Causal chain mapping: a novel method to analyse treatment compliance decisions relating to lymphatic filariasis elimination in Alor, Indonesia

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Many public health programmes require individuals to comply with particular behaviours that are novel to them, for example, acquiring new eating habits, accepting immunizations or taking a new medication. In particular, mass drug administration programmes only work to reduce the prevalence of a disease if significant proportions of the target population take the drug in question. In such cases, knowledge of the factors most likely to lead to high levels of compliance is crucial to the programme’s success. Existing models of compliance tend to either address interpersonal, organizational or psychological causes independently. Here, the authors present a formal method for analysing relevant factors in the situational context of the compliant behaviour, identifying how these factors may interact within the individual. This method was developed from semantic network analysis, augmented to include environmental and demographic variables to show causal linkages—hence the name ‘causal chain mapping’. The ability of this method to provide significant insight into the actual behaviour of individuals is demonstrated with examples from a mass drug administration for lymphatic filariasis in Alor District, Indonesia. The use of this method is likely to help identify key components influencing compliance, and thus make any public health programme reliant on the adoption of novel behaviours more effective.

Keywords Decision-making, mapping, compliance, Indonesia, mass drug administration, lymphatic filariasis, disease control

KEY MESSAGES

• ‘Causal chain mapping’ is a formal system for analysing relevant factors in the situational context of an individual’s compliant behaviour, providing a way to explore how these factors may interact within the individual.

• Examples from a mass drug administration (MDA) for lymphatic filariasis (LF) in Alor District, Indonesia are used to demonstrate the method’s ability to provide insight into individual behaviour.

• Within this context, a key pattern arising is the strong presence of non-health-related factors influencing people’s decision-making processes (e.g. compliance with LF treatment), namely norms, respect for authority, personal values and protection of family and peers.

• Use of this method is likely to help identify key components influencing compliance, and thus make any public health programme reliant on the adoption of novel behaviours more effective.
## Introduction

Many public health programmes require individuals to comply with particular behaviours suggested by external authorities such as doctors or public health officials. For example, patients may be recommended to acquire new eating habits, stop smoking, accept immunizations or take a regimen of medications to alleviate a medical problem. In some cases, the effectiveness of a programme depends on many people adopting the advice of these authorities. Mass drug administration (MDA) programmes in particular require a significant proportion of a population to comply with a suggested treatment. In such cases, knowledge of the factors most likely to lead to high levels of compliance can be crucial to the programme’s overall success. Finding out why people accept or reject the recommended course of behaviour is therefore a necessary component of effective programme design.

Existing models of compliance with MDA programmes for lymphatic filariasis (LF) tend to emphasize interpersonal variation (gender, socio-economic status, education), psychological factors (beliefs, attitudes) or organizational features (knowledge of drug distributor, time of distribution) as influencing treatment decisions. For example, Babu and Kar emphasized the organizational causes that might affect the coverage of, and compliance with, LF treatment in southern India. Factors considered related to health services and community organization (Babu and Kar 2004). Mathieu et al. described psychological factors, specifically that knowledge of transmission via mosquitoes and knowledge about MDA acquired through exposure to mass media were associated with compliance in Haiti (Mathieu et al. 2004). Education level has also been shown to have an influence on compliance (Kasturiratne et al. 2001). Organizational problems such as ignorance about LF treatment programmes have likewise been associated with compliance (Talbot et al. 2008). One study has combined both psychological and interpersonal effects, finding that when adjusted for all other factors, only the type of population (rural and urban), gender and belief that the MDA programme is beneficial were associated with influencing drug compliance (Gunawardena et al. 2007).

Nevertheless, in any one person, factors relating to his or her decision to comply may interact, depending on their personal experiences, beliefs, values and attitudes as well as external forces such as environment or other individuals. Indeed, taking a pill during a mass drug administration event is highly situational—a decision based on the individual’s psychological and demographic traits, and the context of administration (i.e. whether public or in-house, directed by external authorities or local public health workers or family members). None of the existing models in the LF mass compliance literature discusses the interaction of these features and how they might combine to influence compliance; and no study, to date, has combined these potential causes into a single approach.

In order to understand better how these variables interact to guide decision-making, a novel technique was specifically developed for this purpose: ‘causal chain maps’. This technique allows an individual’s decision-making process to be visually displayed for synthesis and easier interpretation. Causal chain maps are based on semantic network analysis (Findler 1979; D’Andrade 1995), a technique for analysing texts that infers cognitive associations between concepts from the primary data, but here applied to the case of causal networks (Riegel 1976) or procedures (Levesque and Mylopoulos 1979) for behavioural decision-making. These associations are then represented in a network graphic in which nodes in the network represent concepts, while the links connecting the nodes represent the type of the association between them (Sowa 2000). This structure is presumed to mirror the way in which knowledge is represented in long-term memory (Schank and Abelson 1977). Comparison of these structures across individuals provides insight into the similarities and differences in relevant knowledge and attitudes (Carley 1993).

Semantic network analysis has been extended in the causal chain maps from modelling psychological variables to include situational and behavioural variables—in particular, the environmental aspects of the situation when the decision is made (prevalence of disease, method of distribution, persons involved in the MDA) as well as the behavioural outcome of the psychological process (e.g. compliance with the medical advice or not). This general flow of causation—from environmental factors to personally defining features to psychological constructs to behaviour—is common to many current models of behaviour determination, especially the dominant class of health promotion models based on expectancy value theory (e.g. the health belief model (Strecher and Rosenstock 1997), theory of planned behaviour (Ajzen and Fishbein 1980) and social cognitive theory (Bandura 1986)).

This paper suggests that causal chain maps can be generally applied to most decisions about compliance in public health programmes, but a particularly important category is MDA programmes, which only work to reduce the prevalence of a disease if significant proportions of the target population participate. The utility of causal chain maps will be demonstrated using a case study from the elimination of lymphatic filariasis (LF) in Alor District, Indonesia, where MDA began in 2002 and continued every year until 2007. It is thought that treating between 75–80% of the total population living in a LF endemic area, excluding pregnant women and children under 2 years (Ottesen 2000), for a period of 4–6 years is sufficient for elimination of LF (Ottesen et al. 1997; Babu and Satyanarayana 2003).

We use the causal chain map methodology to analyse a selection of in-depth interviews from Alor District to show the maps’ ability to illustrate the interaction among influencing factors, as well as to predict an individual’s compliance outcome. The paper concludes with some remarks concerning the general applicability and advantages of using this method for understanding the causes of compliance with medical regimens.

## Causal chain mapping

### Data collection aspects

Causal chain mapping is a technique to assist researchers to better understand the situational (e.g. the mode of provision of the medication), environmental (e.g. disease prevalence) and psychological (e.g. emotion, values, beliefs) causes of medical compliance. As such, it requires researchers to collect information on a wide range of aspects of the treatment situation.
These data can be collected through a variety of methods, ranging from standard questionnaire responses to in-depth and projective techniques. To be more salient, data collection procedures should refer explicitly to particular circumstances, such as the doctor’s visit or the MDA process, as well as to the individual’s personal characteristics.

Analysis aspects

A causal chain map is the end product of several stages of analysis. The first stage includes the analysis of the primary data, such as quantitative analysis of a questionnaire or the identification of themes and patterns in qualitative data. The present project used Framework, a matrix developing method for ordering, synthesizing and analysing the data (Ritchie et al. 2003). Framework requires that the researcher organize the emerging themes from the individualized data into a detailed matrix that provides an opportunity for analysis by theme (vertically) or by individual (horizontally) (Ritchie et al. 2003).

The second stage of analysis, on which this paper focuses, involves the production of a causal chain map for each individual. These maps are graphical devices that represent the various factors influencing the decision to comply with an MDA campaign. While the exact components of the map will depend on the researcher’s own agenda and experience, we suggest that it have the following features at minimum (see Figure 1): representations of the external social world; the disease environment; the event itself (in this case MDA); the individual’s personal characteristics; various psychological traits (e.g. knowledge about the disease, beliefs and values, and personal experience with disease treatment), as well as the outcome (in this case compliance with LF treatment or not). The personal characteristics outlined in the maps [age, gender, education and living environment (rural/urban)] arose from the hypotheses of what may have had an influence on compliance with LF treatment. The psychological traits included should preferably reflect the theoretical constructs of some standard health psychological approaches (Michie et al. 2005) to lend the method internal consistency and comparability to other studies. These aspects of the MDA situation are arranged topographically in such a way as to reflect an input–output analysis in which situational aspects of the event are presented as inputs at the top of the graphic, manipulated by the individual’s psychological processes in the middle of the map, with the output at the bottom being a decision about behavioural compliance.

For the implementation of this tool, clusters of themes are represented in specific locations on the map (see Figure 1). In the upper left-hand corner, there is a hexagon for level of disease prevalence in the area. The top centre of the diagram contains a description of the MDA event (namely the method of distribution). In the upper right-hand corner, a cluster of boxes represents the individual’s relevant social world: family, neighbours, community and religious leaders and health staff. In the centre of the map, an oblong oval contains the respondent’s own characteristics: current health status, education, occupation, age and gender. The cluster of themes on the left entitled ‘knowledge about LF’ relates to cause and transmission, prevention, drugs and biomedicine and traditional medicine. Note that ‘knowledge’, as used here, refers to everything the individual knows or believes about the disease and its treatment; rather than biomedical knowledge specifically (Pelto and Pelto 1997). The middle cluster, ‘beliefs about society’, contains those responses relating to norms, reputation, authority and social roles (including gender). The cluster on the right contains categories relating to the respondent’s ‘personal experience’ with LF treatment, side effects and the health system. These experiences can be the respondent’s own, those they observed personally or those that they have heard about. Note that the psychological traits shown in Figure 1 reflect the kinds of themes that emerged from the first phase of analysis of our case study (described in detail later). However, these are indicative of the kinds of themes or factors that can be considered by other users of this method; they are not required.

At the bottom of the causal map is a long square concerned with ‘values’, namely priority of health, fear/uncertainty, respect, economics (value of money), acceptance/fatalism and moral judgment on behaviour. This list of values is not exhaustive; however these are the specific values that arose out of the interviews conducted for the project in Alor district.

Finally, the oval at the bottom called ‘compliance’ refers to the outcome of the map—in this case, the act of taking the treatment.

Once the conceptual map of the decision-making process has been drawn based on the themes that arise from the Phase 1 analysis of the primary data, then this basic map requires ‘filling in’ for each respondent, based on data available about their own psychological make-up and situation (e.g. from interview data). During the filling-in process, a line is drawn between boxes in the diagram if the respondent made an explicit statement linking two or more of the concepts, values or behaviours. Two types of lines are used in the causal chain maps: those that concern perceived factors affecting compliance (represented by solid lines) and the individual’s personal reasons for compliance or non-compliance (represented by dotted lines). In order to be drawn as a dotted line, the statement must, first, represent the individual’s personal reasons for compliance, and second, be part of a ‘complete’ causal link leading from either the ‘external’ variables about the situation (MDA event, prevalence of disease) or the individual’s personal characteristics, through the map to the decision of compliance. As a result, dotted lines are able to provide an explanation of the individual’s psychological process from the stimulus of the distribution event to their response in terms of compliance. These sets of dotted lines are called ‘causal chains’ and are likely to include the factors that effectively constrain the individual’s decision-making process and determine their behaviour.

Both the dotted and solid lines linking specific factors to the compliance oval on the map have associated plus (+) or minus (−) signs, depending on their expected positive or negative effect on compliance, as determined by the researcher from the corpus of data from the respondent, as well as the situational logic of the final link in the chain (e.g. the researcher asks if the factor is compliance promoting or avoiding). However, only the dotted lines represent causal efficacy for the individual in question, and therefore only the causal chains are added together to predict that individual’s compliance behaviour.
(a balance of positives indicating likely compliance; a balance of negatives suggesting non-compliance).

To illustrate the process of assigning values to a chain, we suggest two examples. If an individual said ‘people were afraid to come for treatment because of side effects’ a solid line would be drawn from experience with side effects to fear to compliance; a minus (−) sign would be attached to the line, as the statement represents a negative influence on compliance. This line symbolizes an individual’s opinion about what influences compliance in his/her community. If another individual said, ‘I swallowed the pills because I am well now and I cannot afford to get sick and miss work’ then a dotted line would be drawn from personal health to economics to compliance with an associated plus (+) sign demonstrating the positive effect on compliance.

It is important to note that all connections are made only from the respondents’ comments that explicitly link a belief or other factor to compliance, so the mapping process minimizes the degree of interpretation about the meaning of the respondent’s statements on the part of the researcher.

The summed total of positive and negative values of the terminal causal chain links to compliance predicts with high probability the behaviour that was actually reported. It should be emphasized again that the data itself determines how lines are drawn, so the predictive quality of the maps is an emergent feature of the method.

For the analysis of the maps, first a visual comparison of the maps was conducted to make initial observations. Second, in order to describe the phenomena represented by the maps, the lines were counted to reveal which complete causal chains were most responsible for thinking on compliance. Finally, composite maps were made to represent these findings.

To demonstrate the utility of this method, we continue by describing a case study of MDA to eliminate LF in Alor District, Indonesia.

**Case study: LF in Alor District, Indonesia**

In 1998, the Global Programme for the Elimination of Lymphatic Filariasis (GPELF) was launched combining the efforts of international research institutions, pharmaceutical companies and national health ministries with the specific goal of eliminating LF as a public health concern by 2020 (World Health Assembly Resolution 50.29) (WHO 2004).
The elimination of LF (in areas where loiasis and onchocerciasis are not co-endemic) depends on the participation of endemic communities worldwide in consuming one or two drugs (Diethylcarbamazine and Albendazole) in an annual MDA for the duration of 4 to 6 years (Ottesen et al. 1997; Babu and Satyanarayana 2003). Prior to MDA, LF carriers may not know their infection status. Furthermore, testing and diagnosis are not a pre-requisite for consumption of the drugs. Commonly cited barriers to achieving compliance with MDA are the difficulty of achieving and maintaining a sufficient coverage rate and a declining coverage rate due to initial adverse reactions to the medication (Evans et al. 2001; Sunish et al. 2003). Challenges to LF elimination include: (1) convincing asymptomatic persons to comply; (2) maintaining high levels of compliance; and (3) managing adverse reactions.

GPELF has called for increased research on individual motivations. In 2004, the international LF research community recommended that investigation into factors affecting compliance is an immediate need and listed it as part of a global strategic research plan (Malecela-Lazaro and Twum-Danso 2004). By creating and using a novel technique to analyse how different themes interact in an individual, this paper proposes to simplify the analysis process whilst illuminating the reasons people report for compliance or non-compliance with MDA to eliminate LF.

The research site: Alor District

Alor is a small district with 13 islands in Nusa Tenggara Timur province in eastern Indonesia with a population of 168,965 in 2003 (Alorese Bureau of Statistics). There are two types of LF present in Alor District, Brugia timori and Wuchereria bancrofti. A survey in a highland area of Alor in 2002 showed a standardized population prevalence of 25% of microfilaria (mf) carriers (for B. timori) (Supali et al. 2002). The highest prevalence of mf positive persons was in men and women aged 40–50 years (50% men and 38% women) (Supali et al. 2002).

Data collection methodology

A quantitative survey was carried out in November 2004 in Alor District in order to identify the knowledge, attitudes and behaviour (KAP) of the population towards LF and its treatment after 3 years of MDA participation (unpublished data from the author AK). The results of that study showed that there were reported influences on compliance that were not related to knowledge about the disease or its transmission, or understanding of treatment efficacy. In order to understand further these stated influences, as well as to uncover other possible motivations, a series of 43 in-depth interviews were carried out in Alor District in November 2005.

The sampling strategy used for the in-depth interviews was purposive quota sampling. Equal quantities of respondents were sought for each of these factors: living in a high or no prevalence area, and being a (prior) complier or non-complier. The interviewers attempted to reach a gender balance in the sample size. Finally, the purposive sample included equal numbers of persons from rural and urban areas.

An unscheduled, unstructured topic guide was designed for the interview. All interviews were carried out in Indonesian by the author (AK), who had previously worked in Alor, accompanied by an Indonesian social scientist who provided assistance on translation and issues of clarity. Interviews were taped in accordance with permission granted by the respondent. Complete transcriptions of all interviews were produced by the author (AK) and two research assistants.

Ethical approval to conduct the study was obtained from the ethical review committee of the London School of Hygiene and Tropical Medicine and by the National Institute of Health and Development Research at the Indonesian Department of Health. All respondents signed an informed consent form and were given an information sheet concerning the specifics of the study as well as addresses to contact if more information was required. According to Indonesian ethical requirements, each respondent was given a towel and a bar of soap as a token of appreciation.

For the purposes of the causal chain maps, the authors analysed 21 interviews and developed individual maps for each one. These 21 individuals were selected randomly from the total sample according to the same selection criteria as the larger sample. The first author used interview transcripts to produce a framework-based matrix of each interview. From this, the two authors independently reviewed the matrix data and each drew maps for comparison. Inter-rater reliability between the two researchers was high in all cases, e.g. both researchers independently devised similar maps from the same data. If a discrepancy was identified between the two maps, a final map was agreed through discussion, with reference to the original transcripts concerning any points of disagreement.

Causal chain mapping analysis: three examples

Three maps have been selected to demonstrate how causal chain maps represent the interaction of different factors and how they influence an individual’s decision on compliance. These narratives are descriptions of the diagrams themselves, reflecting the interview material and the crucial statements that support the complete causal chains revealed in the diagrams. These three maps were chosen as they represent the three behaviours found in the data: compliance, non-compliance and a combination of both compliance and non-compliance.

A non-complying man from the district capital

The first map is for a 57-year-old non-complying man living in the district capital (Figure 2). He is a retired teacher with six children. He offered four positive influences on compliance (solid lines) and demonstrated his understanding of the need for good compliance in the community. He reported that everyone had to take the medication and if one person did not want to take it, then the disease could transmit; so it was better if everyone took it (illustrated by the solid lines from norms to compliance and from LF cause/transmission to compliance). He stated that if the programme was from the government, then he had to accept it, as it must be for public health (illustrated by the solid line from authority to compliance). With these statements he demonstrated his knowledge of the disease and the MDA, the influence of the social norm to conform to treatment taking and the authority of the government programme to command compliance.
He mentioned one negative comment about the LF drugs: they were chemically manufactured and therefore contained chemicals, the effect of which on his body he was unsure of (illustrated by the solid line from drugs to fear/uncertainty to compliance).

With regards to the LF treatment, he reported taking the medication the first year of the MDA when the health staff brought it to him. When his wife brought home the drug the year of the interview, he refused it. For him, traditional medicine and LF medicine had the same use—to prevent disease and keep him healthy. He planned to continue using traditional medicine so that he would not get sick from LF (illustrated by the dotted line from personal health to traditional medicine to compliance).

It is likely that this man thought he was complying with the core reasons behind the MDA, as seen through his statement that he should follow government programmes and his belief that he was protecting his community from LF because of his compliance with traditional medications.

A complying man with a history of non-compliance from a rural village

The second map is for a 37-year-old farmer, who is married, has four children and lives in an endemic village where he is head of his neighbourhood (Figure 3). This man is a complier with a history of non-compliance; his statements revealed he had complied the year of the interview for the first time, after several years of non-compliance. He had initially tested negative for LF, and that was a sufficient reason for him to refuse treatment (illustrated by the dotted line from personal health to compliance). He explained that if there was no diagnostic test, then people would doubt the medication and would fear adverse reactions. He had heard that someone had died from side effects after the MDA. He believed this explained why some people in his community would not want to comply with LF treatment (illustrated by a solid line from side effects to compliance).

He offered some opinions on people’s compliance. He described the norm to conform, explaining if a non-complier saw someone taking the pills then they would want to take them too (illustrated by a solid line from norms to compliance). He understood that people would want to take the treatment for prevention and cure of LF (illustrated by a solid line from LF prevention to compliance).

He later explained that he took the pills this year because he had become the head of a neighbourhood and it was important for him to comply so that people knew this was a government programme (illustrated by the dotted line from...
farmer/community leader to authority to respect to compliance). He understood his own position as a role model and his effect on influencing others in his community to comply.

From these statements, it seems he changed his mind about complying based on his role as head of the neighbourhood rather than a desire to prevent LF. His map illustrates his two positions (compliance and non-compliance) by giving two complete causal chains, one negative and one positive.

A non-complying woman from the district capital

This woman was a 30-year-old housewife, married with three children (Figure 4). At the time of the MDA, the community health worker (CHW) brought the drugs to her house (illustrated by a solid line from MDA to CHW) and left the drugs for the family to take without any explanation about the drugs or LF.

The respondent reported that she forgot to take the pills and that they still may be in the medicine cabinet. She added that she was too busy to take the medication (illustrated by the dotted lines from housewife to priority of health to compliance); however she gave the treatment to her husband and children. She talked about their negative side effects: going to sleep and not waking until the next morning (saying they were unconscious). These side effects frightened her (illustrated by the dotted lines from family to side effects to fear/uncertainty to compliance).

Despite her own non-compliance, this woman was aware of the norm to conform to compliance with treatment. She feared what would happen if everyone else did not comply and the disease spread; however, she had heard that everyone had taken the tablets and she was the only one who had forgotten to comply (illustrated by the solid line from norms to compliance). These comments suggest that she may have understood the protection (herd immunity) she gained from a complying community.

General results: identification of significant factors affecting compliance

Comparing the 21 causal chain maps for compliance reveals some patterns of decision-making. Every map has at least one complete causal chain with either a negative or positive value indicating its influence on compliance. Some individuals’ maps revealed that they had more than one complete causal chain, indicating that they were persuaded by two or more different sets of linked factors.

![Diagram of a complying man with a history of non-compliance]
Not every map had a solid line. Respondents’ opinions about other motivations within their communities (solid lines) seemed to be varied with the richness of the interview. Where respondents offered more information in the interview in general, there were more opinions about other possible influences on compliance. This does not suggest, however, that those maps with few or no solid lines were not valuable interviews; merely that some individuals were more vocal and descriptive in their accounts than others. The fact that at least one complete causal chain could always be found also suggests that regardless of the interview quality, a suite of causal factors that is likely to have been responsible for the respondent’s behaviour could be identified. At least with respect to its primary objective, the mapping method is robust with respect to interview quality.

The complete causal chains (illustrated by dotted lines) were more likely to involve statements about values and beliefs about society than knowledge or personal experience with the disease or the treatment (see Figure 5). In fact, only two people in the cohort had a complete causal chain beginning with the disease environment where they lived. This finding challenges the hypothesis that endemicity might have a strong influence on compliance; e.g. that people living in endemic areas would be more willing to comply with treatment, while those living in areas with no disease would be less likely to comply. This was based on the assumption that people living in endemic areas would better understand their own risk for infection.

Only four individuals based their compliance on factors of their personal experience with treatment, side effects or the health system. All four of these reported experiences with side effects, which negatively affected their decision to comply. This confirms experiences seen in other parts of Indonesia where early elimination campaigns suffered because individuals had negative experiences with adverse reactions associated with LF treatment (Putrali et al. 1975; Sutanto et al. 1985; Oemijati 1999).

Within this cohort, five individuals based their decision to comply on factors related to their knowledge of the disease (left side of the map). This pattern confirms the thematic findings on knowledge of aetiology and transmission of disease where individuals seemed to have a multiple and varied understanding of cause of disease, most often vague in biomedical terms. Two of these individuals spoke about their reason not to comply with biomedical treatment due to their adherence to traditional medicine that they relied on as prevention against LF. The remaining three complied with treatment because of their belief that the drug would prevent disease.
There were seven individuals who made decisions on compliance based on their present health status. This was an unexpected result, as personal health was not referred to specifically during the interview. With the exception of one woman whose condition contraindicated her from taking the treatment (breastfeeding), five other individuals did not take the treatment based on their good health or personal health maintenance. Of these, two men reported that their personal health was good so they saw no reason to comply with the treatment.

Complete causal chains for 10 individuals went through the centre group of factors: beliefs about society (norms, social reputation, authority/government, social roles/gender). The majority of these complete causal chains involved authority while others included norms, social roles/gender and social reputation (in order of frequency). These societal factors were often associated with perceived consequences and benefits of complying or non-complying behaviour such as: achieving a good social reputation, satisfying one’s social role as a man and provider by staying healthy, being a good leader by fulfilling responsibilities to provide a positive example to the rest of the community, respecting orders from authority figures or following the norm of conformity. Interestingly, the solid lines (see Figure 6) representing the perceived influences present in the community also included societal factors. Not only did some respondents experience influence from the society around them, but respondents also perceived this to be an important influence for others.

For the majority of individuals (17), complete causal chains included values: priority of health, fear or uncertainty, respect, economics, acceptance or fatalism and moral judgment on behaviour. A number of complete causal chains (6) featured economic considerations. The links to economics were varied: personal health, social roles, spouse, priority of health and occupation. The influence of economics was not obvious at the beginning of this research; rather the map analysis showed its importance as a positive or negative influence. For example, people are sometimes too busy working to seek treatment and do not want to risk a possible loss of income by seeking treatment during their work hours. Furthermore, if people felt able to work then they did not feel the need to seek treatment. These negative influences on compliance reflect respondents’
primary concerns about their economic stability; losing a day's work would not be an acceptable risk to take for the benefit of the treatment. None of these individuals were civil servants or worked in private enterprise; their income was based on a daily wage. There were also positive influences of compliance linked to economics. For one man, the risk of getting LF if he did not take the treatment was too costly for him in economic terms; who would pay for his operation? He also felt responsible for the economic livelihood of his household so if he was sick with LF, then he would not be able to provide for his family.

Outside influences connected to complete causal chains reflect the holistic approach taken in the MDA campaign in Alor. Community leaders (religious, governmental, cultural) were often enlisted to assist with promotion of compliance with the treatment. In addition, with the often public nature of the distribution—following church or mosque services, in schools, at health centres—crowds would be drawn to the event, and the perception that everyone was complying would be propagated.

Aside from the public nature of the MDA, the closer circle of neighbours and family was also important in influencing compliance. These people offer direct experience about the treatment. In several cases, observing the side effects in the family was enough to influence some respondents to avoid treatment. Others turned to their neighbours for advice before taking the treatment.

The divergence between the composite maps in Figures 5 and 6 reveals the difference between respondents’ perceptions of what influences those around them (solid lines shown in Figure 6) and what actually influences them (dotted lines or complete causal chains shown in Figure 5). While both composite maps show the perceived and real importance of beliefs about society and its influence on compliance, respondents perceived personal experience and knowledge to have a greater influence than they do in reality. Furthermore, respondents expected external influences to play a more significant role in motivating individuals to comply than they actually do. Finally, as seen in Figure 6, respondents did not perceive personal characteristics as playing a role in predicting compliant behaviour, whereas in their own accounts (Figure 5), their health, job status and gender played an important role in their decisions to comply.

Conclusions
Methodological
The use of causal chain mapping constitutes an innovative approach to the analysis of data concerning compliance with an
externally authorized health procedure. It provides an opportunity to identify those statements of crucial importance to an individual’s views on compliance, without isolating them from the context of the individual. These few statements are taken from the transcripts of the individual interviews, and once these themes or factors are placed on the map, the researcher is better able to find relationships among statements that may have not seemed related during the interview. On the map, links can be drawn which further reveal influences on behaviour. By analysing the group of maps, the researcher is able to draw conclusions and observe patterns within the individual’s account that may not be as readily perceived in the thematic evaluation. This provides an opportunity to further generate as well as to check previous hypotheses which have arisen on earlier analyses of the data.

Causal chain mapping also uncovers the effects (positive or negative) that specific factors have on compliance for each individual. These values give the researcher a clear and succinct picture of the relevant influencing factors without some of the detail and complexities that are inherent in the original data. Although these complexities are essential to the analysis of any research question, understanding the effect of these influences at the individual level can be complicated. The maps allow the researcher to see which factors, at the individual level, take precedence in directing behaviour. Then, commonalities in the relevance of these factors can be assessed by comparing maps across individuals, to see which kinds of factors are most important in the population as a whole. These factors can then be targeted during intervention design to ensure maximum levels of compliance.

It is recommended that this method be used in conjunction with data collection in the form of in-depth interviews or semi-structured surveys. These forms allow the interviewer to probe for responses and give the respondent freedom to respond without following set responses, as seen in a closed questionnaire. These methods require preparation of the interview tool (questionnaire, topic guide) and pre-testing of the tool to ensure its clarity and appropriateness before fieldwork can begin. Samples of respondents should be purposive (for example, considering male:female; complier:non-complier; schooled:unschooled; urban:rural) and continue until a point where the saturation of themes (Green and Thorogood 2004) occurs when no new constructs arise in the data collection. The sampling for the data collection will undoubtedly affect the quality of the maps, and as such, every effort should be made in the planning stages to include as representative a sample as possible, remembering the tenet of qualitative research, which is to describe phenomena rather than make comparisons. Analysis of the results in preparation for the use of causal chain mapping follows the principles of qualitative data management (Green and Thorogood 2004). One of the benefits of the causal chain mapping process is that it can be applied to data collected from different methods. Themes in the maps can emerge from grounded theoretical analysis of the data collection itself (as performed here). However, as suggested previously, it is also possible to use domains from standard health psychological theories, such as those outlined in Michie et al. (2005), as the foundation from which to analyse informant data and construct maps.

The limitation of this research is reflected in its novelty. The causal chain maps have only been tried within the field of MDA for LF elimination. In order to further assess the robustness of this new methodology, it should be tested with other research questions where in-depth interviews are used to determine one-time-occurring health behaviours, such as vaccine uptake, helminth prevention, MDA for onchocerciasis or purchase of an insecticide-treated bednet.

**Thematic**

One of the main patterns arising from this research is the strong presence of non-health-related factors influencing people’s decision-making processes. Traditional health promotion theories often root behaviour in knowledge and perception of risk [e.g. the Health Belief Model (Strecher and Rosenstock 1997)]. An examination of these maps shows that in fact, there are many other factors which seem to have a more important effect on decision-making, including fitting in with peers (norms), having a good reputation by following authority, protecting yourself from sanctions (following authority), feeling safe, protecting your family, neighbourhood or village from LF by complying with treatment, etc. Health-related benefits, on the other hand, are represented by prevention of disease or cure of an existing condition. Although some people do express this as a primary influence, the majority of the respondents whose maps were examined do not mention this as their primary reason to comply. Their expressed influences are more related to the non-health-related benefits of compliance.

Furthermore the overall pattern suggests that social factors weighed heavily on respondents’ minds, often more heavily than their own condition or beliefs when it came to compliance; what others were doing was seen as important. One implication of this finding is that MDA in similar societies (rural, agricultural, patriarchal) should be implemented publicly where possible, so that this need to conform to group norms can be leveraged as a reason for each individual to comply.

Other thematic conclusions arose from the maps’ ability to reveal new relationships amongst factors as well as to dispel earlier hypotheses. The maps demonstrated the lack of importance that living in an endemic area had on an individual’s compliance. Analysis of the maps also revealed the importance that economics and personal health each had in determining compliant behaviour in the individual. Evaluating the people involved in influencing decision-making revealed a cross-section of individuals, from village leaders to children. This provided a basis of understanding for the creation of the strong norm of conformity that has been described here.

The examination of the composite maps revealed simply the differences and similarities within this cohort in the perceptions of important factors influencing compliance (solid lines) versus the reality of the respondents’ own reasons for complying with treatment (dotted lines—causal chains). By better understanding both of these concepts, MDA campaigns can more effectively target populations by creating effective messages that will include both real and perceived influences.

Causal chain mapping has proven to be an effective and useful method to determine the influences importantly affecting an individual’s decision to comply with MDA for LF elimination. The use of this method is likely to help make any public health
programme reliant on the adoption of novel behaviours more effective. However, validation with other samples and with respect to other health problems is recommended.

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Conflict of interest

No conflict of interest to report.

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