD SDG goals (Mondal and Van Belle 2018; Ssennyonjo et al. 2021). While the responsibility for clean fuel dissemination lies with energy sectors, scholars assert that health should be the driver of action on HAP reduction (WHO 2020). Smith and Pillarisetti (2017:147) contend that an explanation for prior failed attempts to reduce HAP may be due to “origins in the technology rather than health sector”. Yet, budgeting for HAP reduction remains outside the Ministry of Health (MoH) budget. This is reflective of a broader issue, that public service provisions are often stated in theory as being public health responsibility, but in practice are beyond the scope of MoH capacities (Siddiqi et al. 2009). Buse and Hawkes (2015:5) argue that the current SDGs for health “lacks consistency in distinguishing between health sector action and action in other sectors”, and only implicitly calls to the need for ‘health-in-all’ policies. They contend that achieving the health-SDGs will require a five-fold paradigm, the first of these being intersectoral coherence and coordination on the structural drivers of health (ibid). HAP reduction for NCD prevention provides an interesting insight into intersectoral governance, having gained less attention than the ‘commercial determinants’ of NCDs (Mondal and Belle 2019). Therefore, this dissertation also explores how public health policy-support tools can foster intersectoral cooperation for holistic NCD prevention through HAP reduction.

Situated within this literature, the empirical significance of this dissertation is threefold:

- Demonstrate the usability of new public health policy-support tools for promoting HAP reduction.
- Project the possible NCDs prevented and estimate resources needed for HAP reduction in India by 2030.
- Show how the mechanisms within these tools can foster intersectoral planning for NCD prevention through HAP reduction, offering suggested improvements based on the illustrative experience.

2.3 Test-case: HAP reduction in India

India is used as a test-case to demonstrate the how public health policy-support tools can promote a reduction of HAP in practice. In 2016, India’s Ministry of Petroleum and Natural Gas (MoPNG) introduced Pradhan Mantri Ujjwala Yonja (PMUY), one of the world’s largest clean fuel dissemination programmes, providing free LPG connection to 800 million households by September 2019 (Jindal and Aggarwal 2020). While PMUY has been hailed a success for establishing clean fuel connections to many of the population, scholars have argued that this framing glosses over the lack of sustained use of LPG beyond the initial connection (Harish and Smith 2019). Suboptimal usage has occurred due to affordability issues with fuel refills (Lindgren 2020), gender inequality in decision making (Yadav 2020), and traditional preferences (Day and Malakar 2020). Therefore, while SDG 7.2.1 - measured by the share of population with *access* to clean fuels - is being met, lack of sustained use and therefore persistent high HAP exposure results in potential NCDs, as well as gender equality and climate benefits, falling short of targets. Additionally, 35% of the population continue to lack LPG connection, relying on traditional biomass (NSS 2018). This is concerning, as the loss of productive life years due to NCDs in India estimated to be one of the highest in the world, with younger and poorer parts of the population disproportionately affected (Mondal and Van Belle 2018).

India offers an optimal test-case for this research. Firstly, the Government of India (GoI) are familiar with policy-support tools, having used LiST to guide their maternal and child health plans (MoHFW 2013). Secondly, Dasgupta et al. (2021) explains that India policy initiatives are committing to institutionalising ‘One Health’ approaches to disease control, which involves promoting intersectoral collaboration and cooperation (de Macedo Couto an Brandespim 2020). NITI Aayog, the GoI policy-think-tank, provide strategic design and directions for policies to guide India towards the SDGs (Mondal and Van Belle 2018). Indeed, the fact that India’s energy ministry has undertaken PMUY as its first social welfare scheme reflects a step towards the intersectoral paradigm-shift that Buse and Hawke (2015) argue is necessary to achieve health-SDGs. India therefore provides an optimal case to test how policy-support tools can facilitate holistic intervention planning for a body such as NITI Aayog, as the country enters the second phase of PMUY (2020-2030). Thirdly, while links between ill-health and HAP were known during the first roll-out of PMUY, epidemiological and economic projections were not available, making it unclear where scarce resources would best be utilised. Furthermore, Harish and Smith (2019:5) advised the need to find “standard methods to monetise health impacts at the national level” of HAP reduction in India, a function offered by BAR-HAP but not yet demonstrated for India’s context.

While context-specific suggestions on HAP interventions will apply to India, the demonstration and application of these tools will be transferable to other LMICs struggling with HAP. The following section outlines the methodology used to present these contributions to literature.

3. Methodology

To situate the research questions in their broader contexts, a literature review was conducted scoping Google Scholar, Global Health Medicus, and PubMed. The purpose was to identify mechanisms in the literature that explain how the tools operate in the current public health climate, and to present recent epidemiological evidence pertaining to the health impact of HAP. Manuals for the tools were found on Avenir Health's website and WHO's CHEST website. To situate the test-case in its country context, government reports and policy documents were retrieved through the National Indian Government portal and NITI Aayog portal.

To answer how public health policy-support tools can help to promote a reduction of HAP, this dissertation will provide an illustrative example for HAP reduction in India. To do this, it will deploy quantitative analysis using the data modelling outlined below. Results of the possible NCDs prevented from HAP reduction will be discussed, with the comparable resources necessary to achieve the health and financial benefits across four intervention options. The functionality of the tools will be outlined alongside the presentation of these outputs. Then, borrowing the methodology from Hutchinson et al. (2019), these Results will be discussed by drawing on facets from the Institutional and Context Analysis (ICA) approach launched by the United Nations Development Programme (UNDP 2017). While a full ICA is not possible (see 3.4), this Discussion will use policy documents to explore how the mechanisms within the policy-support tools can foster intersectoral collaboration for the achievement of NCD-related SDGs.

This dissertation is concerned with how tools can support decisions on intervention scale-up. The policy-support tools deemed most suitable are those within Module 2 of CHEST, 'Identification of Technological and Policy Interventions'. BAR-HAP was deemed most appropriate as it is aimed at guiding planning of policy interventions (Das et al. 2021). The Spectrum-based OHT was also chosen from this module, considering the extensive use of the Spectrum software in scholarship and policy-circles, and its ability to complement BAR-HAP outputs.

3.1 Policy support tools: Modelling and Data

This section describes the tools' back-end modelling and data sources. While these tools draw on up-to-date data, these have been cross-referenced to other sources and occasionally changed to improve the accuracy of outputs.

OHT

The inter-agency Spectrum-based OHT (version 6.06, 2021) is used to model mortality and morbidity aversions resulting from HAP reduction by 2030. As part of CHEST, the OHT expanded to integrate HAP into its suite of NCD risk-factors, alongside, for example, hazardous alcohol use. HAP can be evaluated as one of the multiple NCD risk-factors or as an independent risk-factor. To align with the aims of this dissertation, HAP is explored as an independent risk-factor. No study has yet demonstrated the functionality of the HAP model on OHT. To calculate the impact of cooking fuel on health outcomes, the model accounts for baseline information on particle emissions for each cooking method, along with an exposure adjustment factor, taken from Burnett et al. (2018). As these figures are based on scientific evidence, they have remained unchanged. The prevalence/incidence of each NCD attributed to HAP is taken from GBD (2020). The module uses a direct attributable fraction[1] to calculate the percentage of disease burden related to each cooking fuel.

Three other modules are notable for this analysis: Demproj, LiST and AIM. Demproj calculations are based on the standard cohort-component model modified to produce a single-year projection, based on assumptions on future levels of fertility, mortality, and migration (Bollinger and Ross 2021). Baseline data for this is taken from India’s 2015 Demographic and Health Survey and the UN’s 2019 World Population Projections. OHT automatically includes LiST and AIM in its projections. As this analysis is not concerned with child and maternal health or HIV/AIDS, the modules’ country-level data were incorporated without modification.

BAR-HAP

BAR-HAP (version 1.4, 2021) a standalone module for HAP projections, is used to estimate the costs and resources needed to achieve the greatest impact from HAP reduction. The tool incorporates evidence from recent efforts to characterise the relevant set of parameters that determine costs and benefits associated with HAP reduction (Das et al. 2018; Jeuland, Tan Soo, and Shindell 2018; Kaur et al. 2014; Shindell 2015). BAR-HAP is pre-filled with WHO’s NCD costing tool (WHO-CHOICE 2012) to calculate human resources, equipment, and capacity building costs. It is also filled with static demographic data (total population and average household size), epidemiological data from GBD (2020), economic (including stove and fuel cost, stove lifespan, wages, and social discount rate), environmental, and cooking behavioural parameters for South Asia and India (Jeuland, Tan Soo, and Shindell 2018). The costs and benefits incorporated in BAR-HAP are summarised in Table 1. As the time being saved is primarily among women, this output is taken as a proxy for gender empowerment opportunities as it is time that could be spent in economic advancing activities (Lambe et al. 2015).

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[1] $\text{PAF} = 1\,\frac{\sum_{i=1}^{n} P_i * RR_i - \sum_{i=1}^{n} P_i' * RR_i}{\sum_{i=1}^{n} P_i * RR_i}$

<table>
<tr><th colspan="2">Costs</th></tr>
<tr><td>Government costs
- Stove subsidy cost, fuel subsidy cost, programme cost.</td><td>Private costs
- Stove and fuel costs, collection time, maintenance, and learning.</td></tr>
<tr><th colspan="2">Monetized Benefits</th></tr>
<tr><td>Private health benefits
- Morbidity/mortality reductions of COPD, ALRI, IHD, lung cancer, stroke.</td><td>Social health benefits (incorporating HAP contribution to ambient air pollution)
- Morbidity/mortality reductions of diseases using social discount rate (SDR) and accounting for health spill overs.</td></tr>
<tr><td>Time savings</td><td>Climate benefits</td></tr>
</table>

Table 1: Costs and benefits in BAR-HAP.

3.2 Policy-support tools: Assumptions

Energy transitions

National targets seek to eliminate the use of all cooking arrangements that cause HAP across households, aligning with SDG 7 “to ensure access to affordable, reliable, sustainable and modern energy for all” by 2030 (UN 2015). Specificities for the distribution of clean energy are not defined. However, documents for phase 2 of PMUY indicate plans to *extend* LPG to the poorest, *extinguish* LPG among the middle class, and *enhance* the use of LPG (Harish and Smith 2019). Therefore, the decision has been made to set 100% of the population currently using traditional biomass to transition to LPG by 2030. For a second energy transition, the top 20% wealth-quintile have been set to transition from LPG to electricity, freeing up LPG for the poorest. Notably, LPG to electricity is the only ‘clean-to-clean’ transition that BAR-HAP currently offers. After reviewing stakeholder documents and informal conversations, a transition from LPG to Piped Natural Gas (PNG) was deemed appropriate for this second transition. For these provisional results to demonstrate the use of the tools, electricity acts as a placeholder for PNG. Table 2 presents a summary of the energy transitions, inputted into both OHT and BAR-HAP.

Cooking Fuel	Actual: 2018	Target: 2030	Explanations for targets
	% of total households		
Firewood	31.2	0	Not considered ‘clean’ under WHO-IAQ.
Dung cake	3.8	0	
LPG	61.4	76.4	The 35% households using traditional biomass will transition to LPG (‘*extend*’).
Electricity	0	20	The top 20% wealth quintile will transition off LPG (‘*extinguish*’).
Other	3.6	3.6	
Total	**100**	**100**	

Table 2: Cooking fuel usage, actual (2018 figures taken from National Sample Survey 75th round), and targets for 2030 with explanations.

Based on 8 field studies, BAR-HAP assumes that once access is provided, there is a 48% usage rate of the clean fuel due to the cultural phenomenon of ‘stacking’ (continued use of the traditional fuel). Monitoring evaluation from India reflects that far less cooking is done with the clean fuel due to traditional preferences (Harish and Smith 2019). Section **4.4** contextualises the need to ‘*enhance*’ LPG use among the 61% who already have connection when ‘stacking’ assumptions more aptly reflect the reality in India.

Interventions

BAR-HAP offers five interventions to facilitate these transitions. Currently the tool allows users to apply one policy-action per cooking transition. Four out of five interventions were chosen for comparison, based on feasibility for the Indian context, action plans from NITI Aayog, and confirmed as appropriate through informal conversations with experts in the field. Unless specified, the effectiveness of these interventions has been based on good and appropriate evidence and so have remained as default (Das et al. 2021).

Stove Subsidy: GoI rolled-out a stove subsidy intervention in 1985, entitled The National Programme on Improved Cookstoves, led by the Indian Ministry of Non-Conventional Energy Sources. This was cancelled in 2012 due to mixed results, namely due to the lack of accompanying clean fuel provisions (Kishore and Ramana 2002).

Fuel Subsidy: MoPNG currently subsidise the cost of the first LPG cannister for women below-poverty-line. While PMUY has increased the number of those connected to LPG, refill rates have fallen short of the levels needed to achieve substantial HAP exposure reductions necessary to prevent adverse health consequences (Kar et al. 2019).

Financing: This option allows households to spread payments overtime in instalments for clean cookstoves. A pay-as-you-go option is offered for fuel, rather than paying for an entire refill upfront. Time payments increase willingness to pay; purchasing, in turn, increases regular usage of clean energy (Lewis et al. 2015; Beltramo, Levine, and Blalock, 2014).

Intensive Behaviour Change Campaigns (BCCs): BCCs work through participants' barriers to behaviour change, including social norms that may conflict with desired behaviour, frequently accompanying public health interventions (WHO 2021). An 'intensive' BCC refers to households receiving personal stove demonstrations and informational meetings lasting one hour (Lewis et al. 2015). BAR-HAP's default assumption is that BCCs increase demand for clean cooking by 10% based on Beltramo et al. (2015) findings from Uganda. Yet, a multitude of small-scale pilot BCCs were more successful at encouraging clean fuel use in India (Lewis et al. 2015), likely due to the specificities of behavioural barriers rather than access issues. Therefore, BCC's ability to increase demand was changed from the default assumption of 10% to 25%, reflecting recent country-specific findings.

The intervention not chosen for this study is ***fuel ban,*** which although has been used in the United Kingdom, Ireland, and China, has been deemed unfeasible for the Indian context (Zhang and Smith 2007).

Time Frame

Keeping with the time frame embedded in the NCD Costing Tool, BAR-HAP assumes a 15-year implementation frame (WHO 2020). The fixed assumption is that years 1 and 2 comprise planning with no intervention dissemination, years 3, 4 and 5 reflect partial implementation (targeting 1/3rd of total target households), reaching full population targeting by year 6. To keep complementary synchroneity between the two tools, the same scale-up assumptions have been inputted into OHT. For OHT, to provide the most accurate demographic trend assumptions, the baseline was set to 2015 as this is the most recent Demographic and Health Survey year.

3.3 Limitations

A trade-off for using such cutting-edge tools, is that they are in their iterative development processes. While this inhibits accuracy of outputs, it is hoped that this research contributes to their growth. Although a more in-depth appraisal of the scope of these tools will form the basis of the Discussion, some limitations must be signalled.

It was not possible to conduct key informant interviews with stakeholders as it was unethical to draw health policymakers away from the volatile Covid-19 situation in India. Speaking to stakeholders would have enabled a richer ICA to elucidate an understanding of how the tools can foster intersectoral cooperation. It would also have enabled cross-referencing of the assumptions in the tools, such as the daily hours spent cooking, which would have increased the accuracy of the outputs.

Additional limitations within the tools inhibit accurate policy-outputs for India. Firstly, 'stacking' is not accounted for on OHT, meaning the potential prevented NCDs from HAP reduction are likely overstated. A low variant scenario has been applied to these projections to establish a sensitivity range. Secondly, electricity has been used as a placeholder for PNG. Furthermore, in the current version of BAR-HAP, the user is unable to change the intervention time frame from 2020-2035. This is problematic for presenting intervention scale-up that includes a two-year planning period, as one of these years is in the past. Implications of these points are expanded on in the Discussion, though it should be reiterated that due to such unavoidable methodological constraints, the policy suggestions for HAP reduction in India should be taken as provisional. Nevertheless, these restrictions do not detract from gaining insight into the primary aim of this dissertation – to explore how public health policy-support tools can promote a reduction in HAP. Finally, both tools use national average data for India and so cannot account for demographic and economic heterogeneity between Indian states. Yet this research is concerned with policy-support tools for national level planning, for a body such as NITI Aayog.

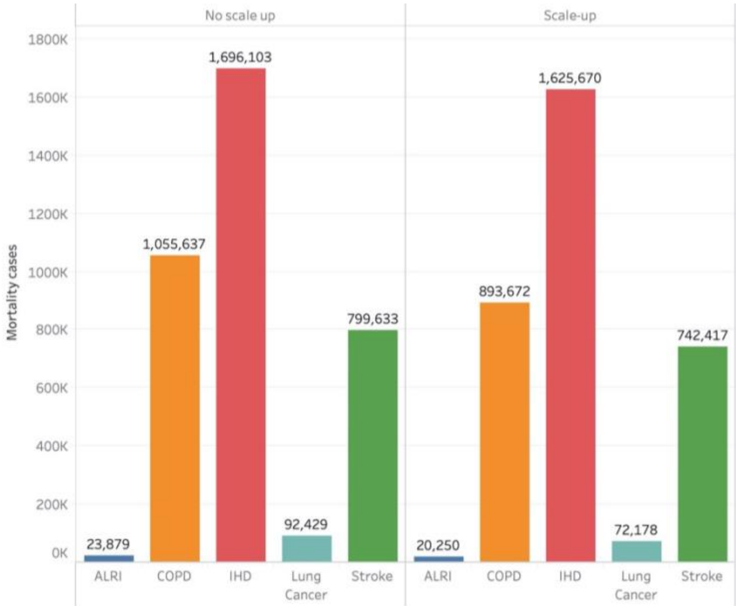
4. Results

This section presents an example application of the tools for India. Within the limits of the available data, OHT's epidemiological modelling presents how many NCDs can be prevented through HAP reduction, and the economic modelling on BAR-HAP estimates what resources are needed to achieve the greatest health and financial benefits from HAP reduction. These results will demonstrate how public health policy-support tools can help to promote a reduction of HAP in LMICs.

4.1 Health Benefits

This section demonstrates the epidemiological and *demographic forecasting* within OHT to present how many NCDs can be prevented in India through HAP reduction. These projections account for the natural increase in NCDs that come with an ageing population, occurring due to falling total fertility rate and increasing life expectancy in some regions in India (Mathur and Mathur 2015).

Mortality cases with and without HAP reduction (India, 2030)



Morbidity cases with and without HAP reduction (India, 2030)

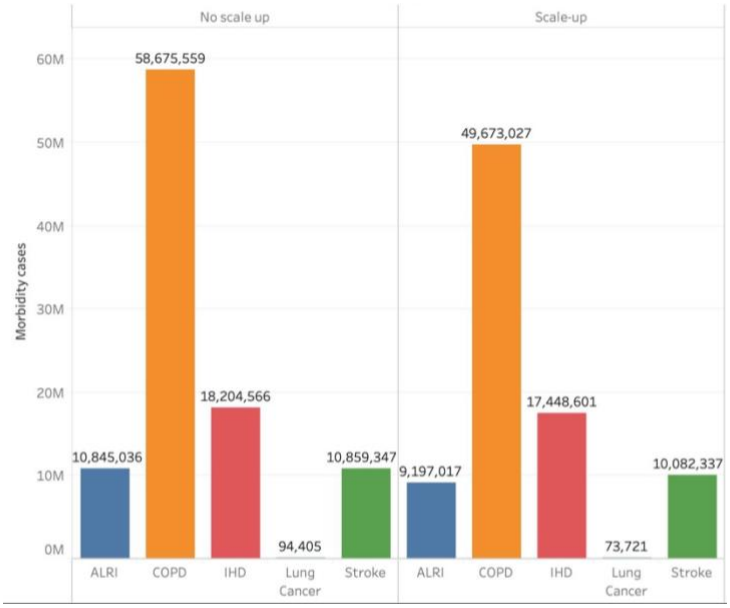


Figure 1 (left) and **Figure 2 (right):** Mortality (left) and morbidity (right) NCD cases in India 2030, with and without HAP intervention scale-up. **Source:** Own projections, OHT v.6.06, formatted on Tableau.

Figures 1 and 2 present the projected morbidity and mortality cases in 2030, with and without HAP intervention scale-up. The greatest impact is on COPD. Epidemiological modelling projects that with no HAP intervention, there will be over 1 million cases of COPD and over 58 cases of COPD morbidity occurring in 2030. With a successful energy transition, 16.2% of COPD deaths (nearly 162 thousand) and 15% of COPD morbidity (over 9 million) can be prevented in 2030 alone. Over the 15-year scale-up (2020-2035), 6.5% of total NCD-related deaths (over 3 million) and 9% of total NCD morbidity cases (over 1.5 billion) would be prevented with HAP reduction.

Mortality prevented in India with clean cooking (2020-2030)

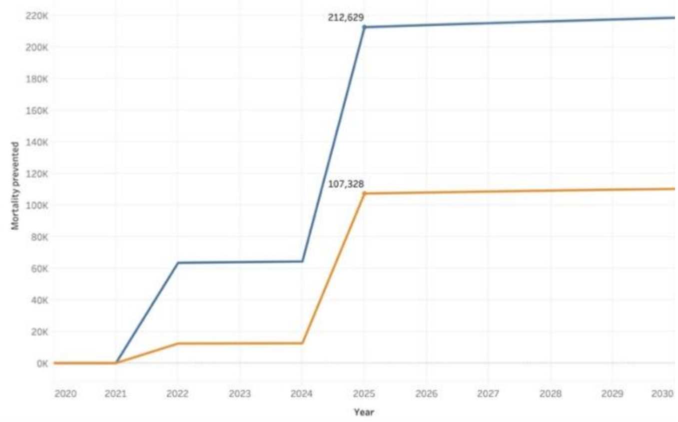


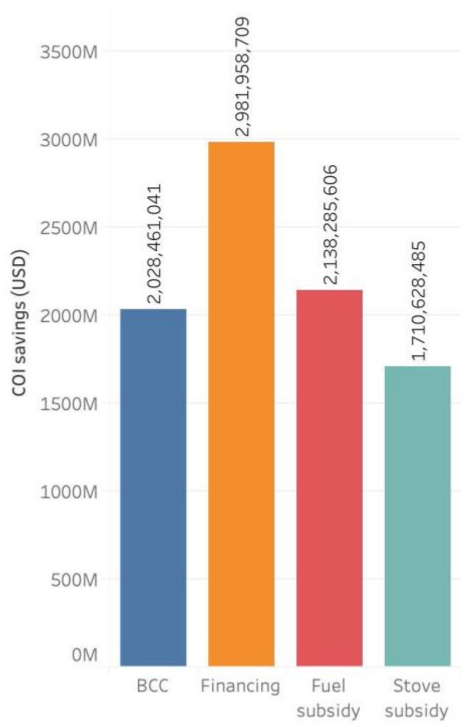
Figure 3: Mortality prevented in India (2020-2030) when 100% of the population use clean fuel as their primary fuel (blue) compared to 75% (orange). **Source:** Own projections, OHT v.6.06, formatted on Tableau.

OHT does not currently account for 'stacking'. These figures are therefore aspirational, as while 100% of India may have connection to LPG by 2030, it is less realistic that clean fuel will be their primary cooking fuel. Figure 3 presents a realistic range of clean fuel use and associated mortality prevented over the 15-year period. The orange line reflects 75% of the population using clean fuel as their primary fuel, in contrast to the mortality prevented when 100% of the population are using the clean fuel only in blue. The area between these two lines reflects a more accurate forecast of likely NCD prevention from HAP reduction.

4.2 Monetized Health Benefits

BAR-HAP translates the health benefits from extending clean fuel to the whole population into monetary gains. As BAR-HAP does not have back-end demographic modelling, these projections do not account for changing population structures. At present, this tool is the only way to activate the *monetizing health* mechanism specifically for HAP reduction. For these projections, the usage rate has been kept as default (48%).

Public Cost-of-Illness (COI) Savings (India, 2020-2035)



Monetized Private Health Benefits (India, 2020-2035)

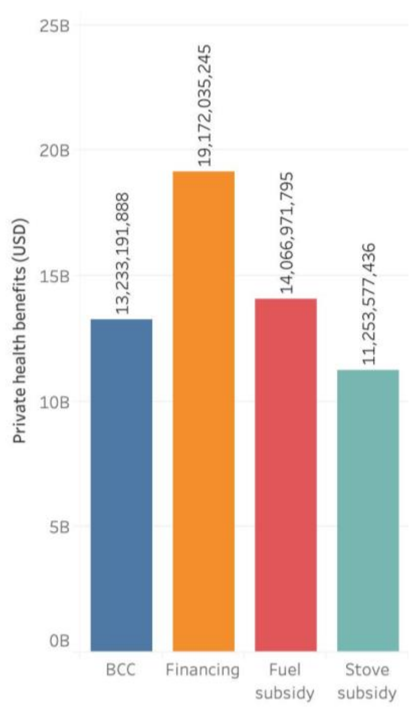


Figure 4 (left): COI savings, and **Figure 5 (right):** private health benefits, shown with intervention options in USD (India 2020-2035). **Source:** Own projection, BAR-HAP (v.1.4) formatted on Tableau.

Figure 4 translates the health benefits into public cost-of-illness (COI) savings with the four intervention options. These figures represent the direct savings from avoiding health sector costs, and indirect savings such as increased value of workforce productivity and reducing job absenteeism (Jo 2014). Figure 5 presents the monetized private health benefits, presented in household savings per Disability Adjusted Life Year (DALY) avoided. Over the 15-year scale-up, the Financing intervention would save almost $3 billion in COI, and over $19 billion in private health savings.

These figures showcase how the change in demand assumptions impact the outputs. Based on *good and appropriate evidence*, BAR-HAP assumes that Financing increases demand for clean fuel by 40%, with a 25% Stove Subsidy leakage and a 50% Fuel Subsidy leakage. As mentioned, the default assumption was that BCCs increased demand for clean fuel by 10% and that this was changed to a more appropriate 25% for India.

4.3 The 'Social Investment Case' for HAP reduction

This section demonstrates what can be achieved through the *monetizing health* mechanism, estimating the needed resources to '*extend*' clean energy to the remainder of the population. In attainment of SDG 3.4, to reduce premature mortality from NCDs, WHO and UNDP initiated 'investment cases' that use OHT to examine the cost-effectiveness of NCD interventions (Hutchinson et al. 2019; Bertram et al. 2018; Chishom et al. 2017; Nugent et al. 2018). Previous investment cases have not been able to include HAP reduction, as HAP costing is not currently available on OHT. The outputs from BAR-HAP have been presented in this format, provisionally filling this gap for studies seeking to calculate the potential cumulative ROIs for NCD prevention efforts. Climate and time savings have been incorporated into these calculations.

	2020 – 2025 (economic target timeframe)				**Total 15-year period (2020 – 2035)**			
Intervention	Total costs	Total benefits	NSB	BCR	Total costs	Total benefits	NSB	BCR
	(Billion USD)				(Billion USD)			
Fuel subsidy	47.5	4.3	**-40.5**	**0.08**	138.3	32.2	**-106.2**	**0.2**
Stove subsidy	3.6	3.4	**-0.2**	**0.8**	13.2	25.6	**12.4**	**1.9**
Financing	5.5	5.8	**0.22**	**1.1**	20.4	43.4	**23.0**	**2.1**
BCC	5.1	4.9	**-0.24**	**0.9**	18.8	37.0	**18.0**	**2.0**

Table 3: Social discounted total costs, benefits, NSP and BCR for four HAP interventions in net present value terms, Billion USD. **Source:** Own projections, BAR-HAP (v.1.4).

Table 3 presents the total monetized costs, benefits, the net social benefit (NSB) in billion USD, and the benefit-cost-ratio (BCR) for each intervention. BAR-HAP calculates the NSB in net present value terms, which captures the total financial value of an investment opportunity, representing the present value of the cash flows at the required rate of return of the project compared to the initial investment (considering the social discount rate and rates of inflation). The BCR is a metric used in other health 'investment cases' as a standardised comparison of ROIs between interventions, calculated by dividing the benefits by the costs. Where the BCR is greater than 1.0, the intervention will deliver a positive ROI. These figures are presented for 2020-2025 to align with India's economic targets, and over the

15-year scale-up. For the 2020-2025 period, it should be remembered that BAR-HAP assumes that planning occurs over the first two years, adding costs with no benefits. Figure 6 presents a visual representation of these results. Table 4 breakdowns the total benefits in table 3, to contextualise these projections for relevant stakeholders. Total breakdowns of the costs and benefits for each intervention are in the appendix.

Intervention	Health benefits	Time benefits	Climate benefits
Fuel subsidy	9.4	6.6	12.7
Stove subsidy	7.7	5.3	10.2
Financing	12.8	8.8	17.0
BCC	10.7	7.5	14.4

Table 4: Monetized health, time, and climate benefits for four HAP interventions. Presented in Billion USD, between 2020-2035, India. **Source:** Own projections, BAR-HAP (v.1.4).

Costs vs. Benefits of HAP interventions (India, 2020-2035)

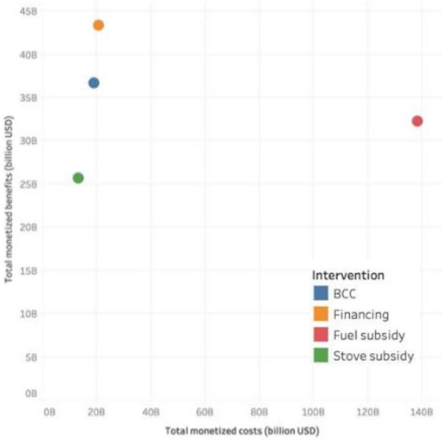


Figure 6: Total benefits against total costs for four HAP interventions. **Source:** Own projections, BAR-HAP (v.1.4). Formatted on Tableau.

The Financing intervention yields both the greatest health and financial prospective benefits from HAP reduction. Fuel Subsidy is by far the least cost-effective, primarily due to the substantially higher costs in government subsidies (-$149 billion) and the likelihood of fuel leakage which decreases the health and climate benefits. The Financing intervention increases the beneficiaries' willingness to pay for the clean fuel, which in turn encourages higher usage rate, lowering overall HAP exposure to yield the greatest health (and time and climate) benefits. Overall, within the confines of the data available, achieving the greatest health and economic benefits from '*extending'* clean fuel to the remainder of the population, would require a $20.4 billion scale-up over the 15-years. Over this period, $23 billion would be gained from this investment. This provisional evidence is useful for NITI Aayog, who have not yet set a budget for phase 2 of PMUY.

4.4 From '*Extend'* to '*Enhance'*

This section contextualises the need to *'enhance'* LPG use among the 61% of the population who already have access. Table 5 displays the total benefits when the Financing intervention is applied with differing usage rates. Notably, rather than estimating the financial resources needed to *'enhance'* LPG use, this section serves to demonstrate the use of the *contestability* mechanism to show how the usage rate of the clean cookstove impacts benefits.

Clean fuel usage rate	Health benefits	Climate benefits	Time benefits	NSB	BCR
	(Billion USD)				
10%	4.0	6.7	3.1	-6.7	0.7
20%	8.5	13.4	7.5	2.2	1.1
30%	13.7	19.9	9.2	11.8	1.4
48% (default)	25.5	32.0	14.7	31.5	1.8
90%	95.8	59.6	27.6	120.2	2.9

Table 5: Monetized health, climate, and time benefits at varying clean stove usage rates, with NSB and BCRs (billion USD), for 2020-2035 India. **Source:** Own projections, BAR-HAP (v.1.4).

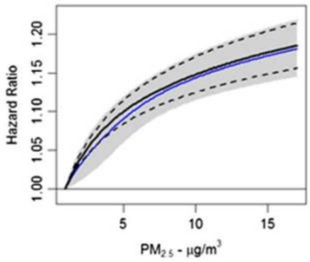


Figure 7: Exposure-response curve for health hazards at different PM **Source:** Nasari et al. 2016:967.

Three significant reflections stem from these outputs. Firstly, these figures reflect the estimated exposure-response relationships within BAR-HAP. The high usage rates translate into linearly decreased PM exposure, improving the health, climate, and time benefits. While the estimated exposure-response relationship for climate emissions and hours saved are linear, increasing the usage rate to 90% reflects the highly nonlinear exposure-response relationship for health: relatively large health effects of PM reductions are concentrated at the low PM exposure portion of the curve (Nasari et al. 2016) (figure 7). Secondly, as a higher usage rate is critical for yielding benefits, when usage rate is set to 10% there is a negative ROI (losing $6.7 million over the 15-year period). Finally, this section reflects how users can *contest* the tools based on their epistemic frame (i.e., focusing on usage rather than merely connection), interacting with the data to understand how different scenarios impact outcomes.

This Chapter has shown how the public health policy-support tools can help to promote HAP reduction, by demonstrating how the user can estimate the possible impacts and necessary resources. The next chapter will situate these findings in India's institutional and contextual climate, to explore how the mechanisms within these tools can foster holistic health planning.

5. Discussion

Drawing on facets from UNDP's ICA, this section situates the quantitative modelling in India's institutional and contextual landscape. An ICA explores how the country-context will facilitate or inhibit the achievement of an SDG, in this case, SDG 3.4 - to reduce premature mortality from NCDs.

Using the provisional results as best available estimates, this section explores how public health policy-support tools can assist the intersectoral governance paradigm-shift (Buse and Hawke 2015) necessary to promote HAP reduction to contribute towards achieving SDG 3.4. To answer this, the tool mechanisms synthesised in the Literature Review will be explicitly linked to India's institutional context. This format also lends itself to offering implications for HAP reduction in India and suggestions for tool improvements based on this experience. Overall, while policy-support tools have foundations to assist intersectoral governance, there are some adjustments to be made for them to reach their full potential for '*fuelling'* holistic NCD reduction in LMICs.

1. ***Demographic forecasting* can tie energy sector goals to public health sector goals**

The *demographic forecasting* mechanism within the policy-support tools can explicitly tie energy sector goals (100% of the population using clean fuel by 2030) to public health goals (reduce premature mortality from NCDs by 33% in 2030). The tools show that in 2030, almost 313,500 deaths would be prevented from NCDs with a reduction in HAP, translating to a 9% reduction from the projected NCD-related mortality in 2030 with no HAP intervention. While the links between poor health and HAP are recognised, *demographic forecasting* (alongside epidemiological modelling) can now explicitly show the best estimated future counterfactual scenario, highlighting the missed potential health opportunities and reframing HAP reduction as a key driver of NCD prevention. Currently, there is no dedicated programme to HAP reduction among the 12 NCD control programmes run by India's National Health Ministry. A suggestion for a BCC programme is offered below. Furthermore, while links between HAP and NCDs are cited in India's 2013-2020 NCD Action Plan, projected figures of the potential NCD prevention were not available in 2013 making it challenging to conceptualise how much attention should be placed on HAP to contribute to NCD control goals. *Demographic forecasting* enables health and energy sectors to strategically align their mid-term visions, a function not previously readily available.

The tools could leverage the *demographic forecasting* mechanism by incorporating it alongside costing for HAP interventions, to project the clean-cooking resources necessary for future populations. Resource allocation must be planned with future populations in mind, rather than assuming populations will remain static (as BAR-HAP does). This function is crucial for projecting HAP interventions for NCD prevention in ageing populations such as India, as the growing NCD burden will require a greater investment for health-system strengthening alongside the scale-up of HAP reduction. Additionally, in sub-Saharan African countries, population growth rate has expanded at 4 times the rate of access to modern cooking fuels (IRENA 2018). Therefore, while the *demographic forecasting* within OHT provides the foundations to tie HAP to NCD targets, which more broadly encourages intersectoral coherence, this can be taken further by leveraging mechanisms within both tools.

2. *Monetizing health* can present HAP reduction as an economic opportunity

By *monetizing health*, policy-support tools present HAP reduction as an economic opportunity. In 2019, Prime Minister Modi envisioned making India a USD 5-trillion-dollar economy by 2025. Covid-19 has set this target back, with the World Bank (2021) projecting that this is more feasible by 2030. For 2020-2025, the Financing intervention is projected to save $3 billion, 0.06% of the 5-trillion-dollar target. Over the 15-year scale up to 2035, the same intervention will provide $23 billion returns, 0.46% of the economic target. While these percentages are small, HAP has not previously been framed as an economic opportunity, rather a dent in fiscal budget. In accordance with Horton (2017:346), while access to medicines, or in this case clean fuel, should be a decisive matter of human rights, advocators must "talk the language" of finance and planning ministries, mediated through the *monetizing health* mechanism.

Enabling *demographic forecasting* alongside the *monetizing health* mechanism would emphasise economic potential from HAP reduction in two ways. Firstly, these mechanisms in tandem would link potential economic gains from NCD prevention to India's productive potential during its demographic dividend. India currently has a 'window of opportunity' with a greater proportion of the population at working age than old or young dependents (Bloom, Canning, and Sevilla 2003). India must capitalise on their demographic dividend to grow their economy before their dependency ratio rises, with an ageing population requiring more costly NCD care and pension provisions (Afroz 2018). Activating the *demographic forecasting* alongside *monetizing health* would situate the possible productivity benefits from HAP reduction within the country's demographic composition. The Ministry of Labour and Employment can use this to plan for employment opportunities to ensure that this 'window' is effectively capitalised on. As populations on BAR-HAP are static, the projected growing working age population over the next 15-years is unaccounted for.

Secondly, *demographic forecasting* alongside the *monetizing health* mechanism could explicate the link between reducing HAP and public health-systems strengthening for economic growth. Improving India's under-funded public health-system is an economic priority for Prime Minister Modi, intended to improve productivity and reduce job absenteeism. It may be assumed that the inclusion of HAP into OHT was to integrate HAP plans into sector-wide health costing, providing a comprehensive vision of economic benefits possible through NCD control methods. However, the HAP model in the NCD-suite is not connected to OHT's costing framework as budgeting for HAP remains outside the MoH. If these two mechanisms were activated in tandem, the tools could include HAP reduction into a case for health-system strengthening for economic potential, providing a clearer shared vision between health, finance, and energy sectors. These suggestions advocate for the inclusion of BAR-HAP's *monetizing health* mechanism into OHT, which is compatible as both tools use the same costing database (WHO CHOICE).

3. ***Good and appropriate evidence* offers an efficient means of achieving social goals, fostering intersectoral policy coherence on HAP reduction**

The results build a case for the ministries who will also benefit from HAP reduction to share the financial responsibility of the Financing intervention to facilitate the remainder of India's energy transition, as suggested by Josey et al. (2020). The evidence underscoring this case is both *good* and *appropriate*, with levels of fuel PM emissions taken from laboratory based RCTs, and field studies testing intervention effectiveness incorporating participants' 'real-life' behaviour. This combination offers certainty on quality of the projections for related stakeholders. The gender equality and climate motivations for reducing HAP are briefly outlined here.

Gender equality

With $20 billion government-wide investment into the Financing intervention, Indian women can save a cumulative $8.8 billion in time over the 15-year period (when fuel usage is set to 48% default). Promoting financial independence is important to enable Indian women to contribute to household decisions (Sharma and Kota 2019). This is pertinent, as women having lower income is a risk-factor for domestic violence in India (Mahapatro, Gupta and Gupta 2012). The Ministry of Women and Child Development therefore has high motivation to reduce HAP and encourage the gained time to be spent in formal employment. Promoting gender equality within the household will foster greater NCD reduction from HAP as, with effective BCCs (outlined next), women are likely to opt for clean fuel when consulted in this household decision (Harish and Smith 2019).

Climate goals

In 2021, India renewed their Nationally Determined Contributions (NDCs) as part of the Paris Agreement, which embodies country efforts to reduce national climate emissions (MoEFC 2021). While cooking fuels are mentioned, these are not presented as central in India's efforts to achieve their NDCs. Additionally, India's NDCs (2021:1) state: "just because the economic development of many countries has come at the cost of the environment, it should not be presumed that a reconciliation of the two is not possible." This sentiment is supported with the evidence presented by the tools, with a possible $17 billion saved in climate benefits by extending clean fuel connection over the population. Furthermore, as ambient air pollution is another risk-factor for NCDs, promoting HAP reduction for climate benefits will directly prevent NCDs (Cohen et al. 2017). Therefore, the tools provide *good and appropriate evidence* to cultivate a shared impetus among stakeholders to prioritise investment in HAP reduction, which in turn, will contribute to a decline in NCDs in obtainment of SDG 3.4.

Suggestions can be made for the *good and appropriate evidence* within the tools to foster intersectoral collaboration further. Firstly, BAR-HAP could account for more 'clean-to-clean' energy transitions, incorporating the costs and benefits for different electricity sources, such as solar-power for off-grid electric cooking (Tiewsoh, Jirásek, and Sivek 2019). Once BAR-HAP offers more energy transitions, an ICA can evaluate any tensions among stakeholders. This analysis would evaluate coordination problems to prevent overlapping mandates that undermine governments' abilities to address cross-cutting policy issues (Ssennyonjo et al. 2021). For example, a transition from LPG to PNG may be costly but environmentally friendly (Kumar, Shastri, and Hoadley 2020), while LPG to solar-power may pollute during manufacturing yet have more health and gender equality benefits by reaching remote regions (Dawn et al. 2016). Furthermore, the tool should distinguish between tribal, rural, and urban India, due to vast differences in necessary infrastructure for fuel dissemination (Rao et al. 2020). If such data and modelling were available, the *good and appropriate evidence* offered by the tools could more actively stimulate intersectoral deliberation.

4. *'Transparent datafication'* and *contestability* can call the public health to account for the persistent ill-health effects of HAP

The *contestability* mechanism was activated to critique the assumptions of usage rates in the tools from a behavioural perspective, rendering visible how important it is to discourage 'stacking' to substantially improve health impacts. This works in conjunction with the *'transparent datafication*' mechanism to call the public health sector to account, by "mobilising accountability metrics" (Hoeyer, Bauer, and Pickersgill 2019:470) of the missed health opportunities despite increased fuel connection. The need to encourage fuel usage rates alongside providing connection is reminiscent of encouraging condom use or stopping smoking after related interventions have been scaled-up. BCCs frequently accompany public health interventions, as encouraging behaviour change are seen as crucial to their success. Roy et al. (2019) conducted small studies testing strategies for encouraging clean fuel usage in remote tribal regions of India. When providing households with health messages on the effect of traditional fuel use, 84% purchased a second cylinder and dismantled their traditional cookstove (ibid). Therefore, '*transparent datafication'* alongside *contestability* fosters a holistic approach to NCD prevention, by presenting the role for public health to improve the usage of clean fuel, alongside the role of the energy sector in fuel dissemination. This sentiment aligns with the 2017 shadow report by Indian civil society on the SDGs, which emphasises how data should be used to identify priority investment areas (WNTA 2017).

A brief explanation on how the public health sector can *enhance* LPG use in PMUY phase 2 is presented here. Public health BCCs ensure that traditional preferences are accounted for in intervention roll-out (Lewis et al. 2015). While MoPNG assumed that offering LPG to women below-the-poverty-line would automatically foster gender equality, this perspective did not account for gender inequality inhibiting LPG use in the first place, causing low usage rates and minimal health benefits. Continued use of LPG remains strongly influenced by the decision-maker who controls household expenses, with only 14%

of women placing orders for an LPG cylinder (Patnaik and Mani 2019). It is therefore pertinent to target men in BCCs (ibid). Interestingly, Day and Malakar (2020) found that some women enjoy collecting firewood as it is a socialising experience. Such cultural nuance is overlooked in the current energy driven PMUY scheme but would likely arise in participatory formative evaluations and incorporated into BCCs, offered alongside clean fuel dissemination. This discussion reflects how by *contesting* the assumptions in the tools, the public health sector is held accountable (through *datafication*) for the preventable ill-health effects from suboptimum LPG use.

One suggestion on how the *transparent datafication* mechanism can be enhanced to actively facilitate intersectoral collaboration, is by enabling both the BCC and the Financing interventions to be applied in tandem. This adjustment would present the user with the full costs and benefits of this intersectoral action and allocate specific fiscal responsibility, bolstering the *datafication* mechanism in holding sectors to account. If new data becomes available on the effects of two interventions in tandem, the tools could more practically facilitate this intersectoral planning through *transparent datafication* and *contestability* mechanisms. Another suggestion is for OHT to incorporate Nasari et al. (2016) exposure-response modelling approach, which is designed to be integrated into health impact assessment software. This would account for realistic 'stacking' for more accurate foresight into the preventable NCDs from HAP reduction, further holding the public health sector to account for persistent preventable deaths, through *datafication*.

Further reflections

Firstly, OHT could develop similar interfaces for finance, energy, and climate planning needs, to present a comprehensive view of different stakeholders whose actions contribute towards NCD reduction. This move would achieve one of Prime Minister Modi's top 10 priorities: sorting inter-ministerial issues through efficient systems (IBEF 2021). Secondly, extending beyond NCDs, Spectrum's LiST on OHT has provisions for incorporating HAP interventions into its platform to project reductions in still births, wasting, stunting and maternal ill-health. While the current state of data is ambiguous, Wooley et al. (2021) recently released a research protocol to synthesise existing data, which could then be incorporated into LiST to contribute to holistic planning for SDG 3.2, to reduce under-5 mortality (WHO 2015).

In sum, mechanisms within the public health policy-support tools can assist intersectoral governance necessary to achieve NCD control goals, by explicitly tying energy sector goals to public health goals, fostering a shared impetus among different sectors, and calling the public health sector to account for their role in HAP reduction. It has been argued that the extent to which the tools can foster intersectoral governance is constrained by both available data and the lack of the *demographic forecasting* mechanism accompanying other mechanisms. This advocates for the inclusion of BAR-

HAP into OHT, which is a feasible next step to improve the tool's ability to '*fuel*' intersectoral governance for holistic NCD planning.

6. Conclusions and Implications

Reducing premature NCDs in LMICs requires a holistic vision of health, incorporating risk-factors often beyond the scope of public health provisions, such as HAP. Currently, HAP is conceptualised as the responsibility of energy and technology sectors, inhibiting the potential for advancements in health. This dissertation explored how public health policy-support tools, which recently expanded to incorporate HAP reduction for NCD prevention, can promote a reduction of HAP and more broadly foster intersectoral coherence needed to approach health holistically and achieve NCD-related SDGs. Through demonstrating the usability of both the HAP module on OHT and the standalone BAR-HAP tool, it was shown how the functioning and mechanisms within the tools can help to promote HAP reduction. Situated within India's broader institutional climate, it was shown that policy-support tools have the foundations to assist intersectoral governance, yet some adjustments could be made for them to reach their full potential in *'fuelling'* holistic NCD reduction in LMICs.

This research has offered empirical contributions to both policy dialogue and scholarship. In the current boundaries of available evidence and methods in the policy-support tools, Box 1.1 presents preliminary suggestions for HAP reduction in India. Based on this experience, Box 1.2 offers some suggestions on improvements to the policy-support tools, many of which depend on further data being collected. The possibility of this is promising, considering the recent surge in public health interest surrounding HAP and the current rate at which new evidence is unfolding. While India was used as a test-case, the demonstration of the tools, techniques such as presenting the 'social investment case' for HAP reduction, and the suggestions for tool improvements can be transferred to other LMICs struggling to reduce HAP. More broadly, this study hopes to provoke scholars to consider the useful mechanisms behind policy-support tools when appraising their outputs, considering how these mechanisms can align with broader paradigm shifts necessary to overcome health and development challenges.

To end, this author would like to draw attention to a concern raised by Smith and Pillarisetti (2017:149):

> While faecal matter in the household environment was confirmed as a major risk-factor for ill-health in the late 1800s, it continues to kill millions today… Both faecal matter and HAP share uncomfortable similarities: they are significant, operate in poor populations, and require behavioural interventions as well as engineering innovations…and are also refractory to cost-effective solutions.

These scholars ask, "how can we be sure that HAP is not still killing millions a century from now?" (ibid). One stark contrast between today and the 1800s is that public health policy-support tools can present future 'missed opportunities' with foresight, hold policymakers accountable through metrics, frame an investment on the poor as an economic opportunity, and explicate multifaceted benefits to cultivate support beyond the health sector. Hopefully, public health policy-support tools will '*fuel*' a shared impetus to foster an effective response to this unjust, preventable, and significant development challenge.

Box 1.1: Policy suggestions for HAP interventions in India

- MoPNG can consider a Financing intervention for the remainder of India's energy transition
- MoH can oversee a BCC to enhance usage of clean fuel among those with access
- Present HAP reduction as an economic opportunity and a chance to strengthen the public health-system

Box 1.2: Suggested improvements to public health policy-support tools for HAP reduction

- Incorporate BAR-HAP costing for HAP interventions onto the Spectrum-based OHT
- Incorporate Nasari et al. (2016) exposure-response modelling approach onto OHT to account for 'stacking'
- Longer-term goal of incorporating platforms for all sectors onto Spectrum's interface

When more evidence becomes available:

- Allow for two HAP interventions to be applied in tandem
- Incorporate more 'clean-to-clean' energy options
- Distinguish between sub-national costing
- Incorporate HAP as a risk-factor for maternal and under-5 health onto LiST

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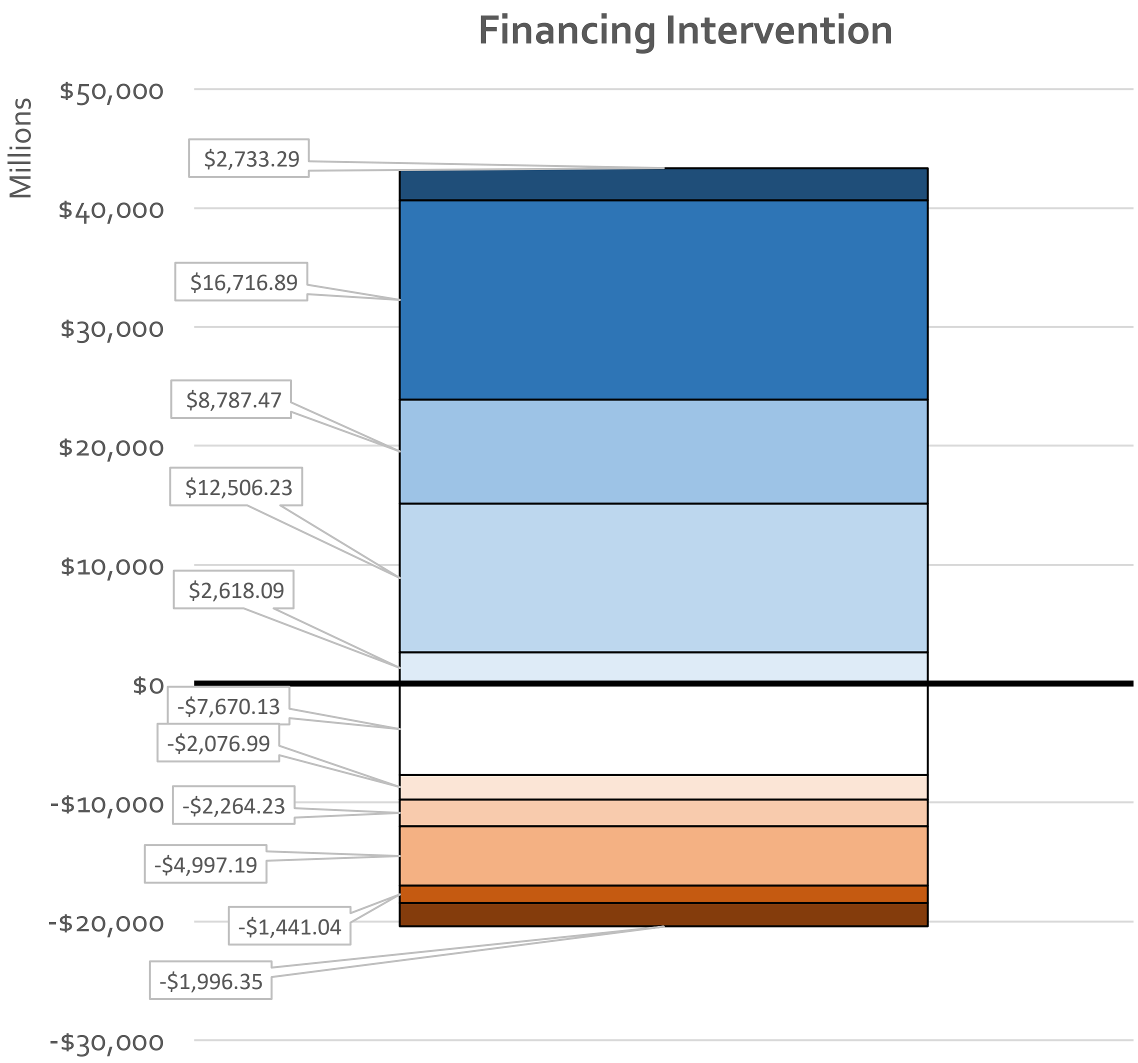
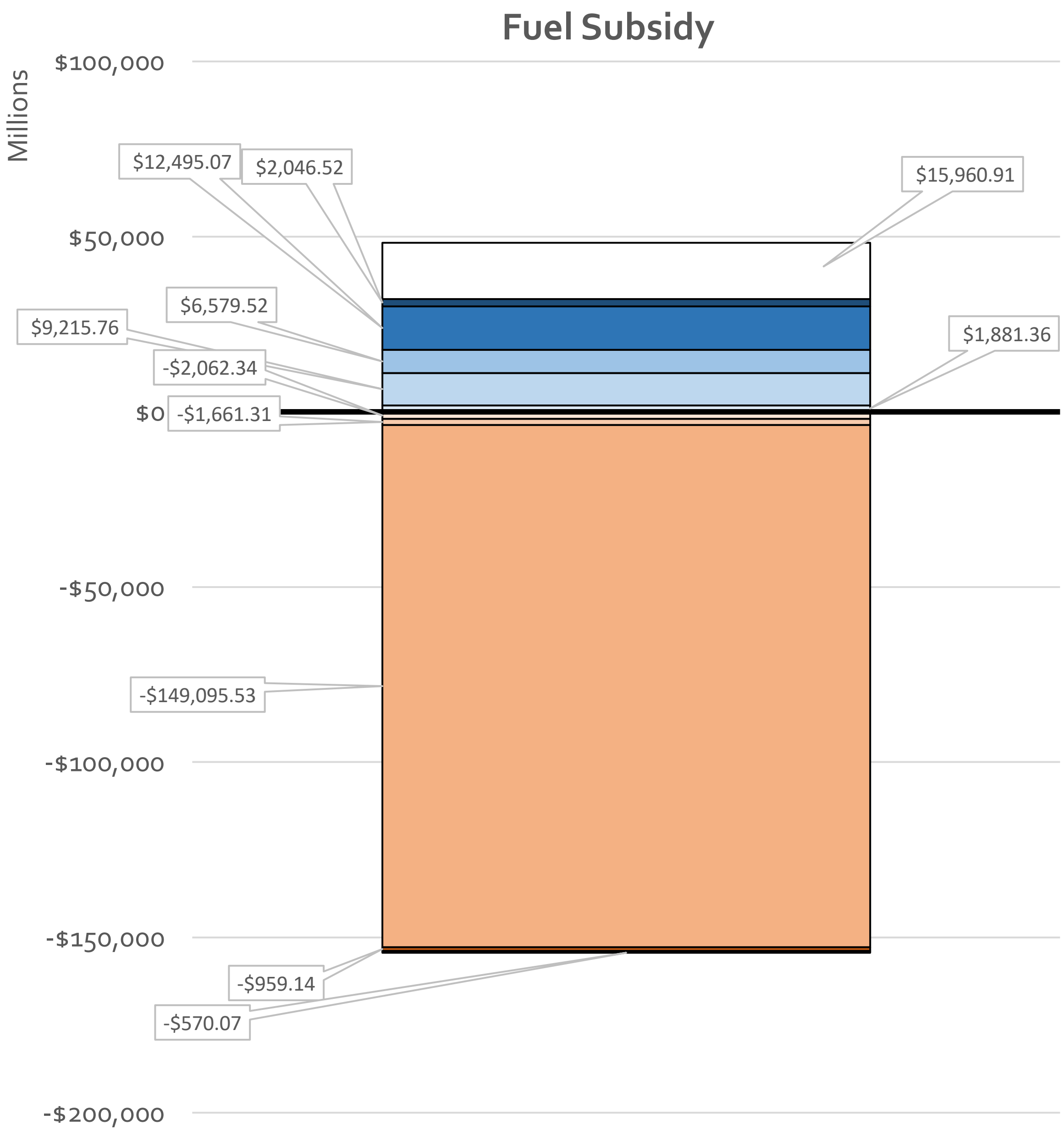
8. Appendix

Appendix 1: Breakdown of total costs and benefits for each intervention over the total 15-year period. Own projections, BAR-HAP (v.1.4).
Please note that hovering over each section will inform the viewer of the value of the specific cost or benefit to avoid confusion with overlapping labels.

Key:




Fuel Subsidy
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-$50,000
-$100,000
-$150,000
-$200,000
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$2,046.52
$15,960.91
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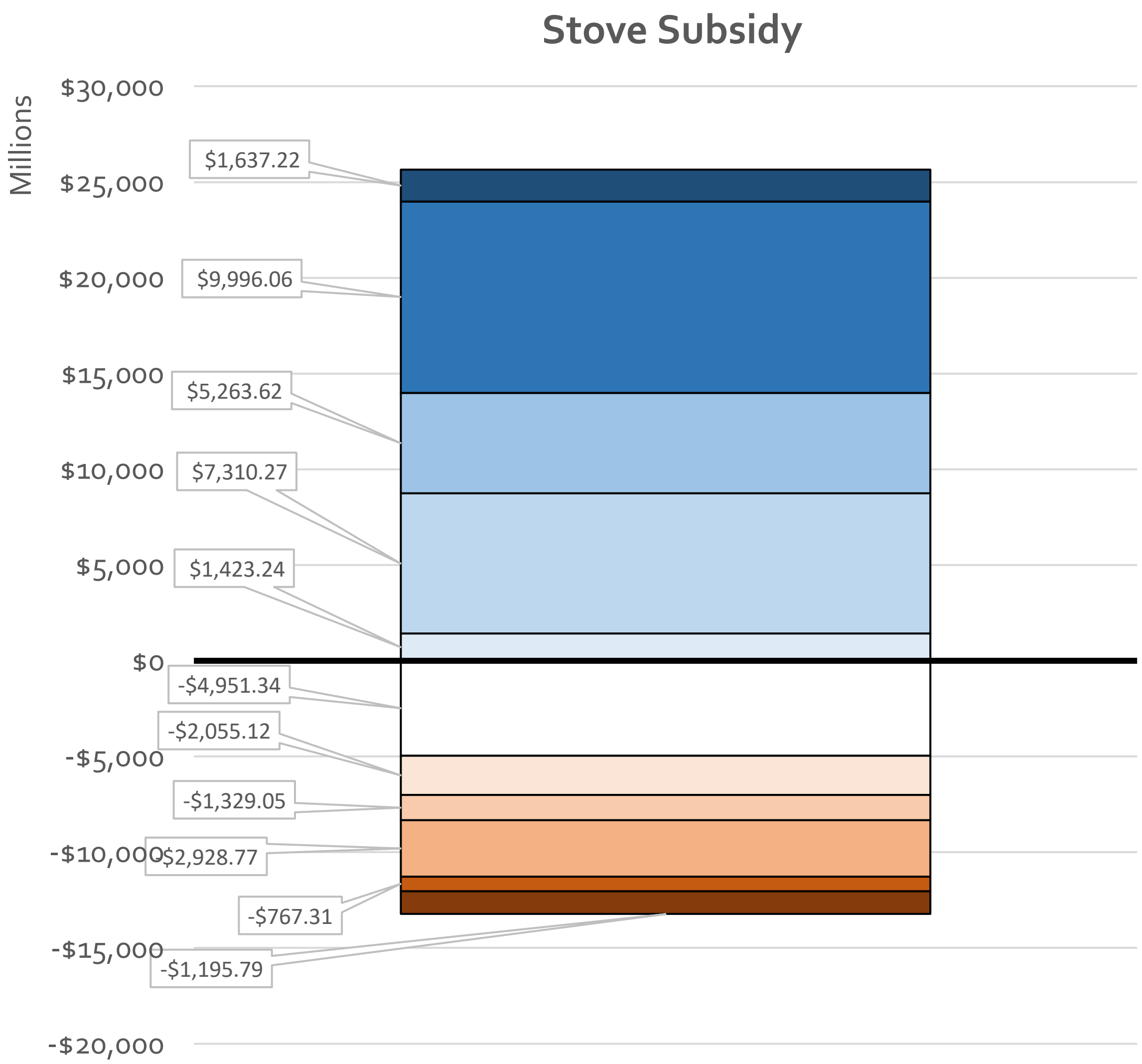
Stove Subsidy
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$15,000
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-$15,000
-$20,000
$1,637.22
$9,996.06
$5,263.62
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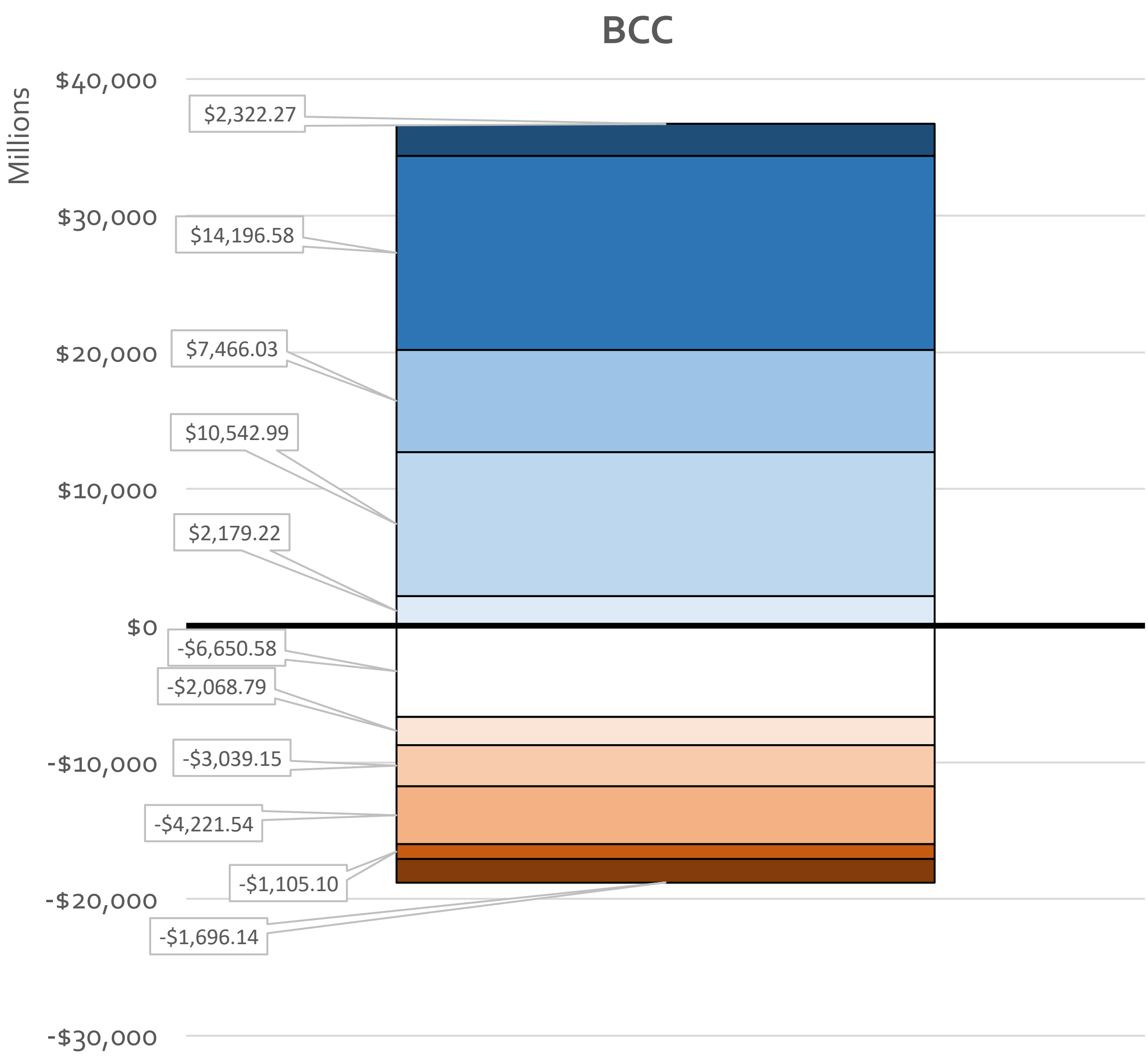
-$2,928.77
-$767.31
-$1,195.79


BCC
Millions
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$0
-$10,000
-$20,000
-$30,000
$2,322.27
$14,196.58
$7,466.03
$10,542.99
$2,179.22
-$6,650.58
-$2,068.79
-$3,039.15
-$4,221.54
-$1,105.10
-$1,696.14