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FREE AND OPEN SOURCE SOFTWARE AS GLOBAL PUBLIC GOODS?: WHAT ARE THE DISTORTIONS AND HOW DO WE ADDRESS THEM?

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Free and Open Source Software as Global Public Goods?: What are the Distortions and how do we Address Them?

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Abstract:
Increasingly, globally there is a trend towards supporting the adoption and use of free and open source based health information systems as a key component of health systems strengthening efforts. Conceptualized as a global public good, FOSS promises ideals of non-rivalry and non-exclusivity. However, these are normative ideals which can never be perfectly reached, as there are various knowledge, power and resource asymmetries between and across developer and use teams. This paper tries to identify the nature of these distortions, and how we may seek to address them.

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1. Introduction

Harbermas's (1981) "ideal speech situation" represents a level playing field in which people can engage in equal and reasoned dialogue as a basis for the practice of western democracy. However, given the inherent power asymmetries that exist between groups of people (due to gender, geography, age, resources distribution etc.), the ideal situation can at best only represent a normative ideal which can never practically be achieved. However, despite this constraint, the ideal speech situation can serve as an important analytical tool to empirically understand what are the "distortions" that hinder achieving this ideal state, and in trying to address them we can move closer to the ideal. Similarly, in this paper we argue that with respect to free and open source software (FOSS), the "global public good" (GPG) can serve as a normative ideal which is fraught with various distortions. Empirically, we need to identify these distortions and strategies to deal with them in order to inch a little closer to the desired ideal and leverage more effectively the potential offered by FOSS.

Our arena for analysis is the public health sector of developing countries, with a focus on India. Within this context, we examine the efforts to introduce and evolve FOSS based Health Information Systems (HIS), and analyze the challenges or distortions experienced, and some approaches to address them. This empirical analysis helps to zoom out and abstract learnings on how can FOSS be made available to the public health sector as a GPG, and enable governments to leverage its potential more fully in order to strengthen their health systems.

The rest of the paper is structured as follows. In the next section, we discuss the general characteristics of a GPG. In the following section we discuss Public Health as a GPG, followed by a presentation of the argument that a FOSS based HIS should be treated as a GPG. An example is provided then of the FOSS platform of DHIS2 (District Health Information Software – Version 2), currently considered as a de-facto global standard for HIS in developing countries, and being positioned as a GPG by various global actors. We conclude this paper with an analysis of the distortions in DHIS2 attaining the ideal status of a GPG, which we position as the "policy-practice gap", and how this may be addressed.

2. Understanding the nature of Global Public Goods

Global public goods (GPG) can include institutions, mechanisms, and outcomes that provide quasi universal benefits, covering more than one group of countries, several population groups, and extending to both current and future generations (Kaul, Grunberg and Stern 1999). One group or country's enjoyment of such a public good does not affect (or reduce) its enjoyment by others and once the good becomes available no country can be excluded from sharing its benefits (Samuelson 1954). Kaul et al. (1999) have underlined that people's well-being depends not only on the provision of public goods by national governments, but increasingly depends on provision of GPGs that only international cooperation can secure.

Public goods are those whose benefits cannot be confined to a single or a set of buyers, for example street names and a clean environment. The benefit of spending money to get a person educated, is not only confined to the first employer of the person, but also includes the various employers the person will have in his/her lifetime. The employed person pays taxes to the state, and this contributes to the development of roads and public

hospitals, which imply the benefits of investments in education spread, directly and indirectly, to the public at large. An interesting challenge for policy makers is how to ensure a more reliable provision of public goods in society. Such provision is often distorted by market failures. Society needs government to overcome these failures to achieve the efficiency and equity required in the allocation of resources. The private sector has inadequate incentives to supply goods that society needs for collective consumption, and tend to focus on the provision of private goods. Public goods include social security, health care provision, national parks and various others. In contemporary times, a public good necessarily needs to take on global dimensions, reflected in issues such as human security, global health, or the reduction of environmental pollution through climate change and ozone depletion. GPGs are global in scope, but necessarily subsume the national and levels below.

An archetypical example of a "pure" public good is traffic lights. Imagine a busy marketplace where there are many people, traffic, shops, with people moving around to do shopping. Without traffic lights, people and transport would be stuck in gridlock traffic or be unable to cross busy streets. Some might even have serious accidents on their way to the market. The provision of traffic lights then helps to benefit the public at large. Traffic light, seen as a public good, satisfies two key criteria. First, they are marked by a high degree of publicness, and that they are characterized by *nonrivalry* and *nonexclusivity*. One person's consumption or use of the traffic light does not rival the use of the same by another. If one person crosses the street using the traffic light, then it does not distract from the utility of the light to other persons. Also, it will be uneconomical and infeasible to restrict the use of the traffic light exclusively to just one person, making its benefits non-excludable, or if technically excludable, only at completely prohibitive costs. Second, the benefits are quasi universal across groups of people, social groups, geographies, and also generations. As more people obey traffic lights, its benefits to each individual grows. Frequent use indicates broad public acceptance of the light's role in regulating traffic flows. Without this broad acceptance, its utility will be low, and can even turn into disutility. The lights, their shared meaning, its use and the behavioral expectations they entail, together constitute a public good.

Global and national public goods have been an object of study in public policy for centuries. They are especially relevant in the context of furthering the global development agenda. Globalization entails growing interconnectedness through trade, migration, and travel which has exponentially increased the number of critical common challenges faced by all, including related to climate change and cross-border epidemics. While these challenges affect us all, those living in the poorest nations - with little or no personal savings, no social safety nets or government assistance programs to fall back on are the most vulnerable. The provision of GPGs then becomes a pre-requisite for furthering development and the reduction of poverty and inequality across and within countries. Birdsall and Diofasi (2015) estimate that out of the total official development assistance globally in 2012 of USD 133 billion, only about 14 billion was towards furthering global public goods. While these figures are constrained by poor reporting by donor agencies, it reflects the need for more efforts in this regard.

By definition, a GPG is aimed at the development of society at large, and depends of collective action for effective results. By its very nature, they also become open to free

riding and vulnerable to the failure of collective action (Olson 1965). There may be variations where GPGs may be "pure" or "impure" and provisioned through public, private and hybrid services. These challenge our conceptualizations of a GPG and need to be empirically examined in specific contexts. We do so in the context of public health and public health information systems in developing countries.

3. Public Health as Global Public Goods

History makes a strong case for public health to be treated as a GPG, especially relating to the provision of care for communicable diseases. The Athenian plague from 430 BC, the first recorded transnational epidemic, the European black death in 1347, successive waves of plague and cholera, the most recent being in 1990s in Latin America, the recent Ebola crises in various West African countries, and now the fast spreading Zika virus in Brazil and other Latin American countries, represent health challenges that affect multiple countries, and are not localized to a single location or country. Provision and control of these diseases are then arguably best provided within the framework of a GPG.

Undoubtedly, the control of communicable diseases can be treated as a GPG, but can the same be said for non-communicable diseases (NCDs) and injuries? Are these primarily private rather than public goods, coming through individual choices? The dividing line between public and private among these diseases was traditionally seen to be rather clear cut. Because of externalities, the treatment of communicable diseases was seen as a public good, but treatment of NCDs and injuries was seen as private as risk factors which were largely a function of individual choices relating to unhealthy diet, lack of exercise, consumption of tobacco or other unsafe habits. Because private choices have personal consequences, there is a correlation between individual risk and private burden of sickness.

However, with the intensification of globalization, the balance between a public and private goods is undoubtedly blurring. By compressing time and distance, globalization is fundamentally influencing the world economy, culture, spread of ideas, labor migration and cross-border travel influencing cultural habits, transmission of information, the growth of international trade and mass media. Rising global concerns around climate change and ozone layer depletion have direct implications on health. As a result, arguably the distinction between public and private is dramatically eroding. Furthermore, there is the emerging "third wave" of health threats – new infections, novel environmental threats, resistance to antibiotics and other diseases and behavioral pathologies. The blend of the new and resurgent older diseases is planetary in scope, and threatens all countries, rich and poor.

There is thus a strong argument to treat global health or public health systems strengthening, rather than the control of a set of transmissible diseases, as a GPG underlying characteristics of non-rivalry and non-exclusivity, with primarily a universal focus. This implies provision of care to one person, should not rival provision to the other, and include the public at large.

However, public health has particularities which need to be considered while analyzing how the concept of a GPG may be applicable. Woodward and Smith (2017) have argued that excludability and rivalry are relative and not absolute concepts, and subject to conditions of access and administrative control. As a result, it may be more relevant to

discuss the extent to which the good or service can be excludable or subject to rivalry. Some diseases may be more relevant to certain countries than others (for example, Malaria in India as contrasted to in Norway), or within particular population groups (women or children) and not the whole population, or to a certain point of time and not necessarily across generations. Malaria and diahorrea can thus be seen as "regional or national public goods" while HIV and TB exhibit characteristics of GPGs. Another important externality aspect to consider are the wider economic externality effects. While there may be some effects which appear essentially private, the cumulative effect on the national/regional economy of the resulting loss of production and income, and thus the potential gains from health improvements may be substantial.

In public health systems, therefore GPGs may be considered to exhibit a significant degree (not absolute) of publicness (i.e. non-excludability and non-rivalry) across national boundaries (and not necessarily population or generational boundaries). Woodward and Smith thus argue that *the core policy issue is one of ensuring collective action at the global level to facilitate the production of, and access to, goods which are largely non-excludable and non-rival in consumption, and yield significant external benefits, across multiple nations.*

Given this broad understanding of public health characteristics in relation to GPGs, we discuss next the role of health information in shaping its provision and access. Woodward and Smith have argued that often private goods are required to access GPGs, for example a private television may be required to access public broadcasts. Obtaining care within a GPG framework, may similarly require individuals to access information often through the use of software, which may or may not be fully or partially under private control. Our challenge then, which is the focus of this paper, is of how can these access goods (health information, the supporting software and infrastructure) be made to increasingly take on characteristics of a GPG, so as to reduce the challenges of excludability and rivalry.

4. Health Information and Supporting Software as "access goods" for GPGs

Knowledge is generated through health information, as it is put into effective practice. Knowledge, when not subject to patent and IP restrictions, can be seen to be nonrival and nonexclusive in nature, benefiting all once it is produced. Information about an epidemic in a particularly country or region will benefit other groups as it will allow them to take measures to protect their people and strengthen their required interventions. There are some caveats to this of course. Not all diseases are expected to strike all countries and regions, and thus there will be varying interests in taking action. Some countries will be better equipped to deal with some diseases than others, and so the interest in drawing upon help and helping others will also vary. Sometimes countries may have interest to withhold information from fear of sanctions, such as travel bans. Historically, many countries have been lukewarm in reporting on disease outbreaks to the WHO. These and more such issues distort the provision of care as a GPG.

Seen as access goods, health information and the underlying infrastructure to generate, disseminate and act upon it, play a key role in the provision of GPGs. The recognition of the fundamental role of information in public health goes back more than a hundred years. In 1897, countries attending the International Sanitary Conference recognized the need for international health surveillance. In 1903, countries adopted the International

Sanitary Convention, which called for the formation of a global organization which could monitor the international ecology of diseases, which subsequently led to the establishment of the World Health Organization (WHO) in 1948. The spread of the HIV virus and AIDS in the early eighties, and an increasing recognition of drug-resistant diseases, catalyzed countries and their politicians to strengthen their reporting systems and surveillance, and to emphasize information sharing.

Given the status and legitimacy WHO has amongst its member states, it plays a central role in advising countries on technical matters, including encouraging them to accurately report outbreaks through strengthened surveillance and other HISs. This strengthening requires collective action between state and non-state actors, including towards building capacities to report, validate, and actively act on information. In recent years, WHO has also been actively engaged with the supporting software systems and standards, and encourage the use of FOSS to help strengthen health information capabilities.

FOSS programs have licenses that allow users to freely run the program for any purpose, modify it as they want, and also to freely distribute copies of either the original or their own modified version. The concept of Free software was inspired by Richard Stallman, where free software is not to be 'free' as in 'free beer', but rather 'free' as in 'free speech.' Open Source Software was inspired by Linus Torvalds' LINUX. Free software and Open Source Software is used in combination as FOSS. While Free software represents a total philosophy, 'open source' is a practical solution to specific problems in software development. May (2006) argues that while there are many philosophical debates around these terms, what is important to note is that neither free nor open software is anti-capitalist, but are *differently* capitalist. While the free software community sees the role of property and markets as being acceptable outside software code, for open source developers, property and market methods are acceptable if chosen by developers, but not when imposed from outside.

Seen as an "access good", FOSS needs to be analyzed with respect to its *production and consumption* processes which determine who controls access, and how effectively is this access materialized. Also, since a HIS application may have multiple levels, it is important to analyze what aspect of it is a GPG or not. At the core is the platform on which the HIS is developed, and which is released under the FOSS license. Using this platform, the user can carry out different kinds of enhancements: a) add new functionalities by making changes in the source code; b) make particular customizations and configurations which do not involve any changes to the source code; c) develop third party Apps which link to the core platform through web API services. It is only the base platform and the subsequent source code modifications which can be treated as a GPG, while user specific customizations and configurations are in the domain of the user, and may or may not be treated as a GPG. Users would need to make significant investments in making customizations, building capacity, managing servers and support, and may want to treat these investments as exclusively belonging to them.

While production relates to the development of the core software platform, the continuing creation of new releases and patches, and providing the required technical support to users. The software code is hosted in public software repositories like Github, from where it can be downloaded by anyone and used for their respective purposes. In this way, the software is provided in a form that characterizes properties of non-rivalry and non-

exclusivity. If one person downloads the code it does not detract another person from doing the same. Further, the code is made available for universal use, and no one in principle is excluded from this. Those who download, then can "own" a bundle of rights around the code (modify, copy, run etc) which are more extensive than traditional proprietary license models. "Ownership" of the code is often a misleading binary term which reinforces a maximalist IP narrative – that code is like handbags, cars or shoes. Here instead we refer to a bundle of rights around the code.

On the consumption side, the situation is more complex, shaped by processes of administrative control, the capacities and infrastructures available, and also the choices made by the governing structures. In public health systems, typically the Ministry of Health (MoH) provides the governance structure, and they set up administrative control systems around procurement which shapes what software can be used or not. Determining access also depends on the in-house or support capacities existing in the MoH on downloading, customizing and troubleshooting the FOSS. The MoH in a particular country may download the code, and customize a particular application, but may choose whether or not to share it with others. While we could expect that an application customized by one particular department or health programme within the MoH should be made available to all other programmes and departments, however, this is not always the case. Code released under the General Public License (GPL) obliges the developers to put back to the repository all enhancements made to the code. However, some other FOSS licenses like BSD (Berkeley Software Distribution) don't carry such obligations, which may contribute to the "free rider" problems. These lead to exclusions and rivalries in this consumption process, detracting from the goals of a GPG.

Despite these particularities in the production and consumption processes around FOSS, there are some distinct relative advantages they provide over proprietary and licensed software.

1. Cost savings and avoidance of vendor lock-ins: FOSS applications are significantly cheaper than proprietary systems because of the absence of licensing costs. Many a HIS has failed in developing countries (Heeks 2006) because they have been developed on a proprietary platform, only modifiable by the vendor who owns the code. But the information needs of the health system are never frozen, and always evolving, which require the supporting HISs to also evolve to remain relevant. However, vendors often disappear after the initial delivery, and demand significant contractual modifications to make further required changes. The extra money, time and administrative effort required to break this vendor lock-in is often beyond the capacity and interest of the MoH, propelling the HIS to obsolescence and a slow death.
2. Proliferation of fragmented systems: For various technical and institutional reasons, including the non-sharing of data across systems, a health system is typically characterized by a multiplicity of systems, often also used for the same purpose. For example, in many countries, there are separate HISs used for reporting malaria data such as the routine reporting system, the disease surveillance system, and that of the vertical national malaria programme. Data on the same disease coming from multiple sources only confuses the decision maker of what is "true" while increasing the work burden of the data providers. The end

result is of information not being used for improving the disease situation in the country. Contributing to this situation is the fact that these different HISs are based on different (proprietary) platforms which restrict sharing of data, and this can be rectified through the use of FOSS platforms. Today, building integrated national systems based on FOSS is acknowledged as the single most important agenda of MoHs and global development partners (Sahay et al 2017).

3. Potential for building in-house capacity: Given that the user has the freedom to modify the code, they have the potential to build their capacity through a process of learning by doing. Such a possibility is not available in proprietary systems. Another enabling factor for capacity building is that since the Ministry is not paying exorbitant fees for software licenses – its procurement and maintenance, the funds saved can potentially be directed towards capacity strengthening efforts. Given that HIS are socio-technical and not merely technical systems, it is advisable in a project, that 10% of the costs are spent on the technology, while the remaining resources are spent on the human, organizational and implementation issues. Within a FOSS context, it is possible to reach this balance, as compared to the 90% which typically gets spent on technical systems with projects involving proprietary software.
4. Greater possibilities for the scaling and sustaining of systems: Many HIS projects in developing countries die as pilots, a phenomenon referred to as "*pilotits*" (Sahay et al 2017). HIS applications necessarily need to have properties of scalability and sustainability to be effective. While scalability refers to the ability of the system to be spread over time and space, sustainability refers to the endurability of the application in the absence of external support. The lack of scalability of systems directly and adversely affects the sustainability of systems, as data is required from the entire catchment population and not isolated pilot sites. A FOSS based system, because of the absence of licensing costs enables scaling and sustainability issues.

Arguably, FOSS has the potential of removing some of the distortions in enabling more effective access to health information which potentially can help strengthen public health systems. Empirically, how FOSS has helped address access to GPGs, what problems exist to the fuller realization of their potential, is discussed in the next section.

5. FOSS experiences for development

There are various FOSS based platforms for HIS in use in various developing countries. Prominent in them include the District Health Information Software Version 2 (DHIS2) being used in nearly 60 countries, the OpenMRS (Open Medical Record System) being used as an Electronic Medical Record (EMR) in various contexts, and the iHRIS (Integrated Human Resources System) used for health workforce management. We discuss the example of DHIS2 to critically examine the effectiveness of FOSS as an access good to GPGs.

5.1 DHIS2 Globally

The growth and impact of DHIS2 (see dhis2.org) globally has been significant, making it a defacto standard for HIS development representing the largest global footprint in terms of national HIS. DHIS2 is a product of the Health Information System Program (HISP)

research and development movement initiated in 1994 by researchers from the University of Oslo (UiO) and collaborating partners in South Africa. DHIS2 is a platform upon which governments and MoHs are relying upon for analysis, decision-making and investment in the tracking, managing and prevention of disease and pandemics, and for monitoring and evaluation support. The significant access which DHIS2 has enabled globally to strengthen HIS can be largely attributed to two key aspects. The first is the design of the core platform and its supporting resources based on principles of a *platform*. The second relates to its governance strategy based on *networks of action*.

Platform based principles of design: In simple terms, platform principles underlie the idea of "build once, use multiple times." A platform can thus be considered anything you can build upon, enabling the ability to do other things that were not originally envisaged. This makes a platform different from a software product which is designed to support specific purposes. Platform can then be thought about as structures that allow multiple products to be built upon using the same technical framework (Tiwana, 2012). A popular example of a platform is Facebook which can be seen as a software product, an App and also a platform. A user can log into it online, use it as a web service, or download it to your device and log into a connected App, and build other features.

DHIS2 can be perceived as a platform on several levels (Braa and Sahay, 2013; dhis2.org), allowing it to be adapted to a multitude of local contexts and use cases. For example, data structures such as data elements, organisation units, forms and user roles can be defined completely freely through the application user interface without the need for core programming. As a result, DHIS2 supports most major requirements for routine data capture and analysis emerging in a country, while also supporting specific management functions such as logistics and human resources. DHIS2 has a modular design, allowing it to be extended with additional software modules, which can coexist with the core DHIS2 and integrated into common portals with additional functionality required to meet country specific requirements. Through Web API (Application Programming Interface) services, other software products can access and retrieve the full list of data elements and forms in standard formats in DHIS2 and build upon them. This feature allows third-party developers to develop software without knowing the DHIS2 specific technology and design constraints.

These platform based characteristics, supporting both aggregate and individual based data systems, coupled with its free and open source licensing, has evolved DHIS2 into the defacto global standard for building HIS across different countries and organization types such as MoH, global donors, and international NGOs (see dhis2.org to view its global impacts). Recognizing this potential for global impact, a consortium of international partners such as NORAD, UNICEF, PEPFAR, WHO and others are now jointly supporting the development, implementation and further evolution of the core platform and its supporting resources (for example, training materials and user guides) as a GPG that can be more easily adopted by MoHs across the world. This is enabled through the lower TCO (Total Cost of Ownership) because there are no licensing restrictions as compared to proprietary software. Further, key functionalities required by MoHs have in some way already been included in the core or as Apps, which can be customized for local needs without having to reinventing the wheel.

Supporting in-country implementations are regional HISP nodes (for example, in India, Vietnam, Bangladesh, South Africa, West Africa etc.) who collaborate with Oslo in a network structure. The HISP network has grown over the last two decades, involving a diverse and heterogeneous group of entities including Universities, MoHs, NGOs, social entrepreneurs, individual consultants, and others. The network is built largely on principles of reciprocity, where individual members draw upon the collective good of DHIS2 and associated resources and, in turn, contribute with their individual experiences and technical enhancements. These regional entities run capacity building programmes based on a training of trainers' approach, where trainers can further support implementation in their respective countries. Resource materials for these Academies are developed using this platform approach, emphasizing its reused across these events in different parts of the world. Local entities, based on feedback received in the Academies, add value and further embellish the material and may contribute by providing local translations.

Governance through networks of action: Governance mechanism used in HISP has consciously tried to promote the principle of building for and in one place, and have that used in multiple places. This approach has been termed as the networks of action approach (Braa et al. 2004). A powerful principle underlying this approach is that we learn more effectively in collectives than as isolated entities, and governance seeks to enable network connections, such that learning can take place in collectives and be shared across the entities in the network.

The University of Oslo coordinates the HISP network enabling collective learning by facilitating actions such as the circulation of people, money, implementation experiences, products and resources across the network. The network entities based on their own proactivity and competencies, based on principles of reciprocity, draw upon resources available through the network, and contribute with new resources, thus also fueling innovation. The network entities further enrol local groups (e.g. universities and NGOs) leading to the creation of "networks of networks" making the overall network more robust and expand the value of DHIS2 as an access good to GPGs. This status and acceptance of DHIS2 as a GPG is not something that has been conferred from the "top" but is something that has been earned, through more than 2 decades of solid and intensive work on the ground, building trust with MoHs, based on an ideology and practice characterizing GPGs.

While the above discussion has highlighted the production side principles of DHIS2, in the next section through the example of DHIS2 adoption in India, we highlight some of the consumption side dynamics.

5.2 DHIS2 in India

DHIS2 was born in Kerala, India in 2006, collaboratively developed by the Oslo technical team and developers from HISP India. The initial application was deployed in one clinic in the state, and there was an ongoing continuous process of getting feedback in use by health practitioners, making technical enhancements by the development team, which led to the State government of Kerala adopting DHIS2 as a state-wide system in 2007, and this status has continued till today. Seeing the evolution of DHIS2 in Kerala, state governments of Gujarat, and then Jharkhand and Madhya Pradesh invited HISP

India to initiate DHIS2 implementation efforts in their respective states. These processes were initiated with mixed results.

In 2008, under the National Rural Health Mission (NRHM) framework, the National Health Systems Resource Centre (NHSRC) collaborated with HISP India as their technical partner during the process of redesign of the national HIS. HISP India, based on their experiences of working in various states, presented a situation assessment of the strengths and weaknesses of existing HIS which provided useful inputs to the national HIS redesign process. NRHM in October 2008, issued instructions to states to adopt new formats, and suggested states could use DHIS2 as a state portal, which could interoperate with the MoH national web portal.

There were ongoing tensions for states to work with two systems – DHIS2 and the national web portal – and over time many states disbanded the use of DHIS2. Despite about 20+ states adopting DHIS2 in the period from 2008-2011, today only about 8 states use DHIS2. These states have continued with DHIS2 despite the MoH directives to use only the national portal, for the following advantage it provides to them:

1. For the state, the base platform is without cost, and they pay minimal costs to HISP India (less than USD 500 a month) for ongoing routine maintenance of the HIS and its support. Outside routine support, if states require larger customizations and development, these are costed additionally based on pre-agreed rates. States pay only for the human resources time required for customization, support and training, and no licensing costs are involved.
2. The states use the DHIS2 as a state data warehouse, where all their health program data is entered, from which reports required for the MoH portal are generated and uploaded into the national portal through an Excel export functionality. Since states use more data for programme management than what they need to report to the national level, the DHIS2 helps to provide them with this flexibility.
3. Since states own the code and the freedom to modify it, they have the flexibility to a) Add new data elements, indicators, reports, data validation rules etc; b) Incorporate GIS analysis based on open source GIS module inbuilt in DHIS2; and c) Create new functionalities and modules as required for different programmes in the same platform.
4. DHIS2 provides strong analytical functionalities, and easy to use dashboards which States use to analyze data quality and view their indicators by charts, graphs, tables, and maps to help aid evidence based decision making. Analysis and use of data is easily decentralized to the district and levels below.
5. DHIS2 provides open APIs to enable integration with other systems and other data entry devices such as mobile phones. Support for offline entry also makes DHIS2 an attractive option to use in areas of weak internet connectivity.
6. The states choose options for server hosting which include in-house or third party data centres or private clouds. HISP India supports some of these hosting options by managing the application, while the hosting services provider supports the

infrastructure. Non Disclosure Agreements are created with the states, and states own their data without ambiguity.

7. The new versions and modules developed by the Global DHIS2 community are made available to the states without cost. Similarly, learnings and developments from DHIS2 in India are shared with the global community.

Some learnings from more than a decade of experience of supporting DHIS2 in states include:

1. States need to build stronger in-house capacity to do at least the routine management and extensions to DHIS2 to become more self-reliant.
2. States need to strengthen capacity to analyze and use information, to take full advantages of the functionalities in offer.
3. Governance systems for the overall HIS in a state needs to be formalized to make explicit the relationship between different systems and strategies for data sharing.
4. States need to adequately budget for long-term adoption and evolution of the platform.
5. Networking between states can be strengthened to enable collective learning.

While there are some characteristics of a GPG inscribed in the manner in which DHIS2 is used in India, still lots more need to be done to make it an effective access good for GPG. In the next section, we discuss some of the existing gaps and how may they be addressed.

6. Some policy-practice gaps relating to FOSS as a GPG

In trying to understand policy-practice gaps, we draw upon learning from more than 2 decades of research in information systems has taught us that “airplanes don’t fly, airlines do”. The implication of this statement is that technology on its own can do little, and for it to be effective it requires complex socio-technical elements such as policies, institutions, people and capacities, histories, infrastructures, practices and other things to come together in a seamless manner. In the context of this workshop, a key implication is that a policy, which focuses only on the FOSS artefact, will undoubtedly fail, as many more things are needed to be in place to enable effective use of FOSS as a GPG. To understand what these “many other things” which needs to be in place are, the perspective of a GPG is arguably relevant, so are the policy-practice gaps in attaining this normative ideal.

With this background, we identify below the following 6 key policy-practice gaps: i) the knowledge gap: ii) the governance gap: iii) the procurement gap; iv) the participation gap; v) the capacity gap; and, vi) the financial gap. These are now briefly discussed.

1. *The knowledge gap:* The knowledge involved is not uni-disciplinary relating only to computers but is multi-disciplinary involving informatics, public health, implementation research and various others. This requires various institutions and experts to be engaged with the FOSS development and use efforts. This is not easy to mobilize in practice, leading to the creation of a knowledge gap. This gap gets also enhanced because of the uneven knowledge which exists across and within countries. If the core development of the FOSS platform is centralized in the West, national users in developing countries face knowledge and

infrastructure constraints in getting their core requirements met, and may contribute to dependencies.

2. *The governance gap:* Governing GPG based solutions is a complex task, as it involves bringing people together from different countries, disciplines, and health programmes representing a variety of interests, sometimes conflicting. Mechanisms of governance need to be established that can give all relevant stakeholders a voice in the process of how choices are made and implemented. This is of course a political process, where certain stakeholders have more power and resources than others, leading to the creation of a governance gap. There are then issues of logistics of how such multi-stakeholder participants can be got together on a single platform, given the very busy schedules that people have in contemporary life.
3. *The procurement gap:* Government systems have historically procured software based on tenders which pre-specify requirements, and which tend to be biased towards large and commercial firms. Organizations dealing with FOSS solutions, typically smaller NGOs and university departments tend to get excluded. Governments often have limited experience in procuring FOSS based systems, where requirements are not necessarily fully pre-specified, and requires them to evolve through a collaboration between developers and users. Often there is a misconception of government that FOSS means that the whole system development is completely free of charge. However, this can never be the case, as it is only the license fees which are not relevant, but other costs of configuration, capacity development and support are to be borne as in any other system development process. There is thus a procurement gap in relation to FOSS.
4. *The participation gap:* Participation is required at various stages of the system development process from the articulation of requirements, ensuring these are taken in the development roadmap, engagement in prototyping, and various other components. For all to be able to participate, they need the opportunities and the capacity to do so. These become difficult given the time and space separation of the developers and users, the knowledge and the capacity gaps that also exist. In light of this gap, the risk gets created of the development process being driven by the technical people, and the required contextualized knowledge being increasingly marginalized.
5. *The capacity gap:* The capacity gap relates to both the technical systems, and also the ability of the users to use the information being generated for improving health action. In light of this capacity gap, there are handicaps that teams in developing countries face in mastering the technology and evolving it to meet their evolving requirements. There are then dependencies created between these developing country users and the central development team responsible for the core, with financial constraints hindering accessing to the required support.
6. *The financial gap:* Often users believe FOSS based HIS are completely free of cost, implying they also don't need to budget for customization, capacity strengthening, server hosting and management and various others. For example FOSS might well be free, but hosting web based systems on servers and/or

> entering into support contracts is not. So, simple cost arguments for FOSS are sometimes disingenuous. Frequently it is cheaper, but the benefits lie elsewhere. That at least is a case which needs to be made. Being unable to determine the Total Cost of Ownership (TCO) of a FOSS based HIS and provisioning for this in the planning phase leads to significant financial gaps, and also a breakdown of trust between the government and the FOSS providers.

These gaps discussed are inter-related, and one issue influences the other. The capacity gap would adversely influence the participation gap, which in the broader context hinders their ability to access the FOSS application, and direct it towards meeting their local needs. These and other relevant gaps need to be addressed both at the levels of policy and practice.

7. Conclusions

We have discussed FOSS based HIS as an access good for GPG which itself needs to take on GPG characteristics to be effective. A GPG is seen to include the good itself, their shared meaning, its use and the behavioral expectations they entail. A *core policy issue is one of ensuring collective action at the global level to facilitate the production of, and access to, goods which are largely non-excludable and non-rival in consumption, and yield significant external benefits, across multiple nations.* The successful example of DHIS2 as a GPG illustrates two key characteristics – one, is design based on principles of platform, and two, is a governance strategy that enables platform principles in design and practice. These principles have to be mobilized both on the production and consumption side of the GPG. There are at least 6 policy-practice gaps that we have identified to move closer to the normative ideal of a GPG, which countries and health programmes will need to address with context-specific strategies.

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