

# The epidemiology of 'bewitchment' as a lay-reported cause of death in rural South Africa

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## ABSTRACT

**Background** Cases of premature death in Africa may be attributed to witchcraft. In such settings, medical registration of causes of death is rare. To fill this gap, verbal autopsy (VA) methods record signs and symptoms of the deceased before death as well as lay opinion regarding the cause of death; this information is then interpreted to derive a medical cause of death. In the Agincourt Health and Demographic Surveillance Site, South Africa, around 6% of deaths are believed to be due to 'bewitchment' by VA respondents.

**Methods** Using 6874 deaths from the Agincourt Health and Socio-Demographic Surveillance System, the epidemiology of deaths reported as bewitchment was explored, and using medical causes of death derived from VA, the association between perceptions of witchcraft and biomedical causes of death was investigated.

**Results** The odds of having one's death reported as being due to bewitchment is significantly higher in children and reproductive-aged women (but not in men) than in older adults. Similarly, sudden deaths or those following an acute illness, deaths occurring before 2001 and those where traditional healthcare was sought are more likely to be reported as being due to bewitchment. Compared with all other deaths, deaths due to external causes are significantly less likely to be attributed to bewitchment, while maternal deaths are significantly more likely to be.

**Conclusions** Understanding how societies interpret the essential factors that affect their health and how health seeking is influenced by local notions and perceived aetiologies of illness and death could better inform sustainable interventions and health promotion efforts.

## INTRODUCTION

Witchcraft provides a moral agency framework that can make sense of seemingly random events in space and time, and in South Africa, witches using Muthi ('medicine') are said to be able to cause disease and misfortune.<sup>1 2</sup> This has important consequences for treatment choices; seeking Western healthcare and remedies for witchcraft-related illness is considered redundant or, at best, secondary to traditional rituals, medicines and sacrifices.<sup>3 4</sup>

In the world's poorest settings, where belief in witchcraft is prevalent and the burden of disease and premature mortality is highest, the vital events of individual lives are not recorded and medical registration of deaths and their causes is rare.<sup>5</sup> Localised surveillance systems have been established in many resource-poor settings in an attempt

to overcome this lack of information. These Health and Socio-Demographic Surveillance Systems (HDSSs) monitor populations in clearly defined geographic areas and record all information on births, deaths and migrations.<sup>6 7</sup> Since 1992, every death occurring in the Agincourt HDSS, South Africa, is subject to a verbal autopsy (VA), whereby trained fieldworkers interview the closest care giver of the deceased to retrospectively record the signs and symptoms of the deceased. These data are later used to derive a probable cause of death.<sup>8</sup> The VA tool also records the respondent's opinion as to what, in their opinion, the main or most important cause of death was, which in numerous instances is 'bewitchment'.

This study explores the epidemiology of reported bewitchment and its associations with individual and household characteristics of the deceased, including VA-derived medical causes of death.

## METHODS

The Agincourt HDSS covers 21 villages and a population of around 70 000 people in Bushbuckridge District of Mpumalanga Province, South Africa.<sup>9 10</sup> Following a baseline census in 1992, the Agincourt HDSS has conducted annual updates of household membership along with individual status variables (relation to household head, nationality, marital, residence and education status) followed by enquiry into vital events (pregnancy outcome, death, in- and out-migration).<sup>10</sup> VAs are conducted for every death using an interview schedule that is written in the local language and based on culturally acceptable terminology. The VA questionnaire includes a closed question seeking the respondent's opinion on the cause of death of the deceased, and typically, only a single cause is recorded.

All completed VAs between 1 January 1992 and 31 December 2006 were selected for this study. Close examination of the family-given cause of death enabled distinction between 'bewitched' and 'non-bewitched' deaths. Informed by local input and interpretations, deaths classified as bewitched included those reported in English as 'bewitchment', 'witchcraft', 'evil spirit' or 'devil spirit' or in the indigenous languages (locally known as Xitsonga or Xishangaan) as 'ku dlukula', 'xifulana', 'ku wutla rigadyi', 'khubalo', 'xidyiso' or 'xifula'—differing local terms reflecting subtleties of meaning and differing symptomatology or behaviour but all associated with malicious supernatural forces and, for the purposes of analysis, grouped together as bewitchment.



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Signs, symptoms and lifestyle behaviours recorded in the VA questionnaires were processed using the computer-based InterVA probabilistic approach to VA interpretation (<http://www.interva.net/>). The InterVA method uses Bayesian methods to assign up to three probable causes of death with associated likelihoods for each case. The method has previously been evaluated in various settings and has been shown to generate population cause-specific mortality profiles comparable to those derived by physician review.<sup>11–13</sup> The major advantage of the InterVA approach is that it objectively processes VA data in a completely standardised and consistent manner, thus overcoming concerns over intra- and interobserver agreement and subjectivity that can preclude meaningful comparisons of cause-specific mortality over time.<sup>14</sup>

Information about the deceased's background characteristics and health-seeking behaviour as well as the family-given cause of death (grouped in this study as bewitched or non-bewitched) was accessed for each completed VA. Asset surveys have been conducted in all households in the surveillance site gathering data on living conditions and assets, including building materials of main dwelling, water and energy supply, ownership of modern appliances and livestock and means of transport available. These assets were used to derive a score for household assets that were used to define five socioeconomic strata, ranked by increasing value of the score and corresponding to wealth quintiles. Cumulative household mortality up to the time of the individual's death was available from the HDSS database. Exploratory cross tabulation and multivariate logistic regression analyses of individual and household characteristics and their association with reports of bewitchment were conducted using Stata V.10.

Population-level cause-specific mortality fractions were derived from the InterVA output, thus giving an estimate of the proportion that each cause category contributes to the total number of deaths. Using logistic regression, it was then possible to investigate the associations between VA-derived medical cause categories and family-reported bewitchment deaths to see if certain death categories were more likely to be reported as bewitched than others when controlling for all other causes, age and sex groupings.

Open-ended sections of the VA questionnaires in which verbatim descriptions of key events and symptoms leading up to an individual's death are recorded were not entered into InterVA. While it would be possible to use such information in InterVA, previous evidence suggests that little to no additional information is provided in the open-ended sections of VA questionnaires that is not also recorded in response to the closed questions, thus having little effect on resulting cause of death profiles and little return for the considerable effort required to extract relevant information from these free-text sections.<sup>13</sup> Nevertheless, the open-ended accounts of the deceased's terminal illnesses in the VA were reviewed by one of the authors for completeness to facilitate a more nuanced discussion of the quantitative results.

Informed consent is obtained at household level at every update visit in the Agincourt HDSS, and community consent from civic and traditional leadership was secured at the start of surveillance activities and is reinforced annually. All surveillance-based studies in Agincourt, including VA, have been approved by the Committee for Research on Human Subjects (Medical) at the University of Witwatersrand.

## RESULTS

Six thousand eight hundred and seventy-four deaths with completed VAs were identified over the 15-year period. Of these,

406 (5.9%) had bewitchment recorded as the family-perceived cause of death. The distributions of bewitched/non-bewitched deaths are shown in table 1 by background and socioeconomic factors. Crude analysis of these distributions shows age–sex group, level of education, terminal illness duration and type of healthcare sought to be significantly ( $p < 0.05$ ) associated with a death being reported as due to bewitchment. When all factors were entered into a multivariate regression model, children and reproductive-aged women had a greater probability of having their death reported as bewitchment than older adults. Similarly, sudden deaths or those following an acute illness, deaths occurring in the earlier period of data collection (ie, before 2001) and those where traditional healthcare was sought were more likely to be reported as bewitchment, compared with deaths following chronic illness, deaths occurring after 2000, and deaths where no healthcare was sought, respectively (table 2).

All 6874 deaths were interpreted using InterVA, which assigned a single cause of death to 5463 individuals (79.5%), two likely causes to 816 individuals (11.9%) and three likely causes to 148 individuals (2.2%). In 447 cases (6.5%), there was not enough information to derive a probable cause of death and such cases were classified as 'indeterminate'. The population-level cause-specific mortality fractions for the bewitched and non-bewitched populations are shown in table 3 along with results of multivariate logistic regression with each cause of death as an exposure and bewitchment as the outcome. Deaths due to external causes (accidental or violent) were significantly less likely to be attributed to bewitchment than other deaths, while maternal causes were significantly more likely to be, although the total sample of maternal deaths is small ( $n = 50$ , 0.73% of all deaths).

## DISCUSSION

Exploration of the epidemiology of bewitchment as a lay-reported cause of death over a 15-year period in the Agincourt HDSS, South Africa, provides a useful insight into a population's understandings of death. Illness duration and specific causes of death appear to be important factors associated with the likelihood of a death being reported as due to bewitchment. Deaths following a long illness and those due to obvious external causes are approximately 60–70% less likely to be reported as bewitchment compared with other causes. Conversely, maternal deaths are almost three times more likely to be reported as bewitchment compared with non-maternal deaths when controlling for age and sex groups. This association with maternal deaths, and the greater proportion of bewitchment deaths among women in the reproductive age group of 15–49 years compared with other age–sex groups, suggests that the Agincourt community may associate the sudden deaths of otherwise healthy young women with malicious supernatural causes.

Judging the generalisability of findings is particularly complex when findings relate to behaviour or attitudes, and such judgements must be based on scientific knowledge, insight, and even conjecture about nature.<sup>15</sup> While there may be something unique about the form witchcraft belief takes in the Agincourt HDSS area,<sup>16</sup> it is reasonable to expect that certain aspects of witchcraft belief, community understanding of mortality and the public health implications of such beliefs transcend contextual differences.<sup>17</sup> Therefore, the findings from this study may be relevant to other areas of South Africa as well as other settings throughout the African continent where belief in witchcraft is strong. Multisite research with due regard to

translocal social spaces would be required to verify this with greater certainty.<sup>18</sup>

Death registration and VA are well established in Agincourt, and the use of InterVA to derive probable causes of death from the VA material is a considerable strength of this study. Though arguably less subtle and nuanced than physician review, the completely standardised and reliable way in which it assigns causes of death facilitates comparisons of cause-specific mortality over the 15-year study period; a necessary aspect of this investigation and one that could not be as reliably achieved using physician review whereby physician diagnoses may have been influenced by reported bewitchment as the family-given cause or in the open-ended sections of the VA questionnaire and where medical diagnoses may have been subject to intra- and interobserver bias over the long time period. Inclusion of physician diagnoses would have introduced confusion, not least because the time period covered saw at least 10 different individuals reviewing the VA data, each inevitably with their own idiosyncrasies and biases. Furthermore, it is impossible to know on a case-by-case basis whether physicians actually read the comments about witchcraft and what individual physicians' perceptions of witchcraft were, meaning that the net effect on

physician interpretation of the witchcraft 'evidence' would be totally unknown.

The broad use of the term *bewitchment* in this study and the focus on only a single cause may undermine the sophistication of lay diagnoses and understandings of misfortune. Evidence of pluralistic use of healthcare in the current study suggests that people may understand causation as being both medical and non-medical simultaneously. Indeed, the subtleties of meanings between the different terms associated with bewitchment in the local language reflect a recognition of differing symptoms and disease histories, which may be directly linked to medical interpretations, yet all with a connection to supernatural causes and witchcraft.

Review of the open-ended sections of VA questionnaires also highlighted the complexity of explanatory models of cause of death, which often included both traditional and medical explanations. Respondents were often aware of a medical diagnosis and were able to report this during the VA interview, yet this did not appear to diminish or in any way contradict their conviction that the true cause of death was bewitchment. The preferential reporting of bewitchment over medical diagnoses in such cases may not necessarily represent a rejection of medical

**Table 1** Distribution of bewitched deaths by background factors and socioeconomic status in Agincourt subdistrict, 1992–2006

Background and socioeconomic factors	Bewitched	Non-bewitched	P value
Mean age in years (95% CI)	36.12 (33.76 to 38.48)	42.81 (42.15 to 43.46)	<0.001*
Age and sex, n (%)			
<15	92 (6.9)	1237 (93.1)	<0.001*
15–49 male	93 (6.2)	1411 (93.8)	
15–49 female	110 (8.5)	1191 (91.5)	
50+	111 (4.1)	2629 (96.0)	
Nationality, n (%)			
Mozambican origin	92 (5.1)	1728 (95.0)	0.071
South African origin	313 (6.2)	4721 (93.8)	
Year of death, n (%)			
1992–1994	41 (5.8)	668 (94.2)	0.484
1995–1997	51 (5.9)	816 (94.1)	
1998–2000	82 (7.0)	1085 (93.0)	
2001–2003	109 (5.8)	1775 (94.2)	
2004–2006	123 (5.5)	2124 (94.5)	
Highest education level, n (%)			
None	148 (4.7)	3033 (95.4)	<0.001*
Primary	99 (6.4)	1447 (93.6)	
Secondary or above	94 (7.5)	1154 (92.5)	
Wealth group, n (%)			
Most poor	61 (5.6)	1018 (94.4)	0.859
2	64 (5.7)	1055 (94.3)	
3	75 (5.6)	1266 (94.4)	
4	86 (6.3)	1279 (93.7)	
Least poor	84 (6.4)	1233 (93.6)	
Cumulative household deaths, n (%)			
1	254 (6.1)	3897 (93.9)	0.272
2	75 (5.1)	1386 (94.9)	
3 or more	41 (6.7)	569 (93.3)	
Terminal illness duration, n (%)			
Sudden/acute (<2 weeks)	120 (7.2)	1544 (92.8)	0.031*
Chronic (>2 weeks)	250 (5.7)	4119 (94.3)	
Treatment sought for terminal illness, n (%)			
None	27 (4.7)	550 (95.3)	<0.001*
Western only	87 (3.9)	2146 (96.1)	
Western and traditional	32 (12.8)	219 (87.3)	
Traditional only	240 (7.4)	2998 (92.6)	

\*Statistically significant associations.

**Table 2** Multivariate analysis of background and socioeconomic factors with 'bewitched' as the outcome factor

Background and socioeconomic factors	Adjusted OR (95% CI)
Age and sex groups (years)	
<15	1.7 (1.1 to 2.6)*
15–49 male	1.5 (1.0 to 2.1)
15–49 female	1.8 (1.3 to 2.6)*
50+	Ref
Nationality	
Mozambican origin	0.9 (0.6 to 1.2)
South African origin	Ref
Year of death	
1992–1994	Ref
1995–1997	0.6 (0.3 to 1.1)
1998–2000	0.8 (0.4 to 1.3)
2001–2003	0.5 (0.3 to 0.9)*
2004–2006	0.5 (0.3 to 0.8)*
Highest education level	
None	Ref
Primary	1.3 (0.9 to 1.8)
Secondary or above	1.5 (1.0 to 2.3)
Wealth group	
Most poor	Ref
2	1.1 (0.7 to 1.7)
3	1.0 (0.6 to 1.5)
4	1.3 (0.8 to 1.9)
Least poor	1.2 (0.7 to 1.8)
Cumulative household deaths	
1	Ref
2	0.9 (0.6 to 1.2)
3 or more	1.3 (0.9 to 1.9)
Terminal illness duration	
Sudden/acute (<2 weeks)	Ref
Chronic (>2 weeks)	0.5 (0.3 to 0.6)*
Treatment sought for terminal illness	
None	Ref
Western only	1.1 (0.6 to 2.2)
Western and traditional	3.7 (1.9 to 7.0)*
Traditional only	5.8 (2.7 to 12.2)*

\*Statistically significant associations.

diagnoses but is likely to reflect the relative importance of different world views in understanding mortality. That medical diagnoses and any subsequent treatment ultimately failed to prevent death in the current study may also be an important factor in reconciling traditional beliefs with the acceptance and understanding of medical science; the perceived value or accuracy of a medical diagnosis may have been diminished or, since Western remedies were unsuccessfully, the cause may have been seen to have had a different 'traditional' aetiology. More nuanced analysis of this phenomenon and subcategorisations of witchcraft beliefs would be worthwhile and would require subcategorisation of witchcraft-related deaths.

The data included in this study coincide with a fascinating period of health transition in South Africa, capturing the beginning and rapid expansion of the HIV epidemic. The fact that the odds of a death being reported as bewitchment was lower in the final 6 years compared with the first 3 years (table 2) may be due to incomprehension and fear of a new apparently supernatural illness to which the population was unaccustomed, but which later developed into a more medical understanding of HIV- and AIDS-related illness as the community became more habituated to this disease. Associations between deaths from HIV/AIDS

**Table 3** Distribution of verbal autopsy-derived causes and ORs in relation to reported 'bewitchment', adjusted for all other causes shown, age and sex, for deaths in Agincourt HDSS, 1992–2006

Cause category	Cause-specific mortality fractions (%)		OR (95% CI)
	Bewitched	Non-bewitched	
Accident	2.1	5.6	0.4 (0.2 to 0.8)*
Homicide/suicide	1.7	5.0	0.3 (0.1 to 0.8)*
Infectious	14.7	10.6	1.4 (0.9 to 2.1)
Infant	0.3	0.5	0.5 (0.1 to 2.3)
Maternal	1.4	0.5	3.0 (1.3 to 7.2)*
Human Immunodeficiency Virus/ Pulmonary Tuberculosis	47.9	46.1	1.1 (0.8 to 1.7)
Kidney	1.6	2.1	1.2 (0.6 to 2.4)
Chronic liver disease	3.7	5.4	0.9 (0.6 to 1.6)
Cardiovascular disease	6.6	7.3	1.1 (0.7 to 1.7)
Respiratory	2.8	2.5	1.5 (0.9 to 2.3)
Malignancy	0.2	1.2	0.3 (0.1 to 1.2)
Other	5.8	5.1	1.3 (0.8 to 2.0)
Indeterminate	11.4	8.0	1.4 (0.8 to 2.4)

\*Statistically significant associations.

HDSS, Health and Socio-Demographic Surveillance System.

and beliefs of bewitchment have been discussed in other studies and case histories.<sup>19–24</sup> Nevertheless, there was no evidence of association between HIV-related deaths and bewitchment in the current study, even when stratifying by year of death (results not shown).

The greater proportion of bewitchment deaths in the mid-1990s may also be related to heightened consciousness of witchcraft activity resulting from politically motivated witch hunts in the area during the early days of post-apartheid.<sup>16 18</sup> During this transitional period in South Africa, characterised by a climate of uncertainty and long-standing mistrust within and between sectors of society, there was an 'epidemic' of occult violence and fear of malicious supernatural forces<sup>25</sup> within the former Northern Province, including the former homeland of Gazankulu in which Agincourt is located. It was also a social climate in which fears about witches flourished, nourished by rapidly expanding charismatic churches that offered sanctuary and support against evil brought by witches.<sup>18</sup> The prevalence of witchcraft during that period has been interpreted by some to be an aggressive rationalisation of misfortune from unknown or uncontrollable forces.<sup>17</sup> Time, and perhaps the gradual success of reconciliation initiatives, may have overcome some of these driving forces towards the beginning of the new millennium, and the incidence of witchcraft-related violence did diminish after 1997.<sup>18</sup>

The study indicates an association between bewitchment beliefs and maternal deaths. Maternal deaths fit well into commonplace understandings of witchcraft. For example, invisible agents or those with a grudge working in mysterious ways and with intent to cause harm target seemingly healthy individuals performing the natural and expected role of child-bearing, causing unexpected illness and death that results in prolonged suffering for the immediate family. Furthermore, witchcraft has previously been identified as an important factor that affects women's reproductive health, with pregnancy being described as a state of acute vulnerability to the actions of jealous others.<sup>3 26 27</sup> Moreover, it is commonly believed that witches are particularly keen on attacking the generative capacities of families and lineages, so an affliction that specialises in fertile victims and as a consequence of sexual activity is considered tailor-made for their craft.<sup>19</sup> The relative rarity of maternal deaths, the role of women in childbirth and the

importance of fertility in African society in general may further explain why maternal deaths are associated with witchcraft in some people's eyes, perhaps echoing beliefs held in Europe until the 17th century that midwives and witchcraft were closely linked.<sup>28</sup> Assigning blame to witchcraft may be a mechanism for dealing with the incomprehensibility of why a woman should die during the natural process of childbirth and the catastrophic consequences of death with respect to infant survival and family life. This can be contrasted to deaths caused by obvious and more comprehensible external causes, such as accidents, homicide and suicide, which were less likely to be reported as witchcraft.

There is an increasing trend in deaths being reported as due to bewitchment in relation to increasing education level of the deceased, although not statistically significant in the multivariate analysis (tables 1 and 2). It has been shown that education is not necessarily a protective factor against belief in witchcraft and that formal education may in fact contribute to the growth of witchcraft by exposing people to new ways of thinking and conduct. Resulting changes in behaviour may clash with local values resulting in suspicions and accusations of witchcraft.<sup>2 19 29</sup>

If the true medical and social causes of illness are not recognised at the community level, it is difficult to intervene and prevent them. An ethnographical study in Nigeria, for example, shows that discussants believe that reproductive health problems and delivery complications caused by curses and witches can only be cured by traditional healers, animal sacrifices and prayers, with medical interventions considered redundant.<sup>3</sup> Similar beliefs were evident from the open histories of the VAs in the current study. For example, one case report of an 18-year-old woman apparently suffering from postnatal psychosis describes how she was separated from her child and taken to an evangelical church to be healed, whereupon she was tied up with ropes so tight that 'there were scars on her ankles and arms'. Following 2 weeks with a traditional healer, the woman was sent home and died within hours. This potentially preventable death highlights the devastating consequences that may result from inappropriate and misguided treatment-seeking behaviour, which are likely to be motivated by lay cultural understandings of illness.

The fact that individuals who sought only traditional treatments for their terminal illnesses were almost six times more likely to have their death reported as bewitchment supports the view that traditional medicine and bewitchment are strongly associated (table 2). Nevertheless, almost 40% of bewitchment cases in this study accessed Western healthcare, occasionally in combination with traditional care (results not shown). This reflects pluralistic healthcare-seeking behaviour characteristic of the Agincourt population and South Africans in general<sup>29–32</sup> and is suggestive of a process of health-seeking behaviour in which personal beliefs and actions are continuously debated and evaluated throughout the course of an illness. The apparent willingness to use Western care reinforces the need to improve the accessibility and, crucially, the quality of existing services. In particular, there is an apparent need for enhanced communication to patients and their relatives regarding the meaning of diagnoses and realistic treatment expectations.

Understanding divergences between biomedical and cultural concepts of illness has implications for health measurement techniques. Rather than replicating a purely clinical paradigm, through which the social context of illness and death may be edited out, VAs should instead be considered as an interface between epidemiological and ethnographical methods that are able to provide important information on the chain of biomedical and

social events associated with preventable mortality.<sup>14 33–36</sup> As demonstrated by the current study, quantitative exploration of certain local concepts or perceptions of illness may facilitate translation of these culture-specific interpretations into more generic medical models useful for health measurement.

Insights gleaned from the people directly affected by specific health issues are also critical in developing sustainable health programmes and building health partnerships.<sup>37</sup> Planners need to understand barriers and enablers to care seeking—which are likely to include local understanding of the causes of illness and consequent perceived appropriateness of Western medicine in the framework of certain world views. With such insights, the perception of witchcraft and its associations with illness and death have real public health implications.

Collective participatory action and social cohesiveness, in line with the philosophy of Ubuntu, one of the founding principles of post-apartheid South Africa, are vital mechanisms for empowering the poor by putting them at the centre of decision-making for health, development and poverty reduction. Yet this essential cohesiveness, the very bonds that hold communities together, may be drastically hindered in societies punctuated by superstitious beliefs.<sup>17 38</sup> For example, this study shows that maternal deaths are closely associated with witchcraft, and as such the social cohesion necessary for effective and equitable participatory safe-motherhood intervention strategies may be weakened and alternative approaches may be needed. Any inclusion of indigenous beliefs into modern healthcare in Africa should be informed by deep understanding of traditional beliefs and practices to avoid propagating any misguided and harmful attitudes and health practices. Indigenous beliefs should not be ignored, rather solutions to health problems in South Africa must be informed by local cultures and knowledge systems and

### What is already known on this subject

- ▶ Lay understanding of the illness and death influences health practices.
- ▶ It is not uncommon for illness and premature mortality in Africa to be attributed to witchcraft, with important implications for care-seeking behaviour.
- ▶ The witchcraft phenomenon has traditionally been explored using ethnographical techniques; quantitative assessment is rare or non-existent despite offering valuable insights into factors associated with witchcraft belief and their association with medical and socio-demographic parameters.

### What this study adds

- ▶ Witchcraft-related deaths in Agincourt, South Africa, are reported in all socioeconomic groups and are associated with short duration of illness, traditional care-seeking practices and deaths in children and reproductive-aged women.
- ▶ Deaths due to external causes are less likely to be attributed to bewitchment, while maternal deaths are more likely to be.
- ▶ Distorted community understanding of the wider societal and medical causes of mortality is a public health challenge that may delay appropriate health seeking and can hinder health and development intervention efforts.

an appreciation of the viability of strategies within specific contexts.

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**Competing interests** None.

**Ethics approval** This study was part of surveillance-based activities in Agincourt, which are conducted with the approval of the Committee for Research on Human Subject (Medical) at the University of Witwatersrand, South Africa.

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