Analysis of the quality of death certification in Islamic Republic of Iran

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Abstract

Background: Death certification is a vital source of information for assessing population health worldwide.

Aim: To assess the quality of death certificates issued by physicians in the Islamic Republic of Iran.

Methods: Using a customized and translated version of the death certificate quality assessment tool designed by the University of Melbourne, we analysed death certificates issued by doctors in Islamic Republic of Iran, to identify errors and make recommendations for quality improvement.

Results: Of the 25 123 certificates reviewed, only 29.3% were correctly completed and 67.7% were incomplete. Most (59.1%) of the certificates were issued in hospitals and 18.9% were issued by other doctors. The majority (63.3%) of deaths occurred in hospitals and few surgery centres while a large proportion occurred at home (32.3%). The most common error (86.3%) was, not recording the interval between the onset of illness and death while the least common error (14.5%) was, illegible handwriting.

Conclusion: This study found errors and quality gaps in physician-issued death certificates in Islamic Republic of Iran. To enhance the quality of mortality data, there is a need to develop guidelines and train physicians on quality assurance of related data collection. Integrating death certification into existing electronic health data systems can help streamline and significantly enhance the accuracy and efficiency of death certification.

Keywords: death certification, mortality, cause of death, Iran

Background

Cause of death data obtained from civil registration and vital statistics systems (CRVS) are very important for public health assessments, identification of health priorities and design of health interventions (1–4). Medical death certificates (MDCs) are used as a key tool for global mortality and cause of death statistics, which are used for surveillance and monitoring of population health at national and local levels (5–7). Death certificates have many uses, including legal documentation of death, public health assessment and design of preventive health measures. They are vital for clinical research, outcome-based studies and for deterring criminal activities (8,9).

Poor quality death certificates can lead to misinformed policies and misdirected resource allocation, which can in turn affect population health outcomes. Misclassification of causes of death can skew disease surveillance data, leading to inappropriate public health responses (10–12). A study reported that 53% of death certificates contained errors, with 51% having significant errors that greatly influenced the interpretation of the cause of death (13). Such high error rate can affect national mortality statistics and public health research.

Global initiatives, such as WHO's International Classification of Diseases (ICD) and Verbal Autopsy Standards, provide frameworks for standardizing death certification practices and improving mortality data accuracy, especially in regions with limited access to medical certification (14), and Islamic Republic of Iran has made efforts to align its death certification system with these global standards. National programmes have focused on training health professionals on accurate death certification and implementation of electronic death registration systems. However, challenges remain, particularly in rural areas that have limited access to trained certifiers (15). In many developing countries, physicians are not sufficiently aware of the importance of death data obtained from MDCs mainly due to inadequate training in this area, resulting in poor data quality (16,17).

Several factors contribute to the low quality of death certificates, including insufficient understanding of the certificates and their relevance, a scarcity of qualified doctors in rural regions, challenges in determining the cause of death, limited experience among physicians in issuing certificates, and limited access to diagnostic tools. Additionally, cultural sensitivities surrounding certain causes of death (e.g. suicide, maternal mortality) may lead to deliberate misclassification or underreporting (18–20).

Countries devote considerable resources to collecting mortality data from different sources, including civil registries, medical facilities, demographic surveillance,

and surveys, to generate evidence for public health policymaking. However, without careful data quality checks and validation, the valuable data collected—often at considerable cost—may not be useful for decision-making.

WHO and other global institutions have established protocols and guidelines for coding mortality and morbidity data (25), and the dependability of cause of death data is linked to the accuracy of the MDC and the precision of the coding process. The 2 aspects may appear to be distinct but they are intrinsically connected. Only qualified medical professionals should issue a death certificate, ensuring that the MDC form is filled correctly (13). The data is then translated into an alphanumeric code by a trained coder from a pool of more than 10 000 possible codes, representing potential underlying causes of death based on the ICD (25).

The most reliable method for obtaining credible death statistics is certification by a medical doctor, which is considered the "gold standard" for producing accurate cause of death information. The accuracy of the doctor's diagnosis depends on several factors, including their education, experience with using MDC and access to clinical records and diagnostic tools. Studies have shown that the quality of MDCs can be low even when completed by a physician (1–4).

MDCs can have 2 kinds of errors: major errors and minor errors. Major errors consist of multiple causes per line, incorrect sequence of events leading to death, illegible handwriting, ill-defined or poorly specified condition entered as the underlying cause of death, insufficient information about the external cause of death, and insufficient information about neoplasms. Minor errors include the presence of gaps within the sequence of events, abbreviations used in certifying the death, absence of disease time interval, and other errors on the certificate (26). The medical education curricula in many countries do not include courses on death certification, which is crucial for medical practice (27).

The efficiency of the medical records department is reflected by the thoroughness of the death certification as inadequate information causes poor quality certification (28). The MDC assessment tool is often used to quickly assess the quality of death certificates. It is a useful tool for identifying common errors and determining the training needs of doctors (29).

Recognizing the need for accurate and dependable mortality data, Islamic Republic of Iran established a comprehensive, multi-source death registration system in 1998. The system aggregates cause of death information from MDCs gathered at hospitals, primary health care facilities, coroners' offices, approved cemeteries, the National Organization of Civil Registration (NOCR), and other potential district level sources (21–24). This research aimed to assess a selection of MDCs issued by doctors in Islamic Republic of Iran, identify errors in the certificates and make recommendations for improvements.

Methods

In this descriptive analytic study, we used an assessment tool developed by the University of Melbourne to assess the quality of death certificates in Islamic Republic of Iran (30). The tool was introduced to participants from several countries during a workshop organized by the WHO Regional Office for the Eastern Mediterranean. We customized the tool and translated it into Farsi, along with the specific guidelines. Subsequently, a workshop was conducted to train a selected group of experts in death registration and cause of death classification at the subnational level on how to use the tool to assess death certificates issued by physicians and identify errors.

We assessed 25 123 death certificates nationwide. We stratified the study sample based on population size: 20% of death certificates issued by provinces or universities with <1 million population and 10% of death certificates issued by areas with >1 million population. This approach helped optimize resource use while ensuring representativeness. By focusing on the prevalent errors using established checklists, we achieved the targeted assessment. We used the chi-square test to investigate whether the errors differed across universities or provinces. The null hypothesis stated that there is no difference between the 2 groups.

Results

Of the 25 123 certificates reviewed, only 29.3% (7360) were correctly completed and 67.7% (17 010) were incomplete (Tables 2 and 3). Most (59.1%) of the certificates were issued in hospitals and 18.9% were issued by other doctors. The majority (63.3%) of deaths occurred in hospitals and few surgery centres while a large proportion occurred at home (32.3%). The most common error (86.3% or 21 681) was, not recording the interval between the onset of illness and death while the least common error (14.5% or 3654) was, illegible handwriting (Table 1). All P values were <0.05, leading to the rejection of the null hypothesis and indicating a significant difference between the responses (Table 1).

Discussion

This was the first comprehensive quality assessment of medical death certificates in Islamic Republic of Iran. The study found that the most common error was, not recording the interval between onset of illness and death (22 098 cases) and the least common was, illegible handwriting (3654 cases). Only 7360 certificates were correctly completed and 17 010 were incomplete. These findings highlight the need for improved accuracy and completeness of death certificates, as well as guidelines and training for physicians on death certification. Addressing these concerns is crucial for enhancing the quality of mortality data for public health planning and policymaking.

Findings from this study align with a similar investigation in Saudi Arabia, which found 80.3%

Table 1 Percentages of death certificate errors, Islamic Republic of Iran

Question	Error type	Yes (%)	No (%)	P
1	Multiple causes per line	27	73	<0.01
2	Time interval between onset and death was blank	86	14	<0.01
3	Blank lines within the sequence/chain of events (not using consecutive lines)	22	78	<0.01
4	Abbreviations used	27	73	<0.01
5	Illegible handwriting	15	85	<0.01
6	Incorrect/clinically improbable sequence of events leading to death	25	75	<0.01
7	An ill-defined condition as the underlying cause of death	30	70	<0.01
	If yes, was the ill defined			<0.01
7_1	Impossible underlying cause (i.e. signs and symptoms)	44	56	<0.01
7_2	Intermediate cause	29	71	<0.01
7_3	Mode of death (i.e. respiratory arrest)	33	67	<0.01
7_4	Unspecified causes within a larger death category (i.e. unspecified accident)	13	87	<0.01
7_5	Others	14	86	<0.01
8	Were there additional errors on the certificate?	35	65	<0.01
	If yes, select all those that apply:			<0.01
8_1	For deaths due to external causes, additional details were missing	7	93	<0.01
8_2	For deaths due to neoplasms, additional details were missing	33	67	<0.01
8_3	Changes/alterations made by any means other than drawing a line through the original text (i.e. using correction fluid)	2	98	<0.01
8_4	No units specified for the age	7	93	<0.01
8-5	Others	99	1	<0.01
9	Overall, was the medical certificate of cause of death correctly filled?	30	70	<0.01

misdiagnosis rate for the main cause of death (5). In India, all 410 forms assessed were incomplete and inaccurate (30). The time between the cause and actual death was mentioned in only 2 certificates and it was also inaccurate. The mode of death was recorded as immediate in 353(86%) cases or antecedent in 170(41%) cases, multiple causes in 229(56%), and use of short forms in 143 (35%). In a cross-sectional study of 139 certificates in Nepal, none was error-free (31). The most common error was incorrect or incompletely reported immediate cause of death (77.7%). Other errors were absence of time of death (17.3%), use of abbreviations (57.6%), illegible writing (22.3%), and omission of hospital stamp or medical council registration

number (8.6%). Based on international criteria, 76.3% had minor errors and 23% had major and minor errors.

Medical death certificates issued by doctors serve as the primary source of mortality information in many countries and the accuracy of such record is crucial because it directly affects the overall correctness of mortality data. However, despite the critical role of these data, many doctors are not meticulous enough when completing the certificates. The main reason for this is the lack of training on death certificate assessment during medical education.

To enhance the quality of medical certification of cause of death, several interventions have been suggested (32).

Table 2 Death certificates assessed by place of death, Islamic Republic of Iran

Place of death	Number	Percentage
Sanatorium	176	0.7
Hospital/surgical centre	15 895	63.2
Home	8125	32.3
Outpatient treatment centre	361	1.4
Passages and public places	132	0.5
Others*	136	0.5
Unknown	298	1.2
Total	25 123	100

Such as on the way to hospital

Table 3 Death certificates assessed by issuer, Islamic Republic of Iran

Issuer of death certificate	Number	Percentage
Hospital	14 852	59.1
Health centre physician	843	3.4
Forensic medicine	4112	16.3
Others*	197	0.8
Other doctors	4737	18.8
Unknown	382	1.5
Total	25 123	100

Such as verbal autopsy

First is the training of doctors. The most effective approach is to incorporate medical certification of cause of death training into the curriculum for undergraduate medical students and to provide on-the-job training for physicians. Training physicians in medical certification has been found to improve the diagnostic accuracy of certification, with the proportion of incorrectly completed certificates decreasing from 73–100% pre-training to 44–75% post-training (33). In the Philippines, training led to a 40% increase in error-free medical certification of cause of death, and in Peru, online interventions reduced error scores by 38% and training by 26% (33). Fewer than 25% of physicians in 19 studies reported being trained on how to fill death certificates (34).

Various training methods can be adopted depending on the specific context, and these include training of trainers, direct training, online, and basic training (35). To be effective and sustainable, medical certification of cause of death training should be institutionalised at country and facility levels. Institutionalisation will enhance consistency and accuracy of cause of death reporting across health facilities (33).

Considering the critical role of information technology in health systems, particularly regarding vital events, electronic medical death certificate can be leveraged to enhance the quality of medical death certificates (36). Using electronic certificate has several benefits. Researchers in France found that electronic death certificates had more options for coding the causes of death than paper certificates and that the proportion of precise death certificates was notably higher for the electronic version (37). Electronic certificates allow more effective application of the ICD principles to death certification.

The use of electronic certificates is of major public health interest for the development of real-time mortality surveillance systems (38). The widespread adoption of electronic medical records in the Iranian health system provides a robust foundation for the development of electronic death certification. By seamlessly integrating electronic death certificates into existing electronic medical records systems, healthcare units can streamline processes, reduce administrative burdens and significantly enhance the accuracy and efficiency of registration and certificate issuance (39).

Study limitations

It is important to acknowledge the limitations inherent in our study. Our analysis provides insight on death certification at the national level, however, quality may vary significantly across provinces due to variations in access to diagnostic and treatment facilities. The absence of information from doctors in specific regions, such as Zahedan University, posed specific challenges. It was impossible to aggregate the data according to occurrence at rural, home or hospital settings. These limitations highlight the importance of focused interventions and additional research within regional and facility contexts.

Conclusion

Information from medical death certificates is vital for evidence-based health policy planning, monitoring and evaluation. Our study identified several limitations in physician-issued death certificates in Islamic Republic of Iran. Targeted interventions are needed to address these limitations, including incorporating death certification into the training curriculum for medical students and the integration of medical death certificates electronic medical systems in public and private health facilities. Improving the accuracy of death certification will enhance the reliability of health data and lead to better-informed health interventions.

Acknowledgements

Analyse de la qualité de la certification des décès en République islamique d'Iran

Résumé

Contexte : La certification des décès est une source d'information essentielle pour évaluer la santé de la population mondiale.

Objectif : Évaluer la qualité des certificats de décès délivrés par les médecins en République islamique d'Iran.

Méthodes : À l'aide d'une version adaptée et traduite de l'outil d'évaluation de la qualité des certificats de décès conçu par l'Université de Melbourne, nous avons analysé les certificats délivrés par des médecins en République islamique d'Iran afin d'identifier les erreurs et de formuler des recommandations en vue d'améliorer la qualité.

Résultats : Sur les 25 123 certificats examinés, seuls 29,3 % étaient correctement remplis et 67,7 % étaient incomplets. La plupart des certificats (59,1 %) ont été délivrés dans des hôpitaux ; 18,9 % émanaient d'autres médecins. La majorité des décès (63,3 %) sont survenus dans des hôpitaux et quelques centres de chirurgie, tandis qu'une proportion importante de ces événements se sont produits à domicile (32,3 %). L'erreur la plus courante (86,3 %) était l'absence d'indication de l'intervalle entre le début de la maladie et le décès, tandis que la moins courante (14,5 %) concernait l'écriture manuscrite illisible.

Conclusion : La présente étude a relevé des erreurs et des lacunes en matière de qualité dans les certificats de décès délivrés par des médecins en République islamique d'Iran. Pour améliorer la qualité des données sur la mortalité, il est nécessaire d'élaborer des lignes directrices portant sur l'assurance qualité lors de la collecte de ces données et de former les médecins à leur mise en œuvre. L'intégration de la certification des décès dans les systèmes électroniques de données de santé existants peut contribuer à rationaliser et à améliorer considérablement l'exactitude et l'efficacité de la certification.

تحليل جودة الإشهاد على الوفاة في جمهورية إيران الإسلامية

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الخلاصة

الخلفية: الإشهاد على الوفاة مصدر مهم للمعلومات اللازمة لتقييم صحة السكان في جميع أنحاء العالم.

الأهداف: هدفت هذه الدراسة إلى تقييم جودة شهادات الوفاة التي يصدرها الأطباء في جمهورية إيران الإسلامية.

طرق البحث: باستخدام نسخة مخصصة ومترجمة من أداة تقييم جودة شهادات الوفاة التي صممتها جامعة ملبورن، حللنا شهادات الوفاة التي يصدرها الأطباء في جمهورية إيران الإسلامية، لاكتشاف الأخطاء وتقديم توصيات لتحسين جودتها.

النتائج: من أصل 25123 شهادة شملها الاستعراض، لم تتجاوز نسبة الشهادات المستوفاة بطريقة صحيحة 29.3%، أما باقي الشهادات (67.7%) فكانت غير مكتملة. كما صدرت أكثر من الشهادات (59.1%) عن المستشفيات، بينما صدرت 18.9% عن أطباء آخرين. وقد وقعت غالبية الوفيات (63.3%) في المستشفيات وعدد محدود من مراكز الجراحة، كما وقعت نسبة كبيرة منها في المنازل (32.3%). وكان أكثر الأخطاء شيوعًا (86.3%) هو عدم تسجيل الفترة بين بداية المرض والوفاة، وأقلها شيوعًا (14.5%) هو الكتابة بخط غير مقروء.

الاستنتاجات: كشفت هذه الدراسة عن وجود أخطاء وثغرات في جودة شهادات الوفاة التي يصدرها الأطباء في جمهورية إيران الإسلامية. ولتعزيز جودة بيانات الوفيات، هناك حاجة إلى وضع مبادئ توجيهية، وتدريب الأطباء على ضمان جودة جمع البيانات المهمة. كما يمكن أن يساعد إدماج

References

1. Hernandez B, Ramirez-Villalobos D, Romero M, Gomez S, Atkinson C, Lozano R. Assessing quality of medical death certification: concordance between gold standard diagnosis and underlying cause of death in selected Mexican hospitals. Pop Health Met 2011;9(38). doi:10.1186/1478-7954-9-38.

2. Macintyre S, Chalmers I, Horton R, Smith R. Using evidence to inform health policy: case studs. Br Med J. 2001;322(7280):222–225. doi: 10.1136/bmj.322.7280.222.

3. Petticrew M, Whitehead M, Macintyre SJ, Graham H, Egan M. Evidence for public health policy on inequalities: 1: the reality according to policymakers. J Epidemiol Community Health 2004;58(10):811–816. doi:10.1136/jech.2003.015289.

4. Victora CG, Habicht JP, Bryce J. Evidence-based public health: moving beyond randomized trials. Am J Public Health 2004;94(3):400–405. doi:10.2105/AJPH.94.3.400.

5. Binsaeed A, Alsaadi A, Aljerian KH, Al-saleh S. Assessment of the accuracy of death certification at two referral hospitals. J Fam Comm Med. 2008;15(1):43-50. doi:10.4103/2230-8229.97064.

6.   Lucero M, Riley ID, Hazard RH, Sanvictores D, Tallo V, Gay D, et al. Assessing the quality of medical death certification: a case study of concordance between national statistics and results from a medical record review in a regional hospital in the Philippines. Pop Health Met 2018;16(23). doi:10.1186/s12963-018-0178-0.

7.   Alipour J, Karimi A, Miri-Aliabad G, Baloochzahei-Shahbakhsh F, Payandeh A, Sharifian R. Quality of death certificates completion for COVID-19 cases in the southeast of Iran: A cross-sectional study. Health Sci Reports 2022;5(5). doi:10.1002/hsr2.802.

8.   Sibai AN, Nuwaihid I, Beydouin M, Chaaya M. Inadequacies of death certification in Beirut: Who is responsible. Bull World Health Org. 2002;80:555-561. https://iris.who.int/handle/10665/268541/.

9.   Swift B, West K. Death Certification: an audit of practice entering the 21st Century. J Clin Pathol 2002;55:275-279. doi:10.1136/jcp.55.4.275.

10. Naghavi M, RichardsHafiz N, Chowdhury, Eynstone-Hinkins J, Franca E, Hegnauer M, et al. Improving the quality of cause of death data for public health policy: are all 'garbage' codes equally problematic? BMC Med. 2020;18(1):55. doi:10.1186/s12916-020-01525-w.

11. Khosravi A, Rao C, Naghavi M, Taylor R, Jafari N, Lopez AD. Impact of misclassification on measures of cardiovascular disease mortality in the Islamic Republic of Iran: a cross-sectional study. Bull World Health Organ. 2008;86(9):688–696. doi: 10.2471/blt.07.046532.

12. G Maudsley, Williams EM. Inaccuracy' in death certification--where are we now? J Public Health Med 1996;18(1):59-66. doi: 10.1093/oxfordjournals.pubmed.a024463.

13. McGivern L, Shulman L, Carney JK, Shapiro S, Bundock E. Death certification errors and the effect on mortality statistics. Public Health Rep. 2017;132(6): 669–675. doi:10.1177/0033354917736514.

14. World Health Organization. Improving the quality and use of birth, death and cause-of-death information, guidance for a standards-based review of country practices. Geneva: World Health Organization, 2010. https://iris.who.int/handle/10665/44274/.

15. Aghamohamadi S, Khosravi A, Kazemi E, Atefi A. Assessment of the data quality of cause of death registration in Iranian hospitals in 2016. IRJE 2020;16(1):90-99. http://irje.tums.ac.ir/article-1-6528-en.html/.

16. Moussa MA, Shafie MZ, Khogali MM, El-Sayed AM, Sugathan TN, Cherian G, et al. Reliability of death certificate diagnosis. J Clin Epidemiol 1990;43(21):1285-1295. doi: 10.1016/0895-4356(90)90094-6.

17. Myers KA, Farquhar DR. Improving the accuracy of death certification. CMAJ 1998;158:1317-1323. PMID: 9614825, PMCID: PMC1229326.

18. Filippatos G, Andriopoulos P, Panoutsopoulos G, Zyga S, Souliotis K, Gennimata V, et al. The quality of death certification practice in Greece. Hippokratia 2016;20(1):19–25. PMID: 27895438, PMCID: PMC5074392.

19. Nojilana BI, Groenewald P, Bradshaw D, Reagon G. Quality of cause of death certification at an academic hospital in Cape Town, South Africa. S Afr Med J. 2009;99(9):648–652. PMID: 20073291.

20. Pillay-van Wyk V, Bradshaw D, Groenewald P, Laubscher R. Improving the quality of medical certification of cause of death: The time is now. S Afr Med J. 2011;101(9):626. PMID: 21920165.

21. Jafari N, Kabir MJ, Motlagh ME. A supplementary Issue on Iran's achievements in health, three decades after the Islamic revolution. Iranian J of Public Health 2009;38(Suppl. 1):127-129. https://unstats.un.org/unsd/vitalstatkb/KnowledgebaseArticle50546.aspx/.

22. Khosravi A, Taylor R, Naghavi M and Lopez A. Mortality in the Islamic republic of Iran, 1964-2004. Bull World Health Organ. 2007;85(8):607–614. doi: 10.2471/BLT.06.038802.

23. Khosravi A, Taylor R, Naghavi M, D Lopez A. Differential mortality in Iran. Pop Health Metrics 2007;5(7). doi:10.1186/1478-7954-5-7.

24. Kazemeini H, Khosravi A, Mousavi SJ, Amanolahi A, Aghamohammadi S. Injury induced mortality in Iran from 2006 to 2010. Open J Prev Medicine 2015;5(11). doi: 10.4236/ojpm.2015.511049.

25. World Health Organization. International statistical classification of diseases and related health problems. Geneva: World Health Organization, 2016. https://iris.who.int/handle/10665/246208.

26. Gamage USH, Adair T, Mikkelsen L, Koralage P, Mahesh B, Hart J, et al. The impact of errors in medical certification on the accuracy of the underlying cause of death. PLoS One 2021;16(11). doi: 10.1371/journal.pone.0259667.

27. Al Busaidi S, Al Alawi AM, Al Masruri R, Al Balushi S, Al Badi A. Quality of death certification based on the documented underlying cause of death: A retrospective study. J Forensic Legal Med. 2023;97(102547). doi: 10.1016/j.jflm.2023.102547.

28. Morgan A, Andrew T, Guerra SMA, Luna V, Davies L, Rees JR. Provider reported challenges with completing death certificates: A focus group study demonstrating potential sources of error, PLoS One 2022;17(5). doi:10.1371/journal.pone.0268566.

29. University of Melbourne. Assessing the quality of death certificates: Guidance for the rapid tool. CRVS resources and tools. Melbourne: University of Melbourne, 2018. www.mspgh.unimelb.edu.au,dataforhealth.

30. Uplap P, Sankhe DWL. Assessment of medical certificate of cause of death at a tertiary care center in Mumbai, India. Ind J Forensic Comm Med. 2019;6(2):70-74. doi: 10.18231/j.ijfcm.2019.017.

31. Atreya A, Acharya B, Yadav PP, Menezes RG, Nepal S. Evaluation of errors on death certificates. J Nepal Health Res Counc. 2024;22(1):150-156. doi: 10.33314/jnhrc.v22i01.4941.

32. Gamage USH, Mahesh PKB, Schnall J, Mikkelsen L, Hart JD, Chowdhury H, et al. Effectiveness of training interventions to improve quality of medical certification of cause of death: systematic review and meta-analysis. BMC Medicine 2020;18(1):384. doi: 10.1186/s12916-020-01840-25.

33. Hart JD, Sorchik R, Bo KS, Chowdhury HR, Gamage S, Joshi R, et al. Improving medical certification of cause of death: effective strategies and approaches based on experiences from the Data for Health Initiative. BMC Medicine 2020;18(74). doi:10.1186/s12916-020-01519-8.

34. Alaha MA, Alchawaa M, Ahmeda S, Osamaa M, Kehyayanb V, Bougmiza I. Death certification status in Eastern Mediterranean Region: A systematic review. Death Stud 2022;46(9):2100-2109. doi: 10.1080/07481187.2021.1890651.

35. Martin BO, Kolomitro K, Lam TCM. Training methods: A review and analysis. Human Res Dev Rev. 2014;13(1):11–35. doi:10.1177/1534484313497947.

36. Vasudevan L, Glenton C, Henschke N, Maayan N, Eyers J, Fønhus MS, et al. Birth and death notification via mobile devices: a mixed methods systematic review. Cochrane Database Syst Rev. 2021;2021(7). doi: 10.1002/14651858.CD012909.pub2.

37. Lefeuvre D, Pavillon G, Aouba A, Lamarche-Vadel A, Fouillet A, Jougla E, Rey G. Quality comparison of electronic versus paper death certificates in France, 2010. Pop Health Metrics 2014;12(3). doi:10.1186/1478-7954-12-3.

38. Lassalle M, Caserio-Schönemann C, Gallay A, Rey G, Fouillet A. Pertinence of electronic death certificates for real-time surveillance and alert, France, 2012–2014. Public Health 2017;143:85-93. doi: 10.1016/j.puhe.2016.10.029.

39. Kalkhajeh SG, Aghajari A, Dindamal B, Shahvali-Kuhshuri Z, Faraji-Khiavi F. The integrated electronic health system in Iranian health centers: benefits and challenges. BMC Prim Care 2023;24:53. doi:10.1186/s12875-023-02011-x.