system, once the poor quality of death certification was identified, they could immediately query the certifier to modify the death certification. Thus a better quality of cause of death statistics could be attained immediately after the evaluation.

One limitation of this method was that the definition of hospital discharge main diagnosis and the UC do not coincide. Johansson and Westerling further innovatively used ACME (Automatic Classification of Medical Entry) software to solve this limitation, which rendered the monitoring system more robust. Many people might not be very familiar with the ACME. In the following, I firstly introduce what ACME is and how it works. Then, I point out some limitations of ACME and the possibility of improvement.

What is ACME?
To improve the comparability of cause of death statistics among different countries, International Selection Rules for selecting the UC was set by World Health Organisation. Nevertheless, the rules leave room for interpretation, which resulted in differences in the selection of UC across countries. To tackle the problem of inconsistency among coders within and across countries, in the late 1960s and early 1970s the US National Center for Health Statistics (NCHS) developed the ACME computer system to standardise the production mortality statistics. ACME uses information based on not only the International Classification of Diseases (ICD) codes for each reported condition on the death certificate, but also their actual location on the death certificate. The computer program then applies each international selection rule in sequence to these codes, resulting in a code for a temporary underlying cause (TUC). This TUC code is then subjected to each international modification rule in sequence, finally yielding assignment of a single UC code. The core of ACME is the Decision Tables, which provide specific relationships between one code and another to establish whether the causal sequence is acceptable, highly improbable, or acceptable as a consequence of Rule 3, or whether other modification rules are needed. ACME has been used in many countries and broad adoption would certainly improve the comparability of mortality across countries. One important feature of ACME is that the logic of selecting the UC for each death certificate could be visualised, which could be used for education and training purposes. The following three examples with different complexity in layouts of diagnoses on death certificates were used to illustrate how ACME processed.

Example 1
I (a) Acute myocardiac infarction (I219)
(b) Hypertension (I10)
(c) Diabetes (E149)
ACME process messages of example 1
01 1219/110/E149
02 Is 1219 due to E149? YES
03 Is 110 due to E149? YES
04 Select Initial TUC = E149—General Principle
05 ACME UC: E149

Example 2
I (a) Congestive heart failure (I509)
(b) Cerebral infarction (I639), endocarditis (I38)
(c) Liver cirrhosis (K746), uremia (N19), Diabetes (E149)
(d) Hypertension (I10)
II Chronic obstructive pulmonary disease (J449), Oral cancer (C069)
ACME process messages of example 2
01 1509/1639 138/K746/I10*J449 C069
02 Is 1509 due to I10? YES
03 Is 1639 due to I10? YES
04 Is 138 due to I10? YES
05 Is K746 due to I10? NO
06 No TUC by General Principle—Apply Rule 1
07 Is 1509 due to I639? YES
08 Is 1639 due to K746? NO
09 Select TUC = 1639—Rule 1
10 ACME UC: 1639

Example 3
I (a) Congestive heart failure (I509)
(b) Cerebral infarction (I639), endocarditis (I38)
(c) Liver cirrhosis (K746), uremia (N19), Diabetes (E149)
(d) Hypertension (I10)
II Chronic obstructive pulmonary disease (J449), Oral cancer (C069)
ACME process messages of example 3
01 1509/1639 138/K746 N19 E149/110*J449 C069
02 Is 1509 due to I10? YES
03 Is 1639 due to I10? YES
04 Is 138 due to I10? YES
05 Is K746 due to I10? NO
06 No TUC by General Principle—Apply Rule 1
07 Is 1509 due to I639? YES
08 Is 1639 due to K746? NO
09 Is 1639 due to N19? YES
10 Is N19 due to I10? YES
11 Select TUC = 110 - Rule 1
12 Linkage due to position condition I10 I509 I38
13 Linkage with mention of combination I10 I639 MAYBE
14 Linkage due to position mention I10 I639 YES
15 Linkage with mention of combination I10 I639 YES
16 Linkage due to position mention I10 I639 YES
17 Is 1509 due to K746? YES
18 Is 1639 due to N19? YES
19 Select TUC = N19—Rule 1
20 Select TUC = 110—Rule C linkage
21 ACME UC: 1120

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Using ACME (Automatic Classification of Medical Entry) software to monitor and improve the quality of cause of death statistics
Various methods have been used to evaluate the quality of cause of death statistics. Traditionally, necropsy findings were deemed as the gold standard to evaluate the accuracy of cause of death certification. However, because of the biased selection of necropsy cases and the decreasing necropsy rate, fewer and fewer evaluation studies have used necropsy findings as the standard. Another commonly used standard to evaluate the quality of death statistics is the consensus of a panel of physicians reviewing all available information related to the deceased. Most of the studies using this method were the byproducts of large cohort studies or randomised clinical trials. These studies wanted to assure that the end point was not biased.

The shortcomings of using physician review as the standard were time consuming, costly, not applicable in a large scale and routinely. As more and more disease specific registries and hospital medical records were computerised, more and more investigators began to use these datasets as the standard to evaluate the quality of cause of death statistics. The merits of this method were time saving, less costly, applicable in large scale and routinely. Several population based studies used computer linkage of cause of death file and hospital discharge file to compare the underlying cause of death (UC) and discharge diagnosis. Almost “every” deceased were medically attended in developed countries, these studies could thus evaluate the quality of “every” death certification. Johansson and Westerling attempted to develop a systematic and routine monitoring mechanism at the national level that can detect the poor death certification “before” the publication of mortality data. Unlike the previous post hoc studies, through this monitoring
Limitations of ACME

Though ACME has been deemed as the de facto international standard for interpreting ICD selection rules, it is not without problems. First limitation was that there were many “MAYBE” causal relations in the decision tables, which led to manual assignments for the UCs. Examples were listed as follow:

- Is K746 (liver cirrhosis) due to A419 (sepsis)? MAYBE
- Is K746 (liver cirrhosis) due to B169 (hepatitis B infection)? MAYBE
- Is I698 (sequels of stroke) due to E149 (diabetes)? MAYBE
- Is J449 (chronic obstructive pulmonary disease) due to I64 (stroke)? MAYBE
- Is J189 (pneumonia) direct sequel of I509? MAYBE
- Is R54 (senility) and I509 (heart failure) combined as R34? MAYBE

If different countries had different decisions for above “MAYBE” cases, this became another source of artefact undermining the comparability of mortality data across countries.

Another limitation, ironically this is in fact the strength of ACME, was the rigid adherence to the selection rules that resulted in the over-coding of mechanism of death (MOD). The MOD is a physiological derangement or a biochemical disturbance produced by a cause of death. Examples include various arthropathies, renal failure, cardiopulmonary failure, sepsis, and hypovolaemic shock. The cause of death, on the other hand, is a distinct entity, and is automatically specific. Examples include cerebrovascular infarction, lung cancer, diabetes mellitus, and alcoholic liver cirrhosis.

Because of their lack of aetiological specificity, MOD should not appear on death certificates.12 Neverthless, because medical treatment is often aimed at modifying or ameliorating mechanisms rather than causes, thereby physicians still filled many MODs on death certificate. This poor certification behaviour was fueled by high frequency of incorrect layout of diagnoses on the death certificates. Previous studies revealed that it was very common for physicians to enter two or more diagnoses in the same line in death certificate.13 Examples were:

- I (a) Uraemia, diabetes
- I (a) Heart failure, liver cancer
- I (a) Hepatic failure, ischaemic heart disease

Another common certification error was the reverse layout of causal relations. For example, hypovolaemic shock (HS) was due to oesophageal varices bleeding (EVB) and EVB due to liver cirrhosis (LC). A correct layout should put HS in line (a), EVB in line (b), and LC in line (c), nevertheless it was not very uncommon that the certifier might put HS in line (c), EVB in line (b), and LC in line (a). Other examples were:

- I (a) Acute myocardial infarction (b) Pneumonia (c) Sepsis
- I (a) Stroke (b) Urinary tract infection (c) Sepsis

According to international selection rule 2 (for first three examples) and general principle (for last two examples), ACME would select MOD—that is, uraemia, heart failure, hepatic failure, and sepsis as the UC for above examples. Most people will agree that these results were obviously not the original intents of the certifiers. MOD could not provide useful information for prevention.

Luckily many of the above mentioned problems might be fixed by Mortality Reference Group (MRG), which was set up by the World Health Organisation with the mandate to issue authoritative instructions on the interpretation of the ICD coding rules and guidelines. The NCHS have pledged themselves to implement the decision of the MRG in ACME decision tables. It is hoped that the modified Decision Tables will be more acceptable to people in most countries.

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References


Seasonality of live birth sex ratio in south-west Siberia, Russia, 1959–2001

Seasonality of sex ratio of live births (SR: male births divided by total births) has been reported in Europe North America, Brazil, and Australia. However, no uniform pattern is seen.1 Moreover, the magnitude of any observed seasonal variation varies from population to population with marked variation in Japan to minor variation in Germany.2 In south western Finland, Scotland, Costa Rica, and Hauza, Africa. The population of Novosibirsk region was 2 767 938 in 1988. Siberian climate exhibits considerable seasonal temperature changes, in Novosibirsk over the period 1951–1980, the average difference in mean monthly air temperature between January (the coldest month, −18.8°C) and July (the warmest month, 19.0°C) was 37.8°C. We tested the null hypothesis that there is no seasonal variation in SR in Siberia.

Records of live singleton births were obtained from the Novosibirsk Regional Committee for Statistics. Data by month were obtained for the years 1959–2001, excluding 1961, 1962, and 1988 because of missing data. Seasonal analysis was carried out by Edwards’ method. Our analysis was quarterly because of the comparatively small number of births. Linear regression analysis was performed to test for secular trend.

A highly significant seasonal pattern was evident (r²=14.4, p=0.001) with an amplitude of 1.2% of the overall birth rate (to be compared with the second quarter (9=129°) and a trough in the fourth quarter (fig 1).

Figure 1 Seasonality of sex ratio at birth in Novosibirsk region, Russia, 1959–2001. SR: male births divided by total births. Values are means and 95% confidence intervals.

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A negative annual secular trend was found for the period 1971–1980 (r = −0.84, p = 0.002), which was replaced by the positive trend during the period 1982–1993 (r = 0.78, p = 0.004). No difference in mean SRs for the entire period was found between urban (0.513) and rural (0.513) populations.

The decrease in male births in the last quarter equates to fewer male conceptions nine months previously—that is, in the first quarter. Climatic variations in west Siberia are extreme, with heavy snowfalls in winter. Thawing of snow requires considerable energy, therefore temperatures remain low in spring, and rise sharply from the second half of April. If the observed variation in SR is indeed temperature related, then it would seem that low temperatures either reduce male conceptions or, through unknown mechanisms, reduce the survival of male conceptuses.

Industrialisation has been blamed for declining SRs in industrialised countries over the past half century. In Siberia, a different pattern is evident in that SR fell and then rose with a turning point in the early 1980s.

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