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Improper cause-of-death statements by specialty of certifying physician: a cross-sectional study in two medical centres in Taiwan

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To cite: Cheng T-J, Lee F-C, Lin S-J, *et al*. Improper cause-of-death statements by specialty of certifying physician: a cross-sectional study in two medical centres in Taiwan. *BMJ Open* 2012;**2**: e001229. doi:10.1136/bmjopen-2012-001229

► Prepublication history for this paper is available online. To view this file please visit the journal online (http://dx.doi.org/10.1136/bmjopen-2012-001229).

Received 1 April 2012
Accepted 26 June 2012

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ABSTRACT

Objective: To determine the frequency of various types of improper cause-of-death (COD) statements reported on death certificates and whether the frequency differed by specialty of the certifying physician.

Design: Cross-sectional descriptive study.

Setting: 2 medical centres in Tainan, Taiwan.

Participants: A total of 2520 death certificates issued by 230 physicians.

Main outcome measures: 4 types of improper COD statements based on the criteria of correctness of the COD causal sequence and the level of specificity of underlying COD selected.

Results: Of 2520 death certificates analysed, 502 (19.9%) had at least one type of improper COD statement. However, only 235 (9.3%) sustained major errors, that is, 91 (3.6%) reported incorrect causal sequence and 144 (5.7%) reported only mechanism(s) of death (such as respiratory failure, heart failure, sepsis and acidosis). The improper reporting rate was highest among nephrologists (53%, 24/45), followed by infectious diseases physicians (45%, 29/65) and was lowest among oncologists (6%, 57/995).

Conclusions: About one-fifth issued death certificates sustained improper COD statements and only one-tenth had noteworthy errors that would threaten the quality of COD statistics. The frequency varied by specialty of the certifying physician because physicians in different specialties manage different types of diseases and conditions with contrasting complexities in terms of determining the causal sequence and specificity of COD statements.

ARTICLE SUMMARY

Article focus

- What is the frequency of various types of improper COD statements reported by certifying physician in medical centre?
- Do the frequencies of improper COD statements differ by specialty of the certifying physician?

Key messages

- One-fifth of issued death certificates sustained at least one type of improper COD statements.
- However, only one-tenth had noteworthy errors that would threaten the quality of COD statistics.
- The improper reporting rate varied by specialty of certifying physician and was highest among nephrologists and infectious diseases physicians and lowest among oncologists.

Strengths and limitations of this study

- Compared with previous similar hospital-based studies, this study has the largest sample size, which allowed us to stratify the improper rate by subspecialties.
- The case-mix and physicians' certification behaviours in the studied hospitals might differ from other hospitals.

INTRODUCTION

Recording cause-of-death (COD) statements on the death certificate is a common practice of medical physicians. Good quality COD statement is prerequisite for good quality COD statistics. Good quality COD statistics are cornerstones for good quality health policy making and medical researches. The tabulation of COD statistics are based on the underlying COD, which has been defined as (1) the disease or injury that initiated the train of morbid events leading directly to death or (2) the circumstances of the accident or violence which produced the fatal injury (see WHO,[1] page 23). This definition is from the standpoint of prevention of death; it is necessary to break the chain of events or to affect a cure at some point, and the most effective public objective is to prevent the precipitating cause from operating.

To facilitate the selection of the underlying COD when two or more COD are recorded, an international standard form of death certificate (figure 1) has been designed and recommended by the WHO[1] (see pages 23 and 24). Part I of the form is for diseases

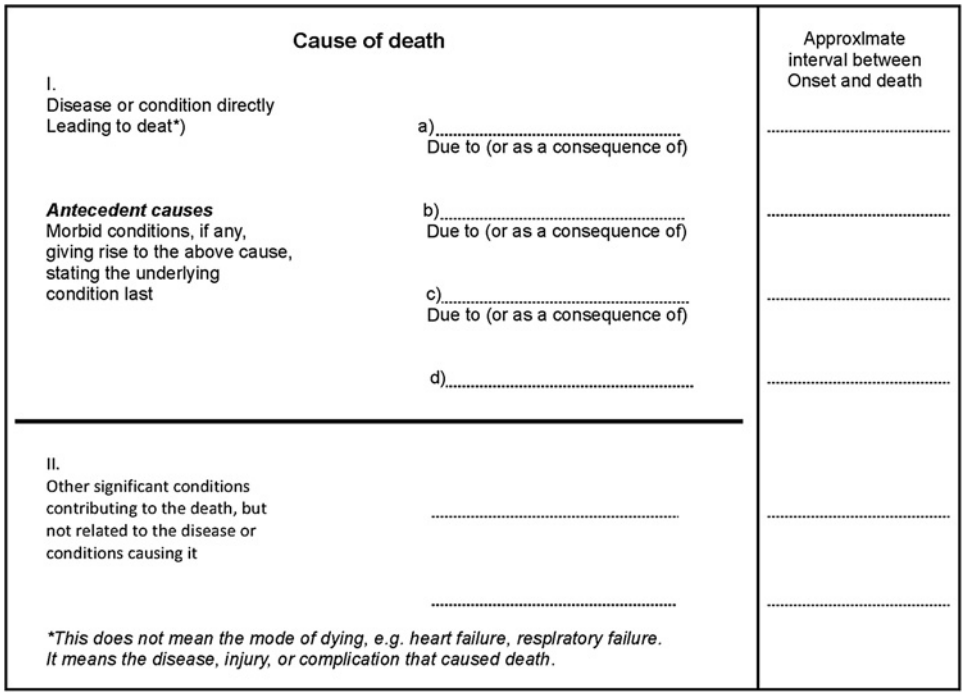

Figure 1 International form of medical certificate of cause of death recommended by the WHO.

related to the train of events leading directly to death, and part II is for unrelated but contributory conditions. It is the responsibility of the medical practitioner signing the death certificate to indicate which morbid conditions led directly to death and to state any antecedent conditions giving rise to this cause.

However, on some occasions, certifying physicians might not report correct causal sequence between diseases or conditions on line a, b, c or d (see examples 10–12 in table 1), the Selection Rules set by the WHO[1] (see pages 25–36) should be used to standardise the process in selection of the underlying COD. Sometimes, the selected underlying COD might not the real intent underlying COD of certifying physician and the derived COS statistics might be biased. Furthermore, if certifying physicians do not provide specific information on the death certificate, it is difficult to provide useful information for the prevention of death.

Different classification schemes were used in previous studies to identify different types of improper COD statements (appendix 1).[2–14] Reporting incorrect COD causal sequence and reporting only mechanism(s) of death are two major errors indicated in every study. Despite many studies demonstrating various types of improper COD statements on death certificates, very few studies have examined the frequency of improper COD statements by specialty of the certifying physician. Information on which specialties have a higher percentage of recording improper COD statements could help to target physicians with a high priority for education and training in how to properly complete COD statements. There were two objectives in this study: (1) to determine the frequencies of various types of improper COD statements on death certificates reported by certifying physicians in two medical centres in Tainan, Taiwan, and (2) to examine whether the frequency of improper reporting differed by specialty of the certifying physician.

METHODS

Setting and data source

This descriptive cross-sectional study was conducted in Tainan, a major city located in southern Taiwan with a population of 1.87 million. There are only two medical centres in Tainan. In 2009, there were 1150 beds in the Chi-Mei Medical Center and 1100 beds in the National Cheng Kung University Hospital. We retrospectively reviewed all death certificates issued from 1 January 2009 to 31 December 2009 in these two medical centres.

Determination of improper COD statements

We used two criteria—correctness of the COD causal sequence and level of specificity—to define four types of improper COD statements. Examples of proper and four types of improper COD statements are illustrated in table 1. Determination of the correctness of the COD causal sequence is according to *Decision Table D* in the *Instruction Manual Part 2c* compiled by the US National Center for Health Statistics, which includes all acceptable causal sequences between diseases or morbid conditions.[15]

Level of specificity was classified as specific COD, unspecific COD and mechanism of death. Specific COD is defined as providing specific information on the aetiology and body region, such as lung cancer, oesophageal varices bleeding, hepatitis B infection, cerebrovascular infarction. Unspecific COD denotes those

Table 1 Examples of four types of improper cause-of-death (COD) statements

Proper: One correct causal sequence and one specific COD reported on the lowest used line		
Example 1	Example 2	Example 3
a. Oesophageal varices bleeding	a. Coma	a. Respiratory failure
b. Portal hypertension	b. Congestive heart failure	b. Pneumonia
c. Liver cirrhosis	c. Myocardial infarction	c.
d. Hepatitis B	d. Hypertension	d.
Type 1: One correct causal sequence and one unspecific COD reported on the lowest used line		
Example 4	Example 5	Example 6
a. Hepatic failure	a. Sepsis	a. Cerebral infarction
b. Liver tumour	b. Aspiration pneumonia	b. Renal failure
c.	c. Stroke	c.
d.	d.	d.
Type 2: Two or more correct causal sequences reported		
Example 10	Example 11	Example 12
a. Arrhythmia, heart failure	a. Respiratory failure	a. Gastric bleeding
b. Diabetes, hypertension	b. Aspiration pneumonia	b. Sepsis, liver cirrhosis
c.	c. Lung and bladder cancer	c.
d.	d.	d.
Type 3: Incorrect causal sequence reported		
Example 13	Example 14	Example 15
a. Renal failure	a. Respiratory failure	a. Pneumonia
b. Obstructive lung disease	b. Lung cancer	b. Pulmonary tuberculosis
c. Ischaemic heart disease	c. Diabetes mellitus	c. Liver cancer
d.	d.	d. Prostate cancer
Type 4: Only mechanism(s) of death reported		
Example 16	Example 17	Example 18
a. Cardiopulmonary failure	a. Septic shock	a. Arrhythmia
b. Renal failure	b.	b. Acidosis
c. Bacteraemia	c.	c.
d.	d.	d.

providing unspecific information on aetiology (stroke without specifying whether it is due to infraction or haemorrhage, tumour without specifying whether is benign or malignant and aspiration pneumonia without specifying whether it is milk or water or other foods) or on body region (gastrointestinal bleeding without specifying whether the bleeding occurred in the oesophagus, stomach, intestine or colon). Mechanism of death is defined as a physiological derangement or a biochemical disturbance produced by a COD, such as congestive heart failure, respiratory failure, various arrhythmias, bacteraemia, sepsis, acidosis. The mechanism of death does not provide aetiology-specific information and therefore should not be the underlying COD.[16 17]

Proper COD statements include one correct causal sequence and one specific COD reported on the lowest used line (see examples 1–3 in table 1). Type 1 improper COD statements comprise one correct causal sequence and one unspecific COD reported on the lowest used line (see examples 4–6 in table 1). Liver tumour (see example 4 in table 1) without specifying whether malignant or benign and stroke (see example 5 in table 1) without specifying whether it was infarction or haemorrhage. We also included cases in which mechanisms of death (eg, renal failure, sepsis, heart failure) were reported on the line below some specific COD (eg, cerebral infarction or acute myocardial infarction) in type 1 improper COD statements (see example 6 in table 1). For example, the true causal sequence might be cerebral infarction resulted in renal failure in example 6 in table 1; however, the reported causal sequence (renal failure resulted in cerebral infarction) is also acceptable according to *Decision Table D* in the *Instruction Manual Part 2c*.[15] Therefore, the underlying COD selected would be the mechanism of death (ie, renal failure in example 6). In this situation, renal failure was less specific than cerebral infarction and were less useful from the point of view of disease prevention.

Type 3 improper COD statements contain two or more correct causal sequences (see examples 10–12 in table 1). In other words, there were more than one diseases or conditions reported on one line. According to the Selection Rules, the first-mentioned COD will be selected as the underlying COD, that is, diabetes in example 10, lung cancer in example 11 and sepsis in example 12. However, the intended underlying COD of the certifying physician might not be the first-mentioned COD.

Type 3 improper COD statements comprise one incorrect causal sequence reported (see examples 13–15 in table 1). There were some specific COD (ischaemic heart disease in example 13, diabetes mellitus in example 14 and prostate cancer in example 15) incorrectly reported on the line below another specific

COD (obstructive lung disease in example 13, lung cancer in example 14 and liver cancer in example 15). Because the specific COD on the lower line could not result in the specific COD on the upper line, therefore, the specific COD on the upper line will be selected as the underlying COD according to the Selection Rules. However, the intended underlying COD of the certifying physician might be the specific COD on the lower line.

Type 4 improper COD statements involve only mechanism(s) of death being reported (see examples 16–18 in table 1). This is the most serious error because mechanism of death could not provide aetiology-specific information for disease prevention.

Authors T-JC and T-HL reviewed all the death certificates to determine whether the COD statement was acceptable or sustained one of the five types of error. T-JC is a senior neurologist and T-HL is a senior family physician and both are in charge of teaching in how to correctly report COD statements on the death certificate for residents in the two medical centres.

Data analysis

We first calculated the frequencies of the four types of improper COD statements among the death certificates analysed. We then computed the improper rate (containing at least one type of improper COD statement) and the major error rate (type 3 and type 4 improper COD statements combined) by specialty of the certifying physician. We classified 19 subspecialties in this study.

RESULTS

In 2009, a total of 2520 death certificates were issued by 230 physicians in two medical centres in Tainan, Taiwan. There were 502 death certificates that sustained at least one type of improper COD statement, with an overall improper statement rate of 20% (502/2520). However, only one-tenth (235/2520) had major errors, that is, 91 (3.6%) reported incorrect causal sequence and 144 (5.7%) reported only mechanism(s) of death (table 2).

The improper rate varied greatly by specialty of the certifying physician, ranging from 53% (24/45) among nephrologists and 45% (29/65) among infectious diseases physicians to 6% (57/995) among oncologists (table 3). Major errors (type 3 and type 4 combined) were highest among nephrologists (27%, 12/45), followed by cardiologists (25%, 31/125).

Table 2 Frequencies of the five types of improper cause-of-death (COD) statements among death certificates issued in two medical centres in Tainan, Taiwan, 2009

	N (%)	(%)
Total death certificates	2520 (100.0)	
Proper COD statements	2018 (80.1)	
Improper COD statements	502 (19.9)	(100.0)
Type 1: one correct causal sequence and one unspecific COD reported on the lowest used line	210 (8.3)	(41.8)
Type 2: two or more correct causal sequences reported	57 (2.3)	(11.4)
Type 3: incorrect causal sequence reported	91 (3.6)	(18.1)
Type 4: only mechanism(s) of death reported	144 (5.7)	(28.7)

DISCUSSION

Main findings

The findings of this study indicate that about one-fifth of death certificates sustained at least one type of improper COD statement. However, only one-tenth had major errors that would have noteworthy threat on the quality of COD statistics. The improper rate varied by specialty of the certifying physician and was highest among nephrologists and infectious disease physicians and lowest among oncologists.

Interpretations in relation to previous studies

Previous studies have presented different distributions of various types of improper COD statements. The most common error was found to be the reporting of an unspecific COD in four studies,[5–7 9] the reporting of an incorrect COD causal sequence in two studies[4 12] and the reporting of mechanism(s) of death only in one study.[13] One of the explanations of the above-mentioned variations are the differences in case-mix encountered in different medical settings. Another explanation is that certifying physicians in different medical settings have different COD certification behaviour patterns.

Consistent with previous Taiwanese study, unspecific COD statements were the most common improper COD statement.[6] The major error rate was 9% in this hospital-based study, which was similar with previous national study in Taiwan (11%). One possible explanation of lower major error rate in this study was that there were more patients with cancer in two medical centres in this study in which the determination of underlying COD was more straightforward.

Despite many studies having examined improper COD statements, few have assessed the improper rate by specialty of the certifying physician. One Canadian study indicated that the overall and major error rates were 61% and 40% in medicine, 65% and 35% in surgery, 50% and 17% in oncology, 27% and 15% in family medicine, 38% and 30% in paediatrics, and 56% and 22% in the critical care trauma unit, respectively.[4] Unfortunately, because of the small sample size, they did not further analyse the error rates by subspecialties. Consistent with the results of that study, the oncologists in this study had the lowest major error rate. Nevertheless, very few family physicians issue death certificates in medical centres in Taiwan.

Physicians of different specialties manage different types of diseases and conditions with contrasting complexities in terms of the determination of the underlying COD. For example, most patients treated by

Table 3 Improper* and major error† rates in cause-of-death (COD) statements by specialty of the certifying physician in two medical centres in Tainan, Taiwan, 2009

Specialty of certifying physician	Number of death certificates issued	Improper N (%)	Major error N (%)
Nephrology	45	24 (53.3)	12 (26.7)
Infection	65	29 (44.6)	8 (12.3)
Cardiology	125	49 (39.2)	31 (24.8)
Emergency	125	42 (33.6)	22 (17.6)
Others	51	16 (31.4)	11 (21.6)
Neurology	44	13 (29.5)	6 (13.6)
Other internal medicine	62	18 (29.0)	7 (11.3)
Neurosurgery	52	15 (28.8)	0 (0.0)
Paediatrics	56	16 (28.6)	9 (16.1)
Critical care medicine	433	118 (27.3)	54 (12.5)
Gastroenterology	157	42 (26.8)	22 (14.0)
General surgery	161	41 (25.5)	16 (9.9)
Respiratory medicine	115	18 (15.7)	6 (5.2)
Cardiac surgery	34	4 (11.8)	2 (5.9)
Oncology	995	57 (5.7)	29 (2.9)
Total	2520	502 (19.9)	235 (9.3)

*Improper denotes a death certificate containing at least one type of improper COD statement.
†Major error refers to death certificates that sustain type 3 'incorrect causal sequence was reported' and type 4 'only mechanism(s) of death reported' improper COD statements.

oncologists have cancer, and the determination of the underlying COD is comparably straightforward. Oncologists, who issued largest amount of death certificates; nevertheless, had the lowest improper rate (9% in this study) compared with their counterparts specialists. On the contrary, physicians in department of nephrology, infectious diseases, critical care, cardiology and respiratory medicine work mostly with patients with diseases or conditions lacking a specific aetiology, such as renal failure, sepsis, heart failure, respiratory failure and/or thus sustained a higher error rate in the COD statements.

As indicated by Kircher and Anderson,[16] most physicians tend to confuse cause and mechanism because medical therapy often attempts to modify or ameliorate mechanisms rather than causes. For example, digoxin is often highly effective in ameliorating the symptoms of congestive heart failure (mechanism) but does nothing to modify the underlying coronary artery disease (cause). It is rather difficult for physicians of infectious diseases, respiratory medicine or nephrology to specify the etiological causes of sepsis, respiratory failure and renal failure.

There were some debates on whether to define pneumonia as a specific COD (see example 3 in table 1). Ideally, the certifying physician should specify whether the pneumonia was due to which type of virus, bacteria or other aetiologies. However, in reality, it was very difficult to get relevant information. Furthermore, pneumonia is a common final pathway to death, which in most occasions was not suitable as the underlying COD. According to *Decision Table D* in the *Instruction Manual Part 2c*, all diseases or conditions could result in pneumonia, similar to other mechanisms of death (such as sepsis, respiratory failure, acidosis).[15]

In the revision of International Selection Rule 3 in the *Second Edition of the Instruction Manual of the International Classification of Diseases, Tenth Revision* (ICD-10) set by the WHO, which denotes that 'any pneumonia in ICD-10 code J12-J18 should be considered an obvious consequence of conditions that impair the immune system. Pneumonia in ICD-10 code J18.0 and J18.2-J18.9 should be considered an obvious consequence of wasting diseases (such as malignant neoplasm and malnutrition) and diseases causing paralysis (such as cerebral haemorrhage or thrombosis), as well as serious respiratory conditions, communicable diseases and serious injuries. Pneumonia in ICD-10 code J18.0 and J18.2-J18.9, J69.0 and J69.8 should also be considered an obvious consequence of conditions that affect the process of swallowing' (see WHO,[1] page 29).

Implications of this study

As there were one-tenth of death certificates analysed had major errors, that is, reported incorrect causal sequence and only mechanism(s) of death. Further studies are needed to retrospectively review the medical records for those death certificates to identify the real underlying COD and to estimate the possible effects on the estimation of cause-specific mortality rates.

With regard to intervention, a review study of educational interventions targeted at improving the quality of COD certification suggested that printed educational material alone is the intervention with the least educational impact and interactive workshops are the most effective intervention.[18]

Another way to improve the quality of COD statistics is to query the certifier who reported vague or incomplete information on the death certificate for clarification.

A study in the USA suggested that 51 of the 52 registration areas queried either demographic or COD information, and almost 90% of queries were returned. The underlying COD changed in approximately 68% of these cases.[19] The Bureau of Health of Tainan city could query death certificates in which only the mechanism of death is reported to obtain more specific information to improve the quality of COD statistics.

Strengths and limitations

Compared with previous similar hospital-based studies, this study has the largest sample size, which allowed us to stratify the improper rates by subspecialties. This study used very detailed classification of types of improper COD statements, which could provide very practical information for the design of materials for medical education.

One of the limitations of this study was that we analysed only the death certificates issued in two medical centres, and the case-mix and physicians' certification behaviours in the two medical centres studied might differ from those in other hospitals. Another limitation was that we were unable to differentiate whether COD statements were reported by junior residents or senior attending physicians because of the co-signature system used in the two medical centres studied. The four types of improper COD statements were by no means complete but were by far the most complete classification as compared with previous studies.

CONCLUSIONS

In conclusion, about one-fifth of death certificates sustained at least one type of improper COD statement. However, only one-tenth had major errors that would have noteworthy threat on the quality of COD statistics. The frequencies of improper COD statements varied greatly by specialty of the certifying physician because physicians with different specialties manage different types of diseases and conditions with contrasting complexities in terms of the determination of a specific COD. Educational intervention and queries should target specialties with a high frequency of improper COD statements.

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Funding This work was funded by the Chi-Mei and National Cheng Kung University Joint Program (CMNCKU9916). The funding sources had no role in the design and conduct of the study; the collection, management, analysis and interpretation of the data or the preparation, review and approval of the manuscript.

Competing interests None.

Ethics approval This study was approved by the Institution Review Boards of Chi-Mei Medical Center (09909-004) and the National Cheng Kung University Hospital (ER-99-170).

Provenance and peer review Not commissioned; externally peer reviewed.

Data sharing statement No additional data are available.

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APPENDIX 1

Types of improper cause-of-death statements used by previous studies

Leadbeatter[2] (1986)
1. No cause given
2. Multiple causes given—sequence not clear
3. Single cause given—relevant detail absent
4. Single cause given—error in layout

Zumwalt and Ritter[3] (1987)
1. Only mechanism(s) of death listed in part I
2. Information in part I reversed

3. Only cardiac arrest listed
4. Cause of death listed in part II instead of part I
5. Complications of cause of death listed in part II
6. Inappropriate material included

Weermanthri and Beresford (1992)
1. Mechanism only
2. Reversed logical sequence
3. Illogical sequence
4. Web
5. Underlying cause in part II

Jordan and Bass[4] (1993)
1. Mechanisms without explanation
2. Sequencing errors
3. 2 causes of death
4. No time interval recorded
5. Inappropriate information recorded

Armour and Bharucha (1997)
1. Mode of dying
2. Poor terminology
3. Clinical term or symptom
4. Sequence error
5. Non-existent terminology

Myers and Farquhar (1998)
1. Mechanism only
2. Improper sequencing
3. Competing causes

Lu *et al*[6] (2001)
1. Only mechanism(s) of death given
2. Multiple causal sequences given in pat I
3. Single causal sequence given but not specific enough
4. Single causal sequence given but the order was incorrect

Katsakiori *et al*[13] (2007)
1. The mechanism but not the cause of death is given
2. Multiple causal statements are given
3. A single but non-precise cause is given
4. A single causal sequence with incorrect order is given

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1, 2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4, 5
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-9 determination of type of improper statements
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6-9
Bias	9	Describe any efforts to address potential sources of bias	*9*
Study size	10	Explain how the study size was arrived at	6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	9
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	9
		(*b*) Describe any methods used to examine subgroups and interactions	9
		(*c*) Explain how missing data were addressed	No missing data
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	No sampling
		(*e*) Describe any sensitivity analyses	No

Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	No follow-up
		(b) Give reasons for non-participation at each stage	No non-participation
		(c) Consider use of a flow diagram	No flow diagram
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8
		(b) Indicate number of participants with missing data for each variable of interest	No missing data
Outcome data	15*	Report numbers of outcome events or summary measures	10
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	No adjusted estimate
		(*b*) Report category boundaries when continuous variables were categorized	No
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	No RR
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	No
Discussion			
Key results	18	Summarise key results with reference to study objectives	11
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	15
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	12
Generalisability	21	Discuss the generalisability (external validity) of the study results	11-14
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	16

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.