

Original Article

A community based cross sectional study on feasibility of lay interviewers in ascertaining causes of adult deaths by using verbal autopsy in rural Wardha

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Abstract:

Background & objectives: 1) To study the causes of adult (15 years and above) deaths using verbal autopsy (VA) and its socio-demographic characteristics. 2) To study the feasibility of use of the lay interviewer to ascertain causes of adult death using verbal autopsy and a simple algorithm. **Methods:** The present study was done in Wardha district, Maharashtra, India. Taking into account feasibility, out of 23 villages of Primary Health Centre, Anji, 15 villages were chosen having total population of 14,590. Out of 273 estimated adult deaths during the study period, 209 (77%) could be traced by house to house visit and a lay interviewer, interviewed the close caretakers of the deceased. Both lay interviewer and a physician individually derived their diagnosis using verbal autopsy report and a simplified algorithm. The data was entered and analyzed by using Epi_info 6.04. The inter-observer reliability between the lay interviewer and a physician for each possible diagnosis was assessed by using the Kappa statistics. Considering the diagnosis made by a physician as a gold standard, the diagnostic and predictive accuracy for each diagnosis made by the lay interviewer was calculated. **Results:** The communicable diseases accounted for 52 percent of the adult deaths while non-communicable for 32 percent and injuries for nine percent deaths. The overall agreement between the lay interviewer and a physician for communicable diseases was found to be good ($k = 0.65 \pm 0.06$) and for non-communicable diseases it was found to be excellent ($k = 0.80 \pm 0.06$). The lay interviewer using VA performed adequately for individual conditions of public health importance like acute febrile illness, diarrheal diseases, tuberculosis and injuries. **Interpretation & conclusions:** The present study has been successful to demonstrate feasibility of use of the lay interviewer to provide useful information on population-level estimation of broad causes of adult deaths and its socio-demographic characteristics that are reasonably reliable. The study suggests the possible utility of the method for rural India, where the majority of deaths occur at home. Further research work on development of sensitive and specific yet simple algorithms for lay interviewers to ascertain causes of adult deaths is required.

Key Words: Adult deaths, Verbal autopsy, Algorithm, Lay interviewer, Physician review

Introduction:

In developing countries, most of the deaths are neither attended by doctors nor medically certified and thus information on causes of deaths is incomplete and of poor quality.¹ Verbal autopsy (VA) has been widely used to determine causes of childhood and maternal deaths, but has had limited use in assessing causes of adult deaths.² In countries with poor data on adult mortality, weak vital registration system and proportion of people who die at home without medical care is high, use of VA to find out causes of death seems an attractive option.^{2,3} The VA technique is based on the assumption that most causes of deaths have distinct symptom complexes which can be recognized, remembered and reported by lay respondents. It also assumes that it is possible to classify deaths, based on the reported information, into useful categories of causes of deaths.⁴

Most often physician review of each VA has been undertaken to arrive at possible cause of death. In South India, Gajalakshmi et al.⁵ have found that trained non medical surveyors could collect information on the signs and symptoms of illness preceding death where the cause of death was ascer-

tained by physicians. In a study conducted by Lulu K et al. in Ethiopia, VA was conducted by lay interviewer and the cause of death was ascertained by computerized algorithm.⁶ Although physician reviews have been shown to produce better results, it demands considerable amount of physician's time and computer program to anticipate the cause of death seems too complex to be practical.⁷ One of the limitations of verbal autopsy has been requirement of skilled office based staff to assess cause of death and lay interviewers to undertake verbal autopsy.⁷ However, little is known about the feasibility of use of these lay interviewers to arrive at cause of adult death using VA and a less complex algorithm (Table 7). In Africa, Quigley et al. have demonstrated that simple VA questionnaire, use of lay interviewers, less complex algorithm and broad categories of diseases increase the validity of the study.⁸

Validation studies on VA in Africa and China used hospital records and death certificates to obtain gold standard diagnosis.^{9,10} In developing countries the cause of death is often inadequately recorded on the death certificate as majority of medical schools do not give instruction about the process

of death certification.¹¹ In rural areas of developing countries, validation studies are not feasible owing to the fact that the vast majority of deaths occur at home.¹⁰ Physician review has high diagnostic accuracy than expert algorithm for use at population level.^{9,12} Hence, considering the above constraints in resource poor rural settings, physician review of VA might be considered as an alternative gold standard to find diagnostic accuracy of lay interviewer using VA and expert algorithm. Hence, the present study was undertaken to study the causes of adult (15 years and above) deaths using verbal autopsy and their socio-demographic characteristics in the study area and to study the feasibility of use of lay interviewer to ascertain causes of adult deaths using verbal autopsy.

Material and Methods:

Study Area: The present study was done in Wardha district of India (Maharashtra state) about 758 km east from the state capital Mumbai. About 60 percent of district population lives in rural area with 80 percent literacy.¹³ There were two medical colleges (one private and one semi-government) and one district hospital in Wardha district. The Kasturba Rural Health Training Centre, Anji (KRHTC) is a peripheral centre of Dr. Sushila Nayar School of Public Health, Mahatma Gandhi Institute of Medical Sciences (MGIMS), Sewagram; undertook the present study. The KRHTC is located in village Anji having a Primary Health Centre (PHC) which is 26 km away from district place Wardha. Apart from the training and sensitization of medical undergraduates, nursing students, medical interns and post-graduate students to rural health problems, the centre runs community based health care programs in surrounding 23 villages of PHC, Anji with population of 31, 482. Considering operational feasibility, out of these 23 villages, 15 villages were chosen for the present study having population of 14,590.

Study subjects: The study subjects were adult deaths (15 years and above) that occurred during January 2004 to December 2006 in study area. The crude death rate for rural Maharashtra was 7.4 per thousand mid-year population.¹⁴ Using the adult death rates from the Sample registration system (SRS) of India, we estimated roughly around 273 adult deaths in study area in the three years preceding the study. Out of these expected 273 deaths, we could manage to get information for

209 (77%) deaths. A trained lay interviewer paid house to house visit and interviewed close caretakers of the deceased. In case of non-availability of the close caretaker of deceased, three more visits, one week apart were paid to the house to ensure maximum coverage. The data collection was done from January 2007 to February 2007.

Data collection Tool: Verbal Autopsy was carried out to find out the most probable cause of adult death. Verbal autopsy questionnaire of the present study was based on the VA developed by Gajalakshmi et al.⁵ The VA questionnaire adopted for the present study was a pre-designed checklist with filters which was translated from English to *Marathi* (local language). The *Marathi* VA questionnaire was validated by back-translating it in English by an independent translator. The discrepancies in translation were resolved by discussion among two translators and the investigator. The developed VA questionnaire was pre-tested on a sample of fifteen deaths in a village (other than study villages) to incorporate local phraseology for signs and symptoms.

The first part of the questionnaire included socio-demographic characteristics of the deceased subjects such as age at death, sex, marital status, education, occupation, health insurance, history of chronic illness, and history of addiction to alcohol, smoking and tobacco. In absence of any reliable and direct measure of income, the color of the ration card was considered as a proxy measure of socio-economic status. Under public distribution system, Government of Maharashtra has distributed color coded ration cards to families depending on its socio-economic status. Yellow color card signifies families below poverty line status. The second part of VA questionnaire included signs and symptoms of various diseases which were present at the time of death, duration of illness, health care seeking and admission to health facility.

Selection and training of interviewer: One local person with 15 years of formal education was a lay interviewer in the present study. During seven days of formal training, the interviewer was trained about various signs and symptoms of diseases, technique of administering VA and finally writing verbal autopsy report and arriving at a single most

probable cause of death using simple algorithm. The training techniques like mock interviews and hands-on-training on writing VA reports was undertaken to enhance the capability of the interviewer. In the presence of investigator, the lay interviewers had to fill at least five VA on different causes of death and ascertain most probable cause of death. This exercise was undertaken in the villages outside the study area.

Data collection: The trained lay interviewer paid house visit and after obtaining informed consent, interviewed the close caretaker of the deceased who was present at the time of death. If the caretaker was able to give the major signs and symptoms and circumstances leading to death, then additional probing questions were asked about associated symptoms using checklist of VA autopsy. If the caretaker was not able to give sufficient information on symptoms prior to death, then after ruling out non-medical causes of death, the lay interviewer read out the signs and symptoms in checklist of VA and then noted down the responses to each. Where there was a positive response, additional information was obtained. A recall period of three years was used as it was found that adult death was relatively regarded as significant memorable event as compared to child death.⁶ Five percent of verbal autopsies were rechecked to ensure quality of data.

Deriving a single most probable cause of death: The present study used simplified expert algorithm adopted by Lulu K et al.⁶ in rural Ethiopia (Annexure I) as mortality situation in India is next to Africa and both are under epidemiological transition phase; secondly, to avoid problems in identification of a single underlying cause for each adult death due to chronic nature of conditions and complex symptoms of diseases. The algorithm was translated from English to *Marathi* (local language) and validated by back-translating it in English by an independent translator. The expert algorithms are combination of symptoms and duration of illness which are deemed by physicians to be essential, confirmatory or supportive in diagnosing a particular cause of death.⁸

Based on VA report data, the trained lay interviewer derived single most probable cause of

death using simplified algorithm. Later, a physician independently reviewed the verbal autopsy and assigned the single most probable cause of death and classified it into broad causes of adult deaths as per expert algorithm. The physician was kept blind to the diagnosis made by the lay interviewer. The main advantage of physician review of verbal autopsy has been utilization of open ended questions and comments in verbal autopsy. Both a lay interviewer and a physician derived their diagnosis at a later stage and not at the time of interview as validity of the diagnosis derived at the interview by lay interviewer was likely to be poor.⁴

Statistical analysis: The data was entered and analyzed by using Epi_info 6.04 software package. The inter-observer reliability between lay interviewer and physician for each possible diagnosis was assessed by using the Kappa statistics described by Fleiss.¹⁵ Kappa reflects the agreement between two or more observers above what would be expected due to chance. Kappa values below 0.40 are usually considered to reflect poor inter-observer agreement, values between 0.40 and 0.70 reflect good agreement and values above 0.70 reflect excellent agreement. Considering diagnosis made by physician as a gold standard, diagnostic and predictive accuracy for diagnosis made by lay interviewer using VA was calculated. For the present study, as a rough guide, the lay interviewer using VA was considered to have good validity for disease or condition for which sensitivity is > 65%, for those with sensitivity in the range 50-65% as tolerable validity and when < 50% as poor validity.

Results:

Out of 209 deceased, 63 percent were male, 37 percent were female and a majority of deaths occurred in older age group (60 years and above). About 42 percent and 46 percent of the deceased were below poverty line and lived in temporary house respectively. Nearly half of the deceased were illiterate, lived in nuclear family and they either belonged to scheduled caste or scheduled tribes. About 42 percent deceased were involved in agricultural work. Only 5 percent deceased were members of community based organizations (CBOs) like self-help group, farmers club etc and 82 percent of deaths occurred at home (Table 1).

Table 1: Socio-demographic characteristics of diseased person			
Socio-demographic variables	Male N (%)	Female N (%)	Total N (%)
Age distribution (Yrs)			
15 – 60	51 (38.6)	33 (42.9)	84 (40.2)
Above 60	81 (61.4)	44 (57.1)	125 (59.8)
Color of ration card			
Below poverty line	58 (43.9)	30 (39)	88 (42.1)
Other	74 (56.1)	47 (61)	121 (57.9)
Type of house			
Kachha	64 (48.5)	33 (42.9)	97 (46.4)
Semi-pacca	36 (27.3)	18 (23.4)	54 (25.8)
Pacca	32 (24.2)	26 (33.7)	58 (27.8)
Type of family			
Joint	68 (51.5)	35 (45.5)	103 (49.3)
Nuclear	64 (48.5)	42 (54.5)	106 (50.7)
Education			
Illiterate	65 (49.2)	51 (66.2)	116 (55.5)
Primary and Middle	41 (31.1)	17 (22.1)	58 (27.8)
Secondary and higher secondary	21 (15.9)	8 (10.4)	29 (13.9)
Graduate and Post graduate	5 (3.8)	1 (1.3)	6 (2.9)
Caste			
Scheduled caste	18 (13.6)	13 (16.9)	31 (14.8)
Scheduled tribe/NT	55 (41.7)	26 (33.8)	81 (38.7)
Other backward class	57 (43.2)	38 (49.4)	95 (45.5)
Others	2 (1.5)	0	2 (1.0)
Occupation			
Housework	2 (1.5)	49 (63.6)	51 (24.4)
Service	7 (5.3)	1 (1.3)	8 (3.8)
Farmer and Agricultural labor	65 (49.2)	23 (29.9)	88 (42.1)
Student	6 (4.5)	4 (5.2)	10 (4.8)
Not working	52 (39.4)	-	52 (24.9)
Membership in Community based organizations			
Yes	8 (6)	2 (2.6)	10 (4.8)
No	124 (94)	75 (97.4)	199 (95.2)
Place of death			
Hospital	26 (19.6)	12 (15.5)	38 (18.2)
Home	106 (80.4)	65 (84.5)	171 (81.8)
Respondents of deceased			
Parents	5 (3.8)	3 (3.9)	8 (3.8)
Spouse	32 (24.2)	7 (9.1)	39 (18.7)
Offspring	59 (44.7)	37 (48)	96 (45.9)
Others	36 (27.3)	30 (39)	66 (31.6)
Total	132 (100)	77 (100)	209 (100)
(Figures in parentheses are percentages)			

The history of cardiovascular disorder was present in 26 percent of females and 17 percent of males. Eighteen percent of deceased had past history of asthma. Out of 80 deceased persons who had history of chronic illness, about 54 percent were taking treatment from a local semi-government hospital. About 32 percent of the deceased had health insurance. Most of the deceased (60%) had history of tobacco chewing. About one fourth of the deceased males had history of alcohol consumption and smoking. Majority of deceased person (75%) were taking mixed diet and used soybean oil for cooking (83%) (Table 2).

Table 2: History of chronic illness, life styles and treatment seeking behaviour of the deceased persons			
History of chronic illness*	Male N (%)	Female N (%)	Total N (%)
History of (H/o) Cardiovascular disorders	23 (17.4)	19 (24.6)	42 (20)
H/o Asthma	24 (18)	14 (18)	38 (18.2)
H/o Tuberculosis	9 (7.8)	2 (2.6)	11(5.3)
H/o HIV/AIDS	1 (0.8)	0	1(0.5)
H/o Diabetes	2 (1.5)	2 (2.6)	4 (1.9)
H/o Cancer	2 (1.5)	1 (1.3)	3 (1.4)
Source of treatment (n=80)			
Government hospital	18 (34.6)	5 (17.9)	23 (28.7)
Semi-government	26 (50)	17 (60.7)	43 (53.8)
Private	8 (15.4)	6 (21.4)	14 (17.5)
Health insurance			
Yes	40 (30.3)	27 (35)	67(32.1)
No	92 (69.7)	50 (65)	142(67.9)
Life style*			
H/o tobacco chewing	81 (61.4)	42 (54.5)	123 (58.9)
H/o alcohol	38 (28.8)	-	38 (18.2)
H/o smoking	33 (25)	-	33 (15.8)
Type of diet			
Vegetarian	26 (19.7)	27 (35)	53(25.4)
Mixed diet	106 (80.3)	50 (65)	156(74.6)
Type of cooking oil used			
Soybean	113 (85.6)	60 (78)	173(82.8)
Linseed	19 (14.4)	17 (22)	36(17.2)
Total	132 (100)	77 (100)	209 (100)
* Multiple response questions (Figures in parentheses are percentages)			

According to physician review, the communicable diseases accounted for 52 percent of the deaths, non-communicable for 32 percent, accidents and injuries for nine percent and undetermined consisted seven percent of deaths. The highest proportion of deaths was due to acute febrile illness (AFI) comprising 18 percent of all causes. About 11 percent of deaths were due to cardio-vascular diseases and chronic obstructive airway diseases each. In general, deaths from communicable diseases were greater in males (54.6%) than in females (46.8%); while deaths from non-communicable diseases were greater in females (35%) than in males (29.5%). There were only two deaths related to maternal causes. As reported by the caretakers, three deaths were due to known cancers and two deaths were due to known diabetes. The deaths from both communicable and non-communicable diseases were greater in older age groups compared to those in adult age group (Table 3).

Table 3: Distribution of most probable causes of deaths (physician review) according to sex and age					
Possible causes of death	According to Sex		According to age		Total % (N)
	Male % (N)	Female % (N)	15-60 Yrs. % (N)	> 60 Yrs % (N)	
Communicable diseases	72 (54.6)	36 (46.8)	33 (39.3)	75 (60)	108 (51.7)
Acute Febrile illness	20 (15.2)	18 (23.4)	8 (9.5)	30 (24)	38 (18.2)
Diarrheal diseases	17 (12.9)	6 (7.8)	3 (3.6)	20 (16)	23 (11)
All forms of Tuberculosis	16 (12.1)	4 (5.2)	10 (11.9)	10 (8)	20 (9.6)
HIV/AIDS	3 (2.3)	2 (2.6)	3 (3.6)	2 (1.6)	5 (2.4)
Pneumonia	9 (6.8)	6 (7.8)	6 (7.1)	9 (7.2)	15 (7.2)
Meningitis	7 (5.3)	0(0)	3 (3.6)	4 (3.2)	7 (3.3)
Non-communicable diseases	39 (29.5)	27 (35)	22 (26.2)	44 (35.2)	66 (31.6)
Liver diseases	3 (2.3)	1 (1.3)	3 (3.6)	1 (0.8)	4 (1.9)
Cardio-vascular diseases (CVD)	14 (10.6)	9 (11.7)	9 (10.7)	14 (11.2)	23 (11)
Chronic obstructive airway diseases (COAD)	13 (9.8)	10 (12.9)	3 (3.6)	20 (16)	23 (11)
Acute abdomen conditions	7 (5.3)	4 (5.2)	5 (6)	6 (4.8)	11 (5.3)
Cancer*	2 (1.5)	1 (1.3)	2 (2.4)	1 (0.8)	3 (1.4)
Diabetes*	0(0)	2 (2.6)	0 (0)	2 (1.6)	2 (1)
Maternal causes	-	2 (2.6)	2 (2.4)	0 (0)	2 (1)
Injuries	11 (8.3)	8 (10.4)	18 (21.4)	1 (0.8)	19 (9.1)
Undetermined	10 (7.6)	4 (5.2)	9 (10.7)	5 (4)	14 (6.6)
Total	132 (100)	77 (100)	84 (100)	125 (100)	209 (100)

* As reported by the caretakers of deceased person

The overall agreement between the lay interviewer and physician for communicable disease was found to be good ($k = 0.65 \pm 0.06$). Overall the agreement was excellent ($k \geq 0.75$) for all communicable diseases and it was ($0.75 < K > 0.40$) for pneumonia. The agreement between the lay interviewer and physician for non-communicable diseases was found to be excellent ($k = 0.80 \pm 0.06$). The lay interviewer appears to have good validity for injuries, diarrheal diseases, all forms of tuberculosis and to some extent acute febrile illnesses. On the other hand, the lay interviewer was much less successful in adequately diagnosing conditions like HIV/AIDS, acute abdomen, pneumonia, meningitis, cardio-vascular diseases and chronic obstructive airway diseases. Notably, the sensitivity and specificity got improved at broader levels of classification like communicable diseases, non-communicable diseases and injuries. At broader levels, the lay interviewer using VA and algorithm appears sensitive to communicable diseases and specific for non-communicable diseases (Table 4).

Table 4: Level of agreement between lay interviewer and physician using verbal autopsy			
Possible causes of death	Lay reporter N (%)	Physician N (%)	Kappa coefficient \pm SE
Communicable diseases	121 (57.9)	108 (51.7)	0.65 \pm 0.06
Acute Febrile illnesses	53 (25.4)	38 (18.2)	0.76 \pm 0.06
Diarrheal diseases	23 (11.0)	23 (11.0)	0.90 \pm 0.06
All forms of Tuberculosis	20 (9.6)	20 (9.6)	0.88 \pm 0.06
HIV/AIDS	5 (2.4)	5 (2.4)	0.79 \pm 0.06
Pneumonia	12 (5.7)	15 (7.2)	0.64 \pm 0.06
Meningitis	8 (3.8)	7(3.3)	0.79 \pm 0.06
Non-communicable diseases	63 (30.1)	66 (31.5)	0.80 \pm 0.06
Liver diseases	7 (3.3)	4 (1.9)	0.72 \pm 0.06
Cardio-vascular diseases	17 (8.1)	23 (11.0)	0.83 \pm 0.06
Chronic obstructive lung diseases	23 (11)	23 (11)	0.75 \pm 0.06
Acute abdomen conditions	11(5.3)	11(5.3)	0.80 \pm 0.06
Cancer	3 (1.4)	3 (1.4)	1 \pm 0.06
Diabetes	2 (1.0)	2 (1.0)	1 \pm 0.06
Maternal causes	2 (1.0)	2 (1.0)	1\pm 0.06
Injuries	19 (9.1)	19 (9.1)	1\pm 0.06
Undetermined	4 (1.9)	14 (6.7)	0.21 \pm 0.06
Total	209 (100.0)	209 (100.0)	-

(Figures in parentheses are percentages)

Despite good sensitivity for acute febrile illness i.e. 97% (84.6-99.9), PPV was low i.e. 70% (55.5-81.3). The lay interviewer misclassified 15 deaths (39%) to other causes in small numbers resulting in poor PPV. The sensitivity for cardio-vascular diseases (CVD) was 73.9% (51.3-88.9) but PPV was 100% (77.1-100) as the lay interviewer could not identify six deaths due to CVD (Table 5). The physician review of VA reported fourteen cases as undetermined, while the lay interviewer using VA classified only four deaths as undetermined. The misclassification matrix for the causes of deaths is shown in Table 5. The row of matrix indicates total number of deaths identified as being due to that cause from VA diagnosis by lay interviewer while cause of deaths in columns were assigned by physician review of VA (Table 6).

Table 5: Diagnostic accuracy of lay interviewer with physician review of verbal autopsy as gold standard			
Cause of death	Sensitivity (95%CI)	Specificity (95%CI)	PPV (95%CI)
Communicable diseases	88.0 (79.9-93.2)	77.2 (68.2-84.3)	78.5 (69.9-85.2)
Acute Febrile illnesses	97.4 (84.6-99.9)	77.8 (85.1-94.4)	69.8 (55.5-81.3)
Diarrheal diseases	91.3 (70.5-98.5)	98.9 (95.8-99.8)	91.3 (70.5-98.5)
All forms of Tuberculosis	90 (66.9-98.2)	99 (95.9-99.8)	90 (66.9-98.2)
HIV/AIDS	80 (29.9-98.9)	99.5 (96.9-100)	80 (29.9-98.9)
Pneumonia	60 (32.9- 82.5)	98.5 (95.3-99.6)	75 (42.8-93.3)
Meningitis	85.7 (42.0-99.2)	99 (96.1-99.8)	75 (35.6-95.5)
Non-communicable diseases	80.3 (68.3-88.7)	93.5 (88.0-96.6)	84.1 (72.3-91.7)
Liver diseases	100 (39.6-100)	98.5 (95.4-99.6)	57.1 (20.2-88.2)
Cardio-vascular diseases	73.9 (51.3-88.9)	100 (97.5-100)	100 (77.1-100)
Chronic obstructive lung diseases	78.3 (55.8-91.7)	97.4 (93.7-99.0)	78.3 (55.8-91.7)
Acute abdomen conditions	81.8 (47.8-96.8)	99.0 (96.1-99.8)	81.8 (47.8-96.8)
Cancer	100 (31-100)	100 (97.7-100)	100 (31-100)
Diabetes	100 (19.8-100)	100 (97.7-100)	100 (19.8-100)
Maternal causes	100 (19.8-100)	100 (97.7-100)	100 (19.8-100)
Injuries	100 (79.1-100)	100 (97.5-100)	100 (79.1-100)

Table 6: Misclassification matrix for causes of deaths by physician review and lay interviewer using VA

Cause of death by VA and lay inter- viewer	Cause of death by physician review												Total
	In- juries	TB	HIV/ AIDS	AFI	Diarrhea	Menin- g-itis	Pneu- mo-nia	Liver disease	Ac ab- domen	COAD	CVD	Undeter- mined & all other causes	
Injuries	19												19
Tuberculosis (TB)		18								2			20
HIV/AIDS			4		1								5
Acute febrile illness (AFI)				37	1	1	4			1	1	8	53
Diarrhea			1		21					1			23
Meningitis				1		6	1						8
Pneumonia							9			1	1	1	12
Liver disease								4	2		1		7
Acute abdomen									9			2	11
Chronic obstructive airway disease (COAD)		2					1			18	2		23
Cardiovascular dis- eases (CVD)											17		17
Undetermined and all other causes											1	10	11
Total	19	20	5	38	23	7	15	4	11	23	23	21	209

Table 7: Summary of methods used in seven published studies using verbal autopsy for adult deaths												
No	Study country	Study period	Age gr.	Objectives of study	No of deaths	Mortality classification	Type of VA	Interviewer		Reference diagnosis	VA diagnosis Derivation	
								Type	Edu		Physician review	Algorithm
1	Africa	1993-95 (Published in 1998)	≥15 years	To develop VA tool and algorithm and test its validity	796	Physician review, computer using algorithm and hospital records.	Structured	Lay	12 yrs	Hospital records and death certificates	Panel of physician	Computerized diagnostic algorithm
2	Africa	1993-95 (Published in 1999)	≥15 years	To compare diagnostic accuracy of physician review, and algorithms	796	Physician review, computer using algorithm and hospital records.	Structured	Lay	12 yrs	Hospital records and death certificates	Panel of physician	Computerized algorithm & Physician using expert algorithm
3	Lebanon	1993—94 (Published in 2001)	≥50 years	To examine mortality pattern among middle aged & older population	1786	Physician review and ICD criteria	NR*	NR*	NR*	-	-	-
4	India	1995-97 (Published in 2002)	≥25 years	To arrive at the probable underlying cause of death and to measure cause specific mortality rates	48000	Physician review and ICD criteria	Structured	Lay	15 yrs	-	-	-
5	Vietnam	1999 (Published in 2003)	All ages	To test feasibility of VA to determine cause of death for all ages	189	Physician review	-	Lay	-	-	-	-
6	Ethiopia	1995-99 (Published in 2005)	15-49 yrs	To identify causes of adult deaths in rural Ethiopia using VA	515	Computerized expert algorithm	Structured	Lay	High school	-	-	Computerized algorithm
7	China (Urban)	2002 (Published in 2005)	Adults	To validate VA procedure for adult deaths in China	2102	Physician review	Structured	NR*	NR*	Physician review of medical records	Physician review	-
*NR- Not reported												

Discussion:

Documentation of the leading causes of deaths and its socio-demographic variables helps planners to design specific policies and preventive strategies. Monitoring of causes of deaths over period enlightens our understanding of epidemiologic transition. In developing countries, due to various deficiencies in existing registration system like incomplete coverage, late registration and missing data, the reliable information on causes of adult deaths and its trend is rarely available.¹¹ Under such constraints, the information on broad causes of deaths as reported by the lay interviewer using verbal autopsy may be useful.

In the present study, nearly, half of the deceased were illiterate, lived in nuclear family and they either belonged to scheduled caste or scheduled tribes. Majority of deaths (60%) had occurred during old age (60 years and above); more among males and mostly among persons living in poor socio-economic conditions with poor social support. Only 32 percent of the deceased had health insurance. Noteworthy, these health insurance schemes were unique to study area, which have been designed and run by a local semi-government hospital and a private hospital with special emphasis on rural population. The above information reflected that the schemes had not yet percolated to deceased old subjects with poor socio-economic conditions. It was found that in India, the poor people lack the power and the knowledge to protect their health rights.¹⁶

In the present study, as per physician review, communicable diseases accounted for 52 percent of the deaths, non-communicable for 32 percent and Injuries for nine percent. These findings are in concordance with the estimates given by World Health Organization.¹⁷ Similar pattern was observed in rural Ethiopia. However, the picture reported in this study may be relevant to a large number of developing countries, including the Indian subcontinent, experiencing dual burden due to epidemiological transition. The deaths from communicable diseases form a useful health status indicator as it indicates magnitude of preventable mortality.¹⁸ It was also noted that most of the diseases by which poor people die are avoidable illnesses.¹⁶ The present study confirms the similar finding.

In the present study about 82 percent deaths took place at home while only 18 percent deaths took place in nearby three hospitals. The records of three hospitals (One government, one semi-government

and other private) were subjected to their own information biases in terms of nature of documentation practices, diagnostic and treatment protocols and strength of clinical laboratory or radiological investigations. Apart from this, difficulty in ascertaining single underlying cause of death from medical records showing multiple causes of death could have had important implications for measuring validity of the lay interviewer using VA. Therefore, in the present study, we employed physician review of verbal autopsy (gold standard) and classified deaths according to broad categories of simple algorithm. A validity study for verbal autopsy in adults had shown that the cause specific mortality fraction obtained using expert algorithms was within $\pm 20\%$ of gold standard for malaria, meningitis, tuberculosis/AIDS, acute abdomen condition, diarrheal diseases, direct maternal causes and chronic liver diseases.⁹

Since the agreement between lay interviewer using VA and physician review was found to be good, it reflected the relative merit of use of a lay interviewer versus a physician who is costly and difficult to get especially in rural area of developing countries. The lay interviewer using VA performed better at broader levels of classification like communicable diseases, non-communicable diseases and injuries. The lay interviewer using VA performed adequately for individual conditions of public health importance like acute febrile illness, diarrheal diseases, tuberculosis and injuries. Broadly, the approach was found to be sensitive to communicable diseases and specific to non-communicable diseases. In China, validation study on physician review of VA had adopted $>75\%$ sensitivity as good.¹⁰ But for the present study on diagnostic accuracy of the lay interviewer using VA and simple algorithm, we considered $>65\%$ sensitivity as acceptable.

In our results, misclassifications were found mostly in closely related categories with symptom overlap except for cardiovascular diseases and chronic obstructive airway disease. Nevertheless, misclassification of a cause of death into a closely related similar category is of less concern than into very different category.⁴ At population level misclassifications appears largely compensatory as total numbers of cause of deaths as reported by the lay interviewer using VA and by physician review were similar for few conditions. Thus, it is the symptom overlap that makes it difficult to distinguish between diseases and thus the validity of the study gets affected.¹⁰ The lay interviewer and physician could not ascertain cause of deaths in four and fourteen cases respectively. The reasons for this difference could be that the physician derived diagnosis at a later stage and used broad categories for death classification given in algorithm.

Annexure I: Algorithm used for the diagnoses of cause of adult death (Lulu K et al)			
No	Symptoms	Duration	Diagnosis
1	Injuries (intentional or unintentional)	< 30 days	Injuries
2	Pregnant or in labor or in puerperal period	-	Maternal causes
Communicable diseases			
3	Fever + headache	< 15 days	Acute Febrile Illness (AFI)
4	Diarrhea + no cough	< 30 days	Diarrheal diseases
5	Cough + weight loss + (bloody sputum or Fever or swelling over body) + no diarrhea	> 30 days	Tuberculosis (TB)
6	Cough + diarrhea + fever + weight loss	> 30 days	HIV/AIDS
7	Cough + fever + (difficulty in breathing or chest pain)	< 30 days	Pneumonia
8	Fever + headache + neck stiffness	< 15 days	Meningitis
Non-communicable diseases			
9	(swelling over legs or body) + Yellow discoloration (Jaundice)	> 15 days	Liver diseases
10	difficulty in breathing + palpitation + (swelling over legs or body)	< 30 days	Cardio-vascular diseases (CVD)
11	Cough + difficulty in breathing + wheezing + no bloody sputum	> 30 days	Chronic obstructive airway diseases (COAD)
12	Abdominal swelling + repeated vomiting + no diarrhea	> 15 days	Acute abdomen

The strengths of the study must be considered in light of some limitations. This was a relatively small size study, in one area. The sensitivity and specificity of verbal autopsy varies between populations depending on the distribution of causes of deaths.¹⁹ The diagnosis of cause of death was based only on verbal autopsy report by single physician. Attributing death to a single primary cause was convenient but arbitrary. Therefore, further studies on feasibility of the lay interviewer to ascertain causes of adult deaths using verbal autopsy and its validity need to be conducted in broad settings to confirm our findings. In the present study, the expert algorithm did not categorize cancer and diabetes mainly because of its varied manifestations and it would be difficult to accommodate these conditions into simple algorithm.

In conclusion, the present study was successful to demonstrate feasibility of use of lay interviewer to provide useful information on population-level estimation of broad causes of adult deaths and their socio-demographic characteristics that are reasonably reliable; however, its validity could not be fully assessed with the appropriate gold standard. The study suggests the possible utility of the method for rural India, where the majority of deaths occur at home. Further research work on development of sensitive and specific yet simple

algorithms for the lay interviewers to ascertain causes of adult deaths is required.

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