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REPORT

Hospital mortality indicators: foreign experience, literature teachings and guidelines

to support public decision-making and the development of indicators in France

This document is a translation of the original French document

July 2017

Description of the publication

Title	**Hospital mortality indicators: foreign experience, literature teachings and guidelines** **to support public decision-making and the development of indicators in France**
Method of production	The report is based on a review of hospital mortality indicators currently used in five countries and a review of the international literature.
Objectif(s)	**This operational document is made up of 3 parts :** – A review of the mortality indicators currently used in five countries (United Kingdom, United States, Canada, Australia and Germany) to compare healthcare institutions. – A review of the international literature in order to discuss the advantages and drawbacks of the different mortality indicators: purpose of the indicator, scope, source data, adjustment models, links with other quality indicators (process, structure) and side-effects of their use. – HAS recommendations to guide public decision-making and the development of hospital mortality indicators that allow the comparison of healthcare institutions in France.
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Summary

A look at the mortality indicators used in five countries (United States, United Kingdom, Canada, Australia and Germany) reveals that the countries use overall mortality indicators, except for the United States, as well as specific mortality indicators. Most of these countries publish the results of these indicators.

Overall mortality or specific mortality ?

A review of international literature reveals that overall mortality is a concept which is easier to grasp than specific mortality and eliminates sample size issues:

- for overall mortality, a few methodological precautions must be taken: exclusion of expected or unavoidable deaths, choice of source data and adjustment model.
- specific mortality is a more precise and more medical measurement. It involves fewer deaths and targets simple conditions or essential surgical procedures of which there is a sufficient number.

In-hospital (IH) mortality or 30-day mortality?

The most widely used measures are IH mortality rates and 30-day mortality rates (from admission/intervention), whether the patient is still hospitalised or not. IH mortality indicators are dependent on the discharge policy of the healthcare institution (ES), unlike the 30-day indicators. The latter are most often used.

The work conducted in France confirms international literature results

- AMPHI[1] project: the IH mortality indicator does not identify excess mortality in the same healthcare institutions as the 30-day indicator (deaths inside or outside the institution). The results of an IH mortality indicator depend on the healthcare institution's average length of stay, which in turn depends on their discharge policy.
- RNMH[2] project (IMER[3] centre/ Hospices Civils de Lyon): the use of an overall IH mortality indicator to assess all of the care provided by a healthcare institution is still premature, whether for public disclosure or inter-ES[4] comparison purposes.

Modalities for using mortality indicators and related impacts:

Published literature reveals that patients rarely seek information on mortality reports, do not understand them, or have no trust in such information. The reports are used to a larger extent by insurers when drawing up contracts with healthcare institutions to select practitioners, and by practitioners to identify aspects that could be improved.

The public disclosure of mortality indicator results or their use in financial incentive programmes can have adverse effects: i) modification of coding practices, ii) selective admission of patients according to their risk of dying, iii) rapid transfer of patients with a high death risk to other healthcare institutions, iv) adaptation of surgeons to the risk according to their competencies.

[1] Analysis of post-hospital mortality: search for institution-specific indicators.

[2] Study of the validity of the Hospital Standardized Mortality Ratio (HSMR), quality of hospital stay documentation in the medical IT system to estimate the HSMR, study report, 30 June 2016 (non-published).

[3] Medical Information, Evaluation and Research centre (IMER) based at Hospices Civils de Lyon (HCL).

[4] In 24 healthcare institutions, 30 anonymous discharge summaries produced in 2010 were selected at random. Their content was examined and then compared to that obtained after analysis of the patient's medical record. Out of the 715 stays examined, 51.3% (CI95%=47.6% - 55.1%) required the recoding of one of the key variables used to calculate the HSMR, which resulted in a modification of the probability of the patient's death during their hospitalisation. Depending on healthcare institutions, 25.9% to 73.3% of the stays examined were thus recoded, with an impact on their HSMR. For 5 healthcare institutions, the *funnel plots* before and after recoding showed major changes in performance, with a different distribution in mortality strata.

Guidelines for the development of mortality indicators in France:

For the development of hospital mortality indicators in France, preference should be given to specific indicators of mortality within 30 days of admission (for medical conditions) or a surgical procedure. As a priority, the conditions/procedures to be chosen are those for which indicators have already been validated on the international level (e.g. CMS) and involving sufficient volumes. Preference should also be given to the use of medico-administrative data sources (SNIIR-AM). The validated indicator results will be transmitted to the healthcare institutions. They may be disclosed to the public if the validation allows it. At this stage, the use of these indicators in a financial incentive programme to improve quality is not envisaged in order to avoid the development of a patient-selection phenomenon.

Prospects for the development of specific mortality indicators in France:

The OECD's Health Care Quality Indicator expert group – of which HAS is a member – launched a pilot data collection in the aim of analysing the variability of mortality within 30 days of hospital admission for myocardial infarction (MI). Its aim is to shed light on the factors responsible for the variability in post-MI mortality in the 15 participating OECD countries and their healthcare institutions. In November 2016, France announced its wish to participate in the data collection[5], with HAS managing the study in partnership with CNAMTS. Indeed, this project involves the use of PMSI hospital data (ATIH) and SNIIR-AM non-hospital data (CNAMTS).

5 In France, the OECD's specifications were analysed. Following the confirmation of the technical feasibility of this study, a memo was sent by the DAEI in May 2016 to request arbitration from the Minister's office on this data collection, the topic of which was never the subject of a national publication. The Minister's office issued a favourable opinion in November 2016.

Introduction

Since 2006, HAS (the French Health Authority) has been involved in the development and rollout of care quality and safety indicators in healthcare institutions, in partnership with the Health Ministry's Directorate General of Health Care Provision (DGOS).

On the longer term, HAS wishes to have a panel of instruments to control the quality and safety of care across most of the patient care pathway, right from the start of their care in the healthcare institutions, for the purposes of internal management, external evaluation, regulation and public disclosure.

Over the past 8 years, HAS has rolled out some 53 indicators grouped under 10 topics, assessing the quality of care processes in over 3,000 healthcare institutions. At the same time, HAS wishes to supplement this programme with measures of the outcome of the care provided in healthcare institution. To this effect, it develops indicators allowing the evaluation of the frequency of complications associated with the care, the frequency of readmissions, the patient experience following their care, and hospital mortality.

On this last topic, national efforts for the routine production of hospital mortality indicators started in 2009, at the request of the President of France[6].

This work has involved different institutions:

➔ General scoping

In 2009, the Health Ministry's Directorate for Research, Surveys, Assessment and Statistics (DREES) examined the methodological aspects involved in the construction of hospital mortality indicators, in coordination with the DGOS and HAS.

➔ 2009-2010 ATIH indicators

In September 2010, at the request of the steering committee for the national rollout of quality indicators in healthcare institutions, ATIH produced in-hospital mortality rates (overall and specific initial mortality rates[7] following hospital stays in Medicine/Surgery/Obstetrics institutions) and 30-day/60-day in-hospital mortality rates for each health sector, based on data from the Medical IT Programme (PMSI).

ATIH produced a report summarising its work on adjustment methods (1). In this report it put forward an adjustment model which is more efficient than the other models tested to estimate the expected number of deaths. In particular, the ATIH model can help identify activities with an abnormally high mortality rate.

6 "In the hospital, I want each institution to carefully analyse the causes of the accidents linked to the care provided within their premises. To accelerate the process, simple indicators such as the mortality rate or infection rate must be published for each healthcare institution." Translation of Nicolas Sarkozy's speech of 18 September 2008 in Bletterans on the health policy and reform of the healthcare system.

7 In-hospital mortality on a single day.

➔ 2011 review of adjustment methods

In 2011, HAS and DREES jointly produced and published a literature review on "adjustment methods in hospital mortality evaluation models" (2).

➔ 2011-2016 HSMR Project

In February 2011, the IMER[3] centre within Hospices Civils de Lyon was mandated by the DGOS to produce an overall in-hospital standardised mortality ratio (HSMR in Medicine/Surgery/Obstetrics institutions) and specific mortality ratios (specific HSMRs in Medicine/Surgery/Obstetrics institutions) based on French PMSI data, with the backing of the previous studies produced by ATIH. A retrospective observational multi-centre study made it possible to quantify coding non-conformities in the PMSI through a review of patient records and thus assess their impact on the variables considered for the calculation of the HSMR. Record-based validation was conducted in 24 public and private Medicine/Surgery/Obstetrics institutions in metropolitan France, selected on the basis of their HSMR. The results of this study[4], released in June 2016, led the authors to consider that, given the state of PMSI coding, it was not appropriate to use an overall in-hospital mortality indicator assessing all of the care provided by an institution, either for public disclosure purposes or to compare hospitals.

➔ 2011-2013 AMPHI Project

In October 2010, an agreement involving DREES, HAS, CNAMTS (the National Health Insurance fund for salaried workers) and INSERM-CépiDc[8] commissioned the latter to develop in-hospital and post-hospital mortality indicators using data from the health insurance inter-scheme IT system (SNIIR-AM) paired with death certificates. The AMPHI1 project released its final results in October 2013.

This study confirmed that the in-hospital (IH) mortality indicator does not identify the same healthcare institutions as having excess mortality as the indicator measuring mortality within 30 days of admission (death inside or outside the hospital). It also showed that 30-day mortality indicator results are similar whether they cover overall deaths from all causes or whether they exclude deaths due to a cause not directly linked to the reason for the hospital admission (deaths not linked to the main diagnosis of the hospital stay) (3).

In this study, outlier institutions were observed irrespective of the scope of the indicator used (in-hospital or 30-day) and the adjustments considered.

The AMPHI[9] Project report confirmed the results published in international literature, i.e. that in-hospital mortality indicator results depend on the institutions' mean length of stay, which in turn depends on their "discharge policy". Due to the probably heavier weight of an institution's independent factors for longer time frames, the AMPHI report advocates the use of a short time frame (30 days) for the overall post-hospital mortality indicator.

Lastly, the authors of the report recommend caution in the interpretation of the results of mortality indicators measured from hospitals' medico-administrative data, and in their use for inter-institution or regional comparisons. Indeed, case-mix adjustment possibilities based on patients' state of health on their admission are limited due to the sparse amount of clinical information actually available in PMSI

8 Epidemiology centre for the medical causes of death which feeds data into the national registry of death certificates. This report has not been disseminated.

9 This report is not available on the CepiDc website.

data. Mortality indicators may be useful to detect the outlier institutions needing to be alerted or investigated, but should not be used for rating purposes. The authors of the report mention the need to carefully assess related benefits and risks before any decision to publish the individual results of hospital mortality indicators.

The studies previously mentioned in the documents focused on the methodological aspects of the construction, interpretation and use of hospital mortality indicators. In order to provide institutions with indicators that help to improve the quality of care, HAS has conducted a review of international literature/experience and issued guidelines on the development of hospital mortality indicators making it possible to compare healthcare institutions in France.

This operational document is made up of 3 parts :

- A review of the mortality indicators currently used in five countries (United Kingdom, United States, Canada, Australia and Germany) to compare healthcare institutions.
- A review of the international literature in order to discuss the advantages and drawbacks of the different mortality indicators: purpose of the indicator, scope, source data, adjustment models, links with other quality indicators (process, structure) and side-effects of their use.
- HAS recommendations to guide public decision-making and the development of hospital mortality indicators that allow the comparison of healthcare institutions in France.

1. Overview of the hospital mortality indicators used in five countries

The hospital mortality indicators chosen for the comparison of institutions were studied for the following 5 countries: the United Kingdom, the United States, Australia, Canada and Germany.

This choice was driven by the long-standing use of mortality indicators in those countries, and the availability of scientific or grey literature in English or French.

For each of these countries, the main institutions providing hospital mortality indicators are presented in a table summarising the following information :

- the list of the different hospital mortality indicators measured in healthcare institutions;
- the source data used;
- the adjustment models and variables used;
- the site(s) publishing the results of the indicators and their presentation modalities.

1.1. United Kingdom

In the United Kingdom, the first attempts to collect mortality data took place before the creation of the National Health Service (NHS) (4). In the middle of the 19th century, in 1859, British nurse Florence Nightingale – a pioneer of modern nursing and the use of statistics in healthcare – encouraged healthcare institutions to collect mortality data for each pathology or intervention. Her goal was to study overall mortality per institution, per pathology, and per adverse event. Mortality outcomes concerning London and provincial institutions for the 1862-1866 period were thus published in the Journal of the Statistical Society of London. Due to the lack of collaboration on the part of certain institutions and methodological problems (measurement, risk adjustment and comparison), the studies were discontinued. The medical professionals' opposition to the public disclosure of these results also contributed to the stoppage of the studies.

More than a hundred years later, in 1993, when the results of a standardised mortality ratio based on age, gender, and diagnosis (medicine or general surgery) were published by the NHS[10] in the Times, medical professionals expressed the same worries.

It was only in 1998, in response to the tragedy that took place in the cardiac surgery service of the Bristol Royal Infirmary, where numerous babies and children died due to poor-quality care (serious adverse events which led to death and failed paediatric cardiac surgery interventions), that mortality statistics were once again published by the British government.

[10] The NHS – National Health System – is the United Kingdom's publicly-funded healthcare system. Founded in 1948, it provides comprehensive care in general medicine, emergency services, long-term care and dentistry. Since the devolution legislation of 1999, the NHS has been divided into 4 independent bodies: NHS England (218 healthcare institutions), NHS Scotland, NHS Wales, and the Health & Social Care Board of Northern Ireland.

In 2001, an independent research body – Dr Foster Intelligence – was created to measure the clinical performance of healthcare institutions. This body was founded on the idea that the collection and publication of information could save lives. It puts forward and publishes mortality indicators. Its monitoring work also includes alerting institutions when it detects excess mortality in a variety of diagnostic and intervention groups. Since the Bristol scandal, Professor Brian Jarman and Dr Foster's unit in the Imperial College London have continuously refined and improved the method of calculation of hospital standardised mortality ratios (HSMRs). Today, 70% of NHS institutions use HSMRs to manage their clinical results via the Dr Foster tool.

In 2013, the scandal of the Mid Staffordshire NHS Foundation Trust once again made the headlines in the press and scientific literature. Following the administrative inquiry conducted by the Care Quality Commission (CQC), a report was published by the Health Department on 5 February 2013, threatening to close the institution (5). This reports tends to show that HSMRs[11] are only useful to compare institutions and do not reflect the quality of care due to HSMR calculation problems linked to the admissions included in the calculation of the indicator: a modification of the distribution of the diagnoses considered in the calculation of HSMRs was thus observed. Following modifications in coding practices, certain institutions obtained HSMRs that outperformed the national average.Jarman supported the assumption that the reduction of the HSMRs of three West Midlands institutions (Mid Staffordshire, Walsall, George Eliot Hospital), between 2007 and 2008, could have been due to a change in palliative care coding practices. He described this as up-coding or gaming.

The explanation given by Jarman is that the increase in palliative care[12] coding increased the expected number of deaths in the institutions concerned, among patients who initially had a higher probability of dying. The HSMRs thus dropped due the increase in the expected number of deaths. The increase in palliative care coding reached its peak in late 2008. At the time, five institutions – including the three West Midlands institutions – had more than 25% of their care coded as palliative care. Between the end of the first quarter and start of the fourth quarter 2008, the coding of care episodes as palliative care varied from 8% to 46% for these three institutions, while it only varied from 6% to 9% at the national level. It should also be noted that the Mid Staffordshire hospital stopped coding hip fractures as primary diagnosis as often as before, most often coding them as secondary diagnosis. This contributed to a reduction in HSMRs. The changes in HSMR coding practices became visible when the first complaints from worried patients reached the NHS and the first audits were requested by the public authorities.

In 2012 and 2013, the CQC made 6 inspection visits which led to warnings being issued due to insufficient staffing in the paediatric hospital's maternity, cardiology and surgery services. Rapid, appropriate measures had to be taken by the hospital, allowing the lifting of the warning for the maternity ward after a further inspection.

In July 2013, Pr Bruce Keogh (6) conducted a review of the quality of care and treatments provided in 14 NHS institutions with above-average mortality rates for two consecutive years. The mortality indicators used for these measurements were the HSMR and the Summary Hospital-Level Mortality Index

11 HSMRs correspond to the observed number of deaths over the expected number of deaths, multiplied by 100.
12 In the United Kingdom, palliative care is included in the calculation of HSMRs.

(SHMI). The results of this review revealed that over 90% of in-hospital deaths concerned patients hospitalised for emergencies, in particular elderly people, and were due to staffing problems, organisational problems, the lack of professional references, and the fact that the admissions took place on weekends or at night.

Table 1: Main institutions providing mortality indicators disseminated to institutions (or practitioners) in the United Kingdom.

Institution	Overview	Mortality indicators calculated at institution level	Data used	Adjustment models and variables used	Site(s) publishing/ presenting the results
National Health Service (NHS) Choice	Site that has been publishing quality indicators per institution and/or consultant surgeon since 28 June 2013. Results are published on this site for over 98% of surgeons, and those who are absent are on a black list on the NHS site.	**Risk-adjusted hospital mortality rates :** – after cardiac surgery; – after endocrine and thyroid surgery; – after cerebrovascular accident (stroke); – after abdominal aortic aneurysm repair **Crude in-hospital mortality rate :** – after bariatric surgery. **30-day risk-adjusted mortality rates** : – after gastro-intestinal surgery (esophagectomy, gastrostomy); – after head/neck cancer surgery; – after carotid endarterectomy; – after neurosurgery. **Crude 30-day mortality rate:** – after head/neck cancer surgery; **90-day risk-adjusted mortality rates :** – after total hip replacement; – after upper gastrointestinal surgery; **Crude 90-day mortality rate:** – after surgery to remove colorectal cancer. **Link :** https://drfoster.com/wp-content/uploads/2019/10/Consultant-Focus-final-WEB.pdf	**The data used depend on the type of intervention:** – **Administrative data from the Hospital Episode Statistics:** cardiac surgery, neurosurgery, etc. – **Registries**: thyroid surgery, – **National clinical audits:** head and neck cancer, cancer of the stomach and oesophagus, etc.	For most interventions, the mortality rates are adjusted according to the patient's risk profile. For a few interventions, there is no adjustment of the mortality rates: bariatric surgery, head/neck cancer surgery, surgery for removal of colorectal cancer. Crude mortality rates are used.	**NHS** **Link :** https://www.nhs.uk/service-search/other-services/Hospital/LocationSearch/7/Consultants
Doctor Foster My Hospital Guide	Private research organisation founded in 2001 by Dr Foster.	**Public disclosure of 7 mortality indicators:** – **Summary Hospital-Level Mortality Index (SHMI):** overall mortality at the hospital or within 30 days of admission;	Administrative data on routine hospitalisations provided by the Hospital Episode	Logistic regression models. The adjustment variables depend on the relevant indicators (see Table 2)	**Dr Foster web link :** – https://drfoster.com/service/quality-and-outcomes-measurement/#product-

Institution	Overview	Mortality indicators calculated at institution level	Data used	Adjustment models and variables used	Site(s) publishing/ presenting the results
	Site that publishes quality indicators. **Covers the whole world:** Europe, USA, Asia, Australia. Over 40 academic hospitals across 9 countries.	– **Hospital Standardised Mortality Ratio (HSMR):** pathological conditions responsible for 80% of deaths; – **HSMR (100):** for 100% of pathological conditions; – Death after a surgical intervention; – Patient mortality in diagnosis-related groups (DRGs) with a low mortality risk. – Acute HSMR (excluding patients who died outside the hospital). **The annual report is accessible through the following link :** http://myhospitalguide.drfosterintelligence.co.uk/downloads/report/ Report.pdf **For more information :** https://drfoster.com/service/quality-and-outcomes-measurement/#product-trustview	Statistics (HES) office. + **other data**: Secondary Uses Service Data (SUS); Commissioning Datasets (CDS).		mortality-and-quality-improvement-service – https://drfoster.com/service/quality-and-outcomes-measurement/#product-mortality-comparator Online publication of national and per-institution mortality rates. Results expressed according to positioning in relation to national results.
NHS Digital (formerly Health Social Care Information (HSCIC))	National supplier of reliable health information from health and social care data and IT systems. Founded by the Department of Health in April 2013. Institutional dissemination site, exclusively handling validated data. **NHS Digital web link :** https://digital.nhs.uk/home	**SHMI:** Summary Hospital-Level Mortality Index (developed by Dr Foster). The SHMI has a reference value of 1 and also includes deaths occurring with 30 days following the patient's discharge. The SHMI specifications (calculation methodology) are detailed on the NHS Dgital site. **Link :** https://digital.nhs.uk/data-and-information/publications/ci-hub/summary-hospital-level-mortality-indicator-shmi#shmi-specification	Administrative data on routine hospitalisations provided by the Hospital Episode Statistics (HES).	Logistic regression model. **Adjustment variables:** age, gender, type of admission, month of admission, year of discharge, poverty, comorbidities, number of A&E admissions over the 12 previous months.	National SHMI results in reports available on the NHS Digital site. **Web link :** https://digital.nhs.uk/data-and-information/publications/statistical/shmi Publication of per-institution data.

Institution	Overview	Mortality indicators calculated at institution level	Data used	Adjustment models and variables used	Site(s) publishing/ presenting the results
Caspe Healthcare Knowledge System (CHKS)	Independent company founded in 1989, providing health data analysis services to improve the quality of healthcare. CHKS covers over 20 countries and has worked with nearly 400 healthcare institutions over the past 25 years. It provides benchmarking backed by the experience of NHS consultants, who transform data into relevant information for decision-making.	CHKS provides institutions with profiling tools to improve their understanding of the differences between SHMI, RAMI and HSMR. An online tool backed by CHKS consultants helps healthcare institutions identify risks and opportunities and improve the quality and safety of care. **Link :** http://www.chks.co.uk/userfiles/files/Flyers/Mortality%20Profiling.p df The Risk Adjusted Mortality Indicator (RAMI) has a reference value of 100 and only includes in-hospital deaths. It excludes A&E care, palliative care (code Z51.5), maternal deaths and infant deaths. RAMI uses the highest-risk diagnosis and provides greater differentiation. The impact of this new measurement on hospital results is not known. **Link :** http://www.chks.co.uk/userfiles/files/Differences_RAMI_AND_SHM I.pdf	Administrative data on routine hospitalisations provided by the Hospital Episode Statistics (HES).	Logistic regression model. **Adjustment variables:** age, gender, length of stay, type of admission, Healthcare Resource Group (HRG)), primary and secondary diagnosis (CIM 10), primary or secondary procedure, type of hospital, and type of discharge. **Link :** https://www.chks.co.uk/Benchmarking	**NO**

Campbell et al. described the main differences between the HSMR (Dr Foster) and the SHMI, which are summarised in the table below (7).

Table 2. Main differences between the SHMI and the HSMR.

Description	SHMI	HSMR
Type of indicator	In-hospital mortality within 30 days of discharge	In-hospital mortality
Construction	Report of the number of observed deaths / number of expected deaths	Report of the number of observed deaths / number of expected deaths x 100
Reference value	1	100
Admissions included and proportion of deaths considered	100% of admissions ending in death, including palliative care and A&E care (0 day)	Admissions from 56 diagnosis-related groups out of 259, corresponding to 83% of in-hospital mortality
Admissions excluded	Outpatient care	Outpatient care
Adjustment variables	age, gender, type of admission, month of admission, year of discharge, poverty, comorbidities, number of A&E admissions over the 12 previous months.	age, gender, type of admission, month of admission, year of discharge, poverty, comorbidities, number of A&E admissions over the 12 previous months, palliative care, ethnicity, type of admission.
Missing values	No exclusion, 100% of deaths maintained	Exclusion of stays for which the age, gender, type of admission, and year of discharge is missing
Allocation of deaths among hospitals which participated in the admissions	Allocation of death to the last healthcare institution that cared for the patient	Allocation to all healthcare institutions involved in the patient care

1.2. United States

At the beginning of the 20th century, Dr Ernest Codman stressed the need for a thorough collection of data on the outcome of the surgical operations performed, and the publication of this work (8). He defended the clinical approach put in place by Florence Nightingale in Great Britain by conducting full assessments of surgical errors (9). Dr Codman introduced the first conferences on morbidity and mortality at Harvard. In 1911, he opened his own private hospital (the Massachusetts General Hospital) where he monitored and published mortality and morbidity outcomes. In 1914, the Massachusetts General Hospital refused his plan to assess the performance of surgeons (9). He thus resigned, regretting the fact that the promotion system was not based on the evaluation of performance (9). In 1915, he caused a scandal at a public meeting by unveiling a satirical drawing of Boston's medical world portraying the golden eggs laid by an ostrich symbolising the general public, in order to criticise the implementation of costly procedures of which the usefulness was unproven (9). Reproductions were made by Reverby (1981) and Donabedian (1989). Following this scandal, Dr Codman continued to teach at Harvard and established his own hospital (the "End Result Hospital") to pursue his goal of measuring and improving quality. To support his "end result theory", he released his own hospital's results in a privately published book (A Study in Hospital Efficiency).

In the United States, mortality indicators started to be used in the 1980s, at the time when the Health Care Financing Administration (HCFA) began the publication of mortality data from Medicare entities (10). In 1986, HCFA published the first list of institutions with mortality rates significantly higher or lower than the national average. A more in-depth HCFA study revealed that the institution with the highest mortality rate was an institution caring for terminal cancer patients. The HCFA report and ensuing criticism led to two major conclusions: 1) the importance of reinforcing risk adjustment techniques; 2) the need to develop performance measurement methods to compare institutions and care providers (11).

The rating of institutions based on mortality data was so difficult and controversial that HFCA abandoned the idea of producing hospital mortality reports in 1993, due to comparison validity issues (12). Between 1993 and 2001, other organisations (government agencies, business groups, etc.) published comparative data on hospital performance. At the same time, starting in 1990, the state of New York and the local administration undertook the calculation of mortality rates after coronary bypass, with the approval of cardiologists and cardio-thoracic surgeons and the support of learned societies. Scientific precautions were taken and the indicators were built with a group of expert statisticians specialised in mortality indicators, in coordination with clinicians. For hospitals, the goal was to improve the quality of the care provided. For surgeons, the aim was to gain better knowledge of their results and improve their surgical techniques (12-17).

In 2001, HCFA was renamed Center for Medicare and Medicaid Services (CMS), a public federal agency serving Medicare and Medicaid affiliates. It notably offers mortality indicators, available on the Hospital Compare site.

Table 3 below lists the main American institutions that produce and/or publish mortality indicators. For the United States, due to the large number of initiatives, a summary has been added.

Table 3. Main American institutions developing mortality indicators disseminated within institutions.

Institution	Overview	Mortality indicators calculated at institution level	Data used	Adjustment models and variables used	Site(s) which publish/present results
Center for Medicare and Medicaid Services (CMS)	Public federal agency created in 2001, dedicated to the persons covered by the Medicare/Medicaid programmes. Medicare is a health insurance programme for persons aged 65 or over (77 million Americans). Medicaid is a health insurance programme that provides cover to some 60 million Americans (low-income families and elderly people, pregnant women and persons with disabilities). **Link :** https://www.cms.gov/	**Medicare 30-day mortality rate (after admission) :** ■ **5 pathological conditions**: – myocardial infarction (MI) ; – heart failure ; – pneumonia ; – cerebral vascular accident (stroke) ; – chronic obstructive pulmonary disease (since 2015). ■ **1 procedure (since 2015):** coronary bypass. **Link :** https://www.cms.gov/Medicare/Quality-Initiatives-Patient-Assessment-Instruments/HospitalQualityInits/OutcomeMeasures ***Last accessed :*** 03/12/2020 All CMS indicators and programmes are available at the following address: https://www.qualitynet.org/	**Medico-administrative hospital data (national Medicare/MedPAR data)**[13].	Hierarchical models obtained by logistic regression. Adjustment according to patient characteristics: age, medical history, other illnesses or comorbidities before admission. The method used for the calculation of the 30-day risk-adjusted mortality rate can be viewed by clicking the following link : https://www.cms.gov/Medicare/Quality-Initiatives-Patient-Assessment-Instruments/HospitalQualityInits/OutcomeMeasures	■ **Hospital Compare :** https://www.medicare.gov/care-compare/ The statistical model used for the calculation of 30-day mortality rates measures the degree of precision of the estimates made and provides the 95% confidence interval (CI 95%). The results are divided into three performance levels by comparison to the national average. ***Last accessed :*** 03/12/2020 ■ **Qualitynet (secure password-protected site) :** http://www.qualitynet.org/dcs/ContentServer?cid=1163010398556&pagename=QnetPublic/Page/QnetTier2&c=Page

[13] **MEDPAR:** data transmitted to Medicare by the institutions for the reimbursement of the care provided to patients covered by the Medicare system.

Institution	Overview	Mortality indicators calculated at institution level	Data used	Adjustment models and variables used	Site(s) which publish/present results
Veterans Health Affairs (VHA)	American administration created in 1930, dedicated to veterans aged 65 or over. This is the USA's largest integrated healthcare system, with over 1,700 healthcare sites. **Link :** http://www.va.gov/health	**30-day mortality rates for 3 pathological conditions:** - acute myocardial infarction ; - heart failure ; - pneumonia.	American Community Survey, Current Population Survey focusing on income and participation in the programme, and ten-year census before 2010.	Same construction as CMS indicators Adjustment according to patient characteristics: age, medical history, other illnesses or comorbidities before admission.	■ **Veteran Hospital Compare :** https://catalog.data.gov/dataset/ va-hospital-compare/resource/faeca1b8fe4d-44d0-8161-94a588afef32 The 30-day mortality rate adjusted for patient severity is produced, along with its CI 95%. A comparison with the national average is made for all Veteran healthcare institutions in order to check whether the institution's CI 95% contains the national average.
Agency for Healthcare Research and Quality (AHRQ)	Public agency of the United States Department of Health and Human Services created in 1989. AHRQ works with the United States Department of Health and Human Services to ensure healthcare quality and safety and to improve access to care. AHRQ produces indicators from medico-administrative hospital data (hospitalisation data from the Health Care Cost and Utilization Project).	**In-hospital mortality rates:** ■ ***Inpatient Quality Indicators:*** – 7 pathological conditions : MI; MI without transfer; heart failure; stroke; gastrointestinal haemorrhage; hip fracture; pneumonia. – 8 procedures : abdominal aortic aneurysm repair; coronary bypass; oesophageal resection, pancreatic resection; craniotomy; total hip replacement; percutaneous coronary intervention; carotid endarterectomy. **Link :** https://www.qualityindicators.ahrq.gov/Modules/IQI_TechSpec_ICD10_v2020.aspx ■ ***2 Patient Safety Indicators :*** – **PSI 2 :** Death rate in low-mortality diagnosis-related groups (DRGs). – **PSI 4 :** Death rate among surgical inpatients with serious treatable complications.	**Medicare/Medicaid medico-administrative data :** – Available data : healthcare, cost of care, hospital care trends, health insurance cover, additional expenditure and patient satisfaction. – Medical Expenditure Panel Survey. – State Snapshots. – U.S. Health Information	Adjustment models obtained through logistic regression. Adjustment according to patient characteristics: age, gender, comorbidities and reason for admission.	No publication found.

Institution	Overview	Mortality indicators calculated at institution level	Data used	Adjustment models and variables used	Site(s) which publish/present results
	Link : http://www.ahrq.gov/index.html	**Link :** https://www.qualityindicators.ahrq.gov/Modules/PSI_TechSpec_ICD10_v2020.aspx ■ ***2 Pediatric Quality Indicators :*** – NQI 02 : Neonatal mortality rate. – PDI 06 RACHS-1 : Paediatric heart surgery mortality rate. **Link :** https://www.qualityindicators.ahrq.gov/Modules/PDI_TechSpec_ICD10_v2020.aspx	Knowledgebase.		
Leapfrog Group	Group of private insurers who publish a series of hospital care quality indicators on their website on a monthly basis. Voluntary participation of 1,500 institutions. **Link :** https://survey.leapfroggroup.org/login?destination=dashboard An annual survey assesses the performance of healthcare institutions based on more than 20 performance measures. The Leapfrog Group produces reports allowing the comparison of institutions at national and state levels.	The Leapfrog Group has developed a composite score corresponding to a weighted combination of a 30-day mortality rate (in-hospital and post-hospital) associated with a surgical procedure and the volume of this procedure. ■ **Six high-risk surgical procedures covered :** – coronary bypass; – aortic valve replacement; – abdominal aorta aneurysm surgery; – percutaneous coronary interventions; – pancreatic cancer resection; – oesophageal cancer resection. **The description of the score is accessible via the following link :** http://www.leapfroggroup.org/sites/default/files/File s/Survival%20Predictor%20Fact%20Sheet.pdf	Survey data and medico-administrative hospital data (national Medicare/MedPAR13 databases).	The predicted (or expected) mortality rate is estimated using a multi-level logistic regression model which takes account of volume for a given surgical procedure.	No public disclosure of the composite score or specific mortality rates. **For each healthcare institution, access to survival odds ratios for 4 procedures :** aortic valve replacement, abdominal aorta aneurysm surgery, pancreatic cancer resection, oesophageal cancer resection. **Link :** http://www.leapfroggroup.org/compa re-hospitals

Institution	Overview	Mortality indicators calculated at institution level	Data used	Adjustment models and variables used	Site(s) which publish/present results
	Link : https://www.leapfroggroup.org/asc-survey-materials/get-started	**The score calculation method is described on the following web page :** http://www.leapfroggroup.org/sites/default/files/File s/Scoring_Survival_Predictors.pdf			
American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP)	Scientific and educational association of surgeons founded in 1913 to improve the quality of surgical care by setting high standards for surgical practices and training. It develops quality improvement, training and advocacy programmes. It covered 640 healthcare institutions in 2014. **Link :** https://www.facs.org/	**30-day mortality odds-ratio following 3 types of surgery :** – lower extremity bypass, – colon surgery, – surgery in patients aged 65 or over. **Information on the construction of these indicators :** https://riskcalculator.facs.org/RiskCalculator/about.html	Data from surgical records.	Use of hierarchical regression models to calculate mortality odds ratios. For more information on the construction and adjustment of these ratios : **Links :** – https://riskcalculator.facs.org/RiskCalculator/about.html – https://riskcalculator.facs.org/RiskCalculator/	■ **Hospital Compare :** https://data.medicare.gov/Hospit al-Compare/Hospital-ACSMeasures/akfs-5dgr **Last accessed:** 01/03/2016 The 30-day mortality odds ratio adjusted for patient severity is produced, along with its CI 95%.
US News & World Report	American news magazine created in 1933, publishing rankings since 1990 including the rating of American hospitals at the national and local levels (state and urban community). "US News & World Report" website.	■ For 2016-2017, Best Hospitals analysed the data of 5,000 healthcare institutions and the survey results of over 9,500 doctors to establish a ranking of the best healthcare institutions for 16 adult specialities and 9 illnesses/surgical procedures. Nationally, 154 healthcare institutions were listed in at least one of the specialities. The Best Hospitals Honor Roll lists the 20 highest rated hospitals across the 16 specialities and 9 illnesses/surgical procedures.	MedPAR medico-administrative hospital data. Patients over the age of 65. Use of risk-adjusted data in clinical registries.	30-day standardised mortality ratios measured for each speciality. Use of the 3M APR-DRG adjustment method, in particular to calculate the expected mortality rate excluding transfers. The clinical groups are defined on the basis of their diagnosis-	**Access to results per institution, speciality, city, region, or state:** https://health.usnews.com/best-hospitals/area?int=top_nav_Best_Hospitals_by_State Overall score and score for all components, including the survival score, based on the probability of 30-day survival, adjusted for severity and other risks.

Institution	Overview	Mortality indicators calculated at institution level	Data used	Adjustment models and variables used	Site(s) which publish/present results
	Link : https://health.us-news.com/best-hospi-tals/rankings *Last accessed:* 02/12/2020	■ For 2016-2017, Best Children's Hospi-tals analysed the clinical data of 78 paedi-atric hospitals through a detailed survey. For each hospital, part of the score is de-rived from surveys of more than10,000 paediatric specialists who are asked where they would send the sickest chil-dren. **For each speciality :** – Calculation of 30-day risk-adjusted mortality ratios (excluding transfers). – Each mortality ratio is then transformed into a 30-day survival ratio (1 minus the mortality ratio). Each 30-day survival ratio is transformed into a 30-day survival score ranging be-tween 1 and 10, based on the most re-cent percentile distribution over a 3-year period. The hospital quality index is a score out of 100 weighted according to process indicators (27.5%), outcome indi-cators (32.5%), structure indicators (30%) and safety indicators (10%).		related group (DRG) ("MS-DRG"), their sever-ity level ("APR-DRG se-verity level"), the risk of death, and the hospital resources used.	The methodology report on the 2020 **"Best Hos-pitals"** ranking is accessible via the following **Link :** https://d.newsweek.com/en/file/459993/wbh2020-methodology-v2.pdf

Summary of the hospital mortality indicators used in the United States:

The most widely found hospital mortality indicators are:

– 30-day mortality rates (after admission) for a specific pathology: MI, heart failure, pneumonia (for CMS and VHA); and ischaemic stroke and COPD exacerbation for CMS since 2015.
– In-hospital mortality rates for specific pathological conditions (MI (with and without transfers), heart failure, stroke, gastrointestinal haemorrhage, hip fracture, pneumonia; surgical procedures (abdominal aortic aneurysm repair; coronary bypass; oesophageal resection; pancreatic resection; craniotomy; total hip replacement; percutaneous coronary intervention; carotid endarterectomy) (AHRQ).
– Survival odds ratios and predicted survival time for 4 surgical procedures: 1) aortic valve replacement, 2) aortic aneurysm repair, 3) pancreatic resection; 4) oesophageal resection (Leapfrog).
– 30-day mortality odds ratios for 3 types of surgery: 1) lower extremity bypass, 2) colon surgery, 3) surgery in patients aged 65 or over (ACS NSQIP).
– 30-day survival scores for 16 adult specialities and 10 paediatric specialities (US News & World Report).

The most widely used data are the following:

– Medico-administrative hospital data (MedPAR/Medicare inpatient data for CMS, the Leapfrog Group, US News & World Report and AHRQ).
– Survey data for VHA and the Leapfrog Group.
– The National Surgical Quality Improvement Program (NSQIP) of the American College of Surgeons (ACS) uses data from surgical records to estimate a per-patient death risk. US News & World Report also uses data from clinical records.

Adjustment methods vary according to the initiative: logistic/hierarchical regressions.

Public dissemination sites vary according to the initiative:

– Certain sites publish mortality indicators from several initiatives: Hospital Compare publishes the indicators of CMS, VHA and ACS NSQIP.
– Other indicator producers publish them themselves: Leapfrog Group, US News & World Report.

CMS financial incentive programmes using mortality indicators:

– The Hospital Inpatient Quality Reporting program (Hospital IQR[14] funds hospitals according to quality measures. The federal law of 2003 used to sanction hospitals that didn't report their quality measures by reducing their funding by 0.4%. The Deficit Reduction Act of 2005 increased this funding cut to 2%.
  For 2018 (2016 data), the Hospital IQR Program will consider:
  1. five mortality indicators: the 30-day mortality rate after MI, heart failure, pneumonia, stroke or COPD [CMS].
  2. PSI 4: Death rate among surgical inpatients with serious treatable complications [AHRQ].

[14] Programme authorised under Article 501 (b) of a federal law dating back to 2003 (Medicare Prescription Drug, Improvement, and Modernization Act (MMA) of 2003). https://www.cms.gov/Medicare/Quality-Initiatives-Patient-AssessmentInstruments/HospitalQualityInits/HospitalRHQDAPU.html

– Hospital Value-Based Purchasing (VBP) is a programme dedicated to the set-up of a performance-based payment system to improve the quality of healthcare[15]. This programme accounts for the largest proportion of health insurance expenditures and allocates hospital stay payments to over 3,500 US hospitals. The VBP programme uses quality data reported by healthcare institutions under the Hospital IQR Program.
CMS uses an adjustment factor for the institution-based calculation of financial incentives, as well as the proportion of hospitalisations to be covered by this adjustment, after the institution's remuneration. In line with the VBP programme, CMS has updated the percentage applicable to the 2015 programme, ranging between 1.25% and 1.5% of the amounts of the DRG payments to all participating institutions. In 2015, the amount available for the payment of financial incentives totalled $1.4 billion. In 2015, the VBP programme integrated three specific mortality indicators: the 30-day mortality rates after MI, heart failure and pneumonia (CMS).

1.3. Canada

The only hospital mortality data published in Canada are provided by the Canadian Institute for Health Information (CIHI). This independent non-profit organisation, created in 1994, provides information on Canada's healthcare system and the health of Canadians.

The CIHI website offers indicators to improve the quality of care, compare institutions (provincial/regional/national averages) and assess hospital practices, policies and procedures. The available tool is interactive and makes it possible to explore 45 indicators classified according to 7 main aspects: 1) accessibility, 2) people-centred services, 3) patient safety, 4) relevance and effectiveness, 5) cost-effectiveness, 6) social determinants, 7) health status.

Mortality indicators are provided for the following three aspects: 3) patient safety; 4) relevance and effectiveness and 5) health status (see Table 4 below).

[15] Hospital Value-Based Purchasing : https://www.cms.gov/Medicare/Quality-Initiatives-Patient-Assessment-Instruments/hospital-value-based-purchasing/index.html?redirect=/Hospital-Value-Based-Purchasing/

Table 4. Overview of the CIHI website which publishes mortality indicators in Canada.

Institution	Overview	Hospital mortality indicator(s)	Data used (medico-administrative, medical, registries)	Adjustment models and variables used	Publication site(s) / method used for presenting the results
CIHI (Canadian Institute for Health Information)	Independent non-profit organisation, created in 1994, providing information on Canada's healthcare system and the health of Canadians. It is funded by the federal, provincial and territorial governments and supervised by a Board of Directors whose members represent all health sectors across the country. **Link :** https://www.cihi.ca/en The CIHI website has an interactive tool called "Your Health System", presenting the results of the 45 indicators on the scale of the country, provinces/territories, regions and institutions ("In Depth" tab). The results can be viewed for over 600 Canadian hospitals and over 1,000 long-term care institutions. **Link :** http://yourhealthsystem.cihi.ca/	■ **Aspect 3 : Patient Safety – two indicators under development:** – Sepsis rates and sepsis-related hospital mortality rates (2014-2015); – Sepsis-related hospital mortality rates (2015-2016); – 30-day in-hospital mortality after a stroke (not available since 2013); – 30-day in-hospital mortality after acute myocardial infarction (not available since 2013). ■ **Aspect 4 : Relevance and Effectiveness – two indicators :** – In-hospital mortality (HSMR) ; – In-hospital mortality following major ; surgery (per 100 cases). ■ **Aspect 5 : Health Status :** – Avoidable deaths ; – Avoidable deaths from preventable causes ; – Avoidable deaths from treatable causes. ICIS has been calculating and disseminating HSMRs covering all of the country's hospitals and regions since 2007. ■ **HSMR :** (number of observed deaths / number of expected deaths) x 100.	Hospital Morbidity Database. Discharge Abstract Database (DAD). The number of expected deaths is derived from the mean statistics of the Medicine/Surgery/Obstetrics institutions who submit their data for DAD calculation (all institutions except in Quebec).	**HSMR :** Canadian adaptation of the Jarman model. Coefficients derived from logistic regression models are used to calculate the probability of in-hospital death. The HSMR is based on 72 diagnosis-related groups which account for 80% of deaths in short-term care institutions, excluding patients in palliative care. For each diagnosis, a logistic regression model takes account of the following independent variables: age, gender, length of stay, admission category (patient diagnosis and health state), comorbidity group and transfers. The HSMR calculation covers 3 consecutive years. The HSMR calculation method is described in detail on the following web page : https://www.cihi.ca/sites/default/files/document/hsmr-tech-notes-sept-2019-fr-web.pdf	Publication of mortality indicators per hospital, long-term healthcare institution, city, health region, province or territory. The HSMRs published cover institutions and health regions with at least 2,500 HSMR-admissible cases for 3 consecutive years. The results are given with their positioning in relation to the 95% confidence interval. **Link :** https://votresystemedesante.icis.ca/hsp/endetail;jsessionid=VE4PmqXWRIn5NQ4+lr4phkqk.yhs?lang=fr#/

1.4. Australia

In Australia, the scandals that broke out in several hospitals spurred the drive to publish mortality indicators. The first scandals concerned the King Edward Memorial Hospital in Perth (1999), the Canberra Hospital (2000) and the Campbelltown and Camden hospitals (2002). All of the incidents had common characteristics: i) patient safety issues going undetected in the reporting of adverse events; ii) deficient clinical governance; iii) healthcare professionals frustrated by the lack of action after the internal reporting of adverse events, who alerted politicians and iv) all of the incidents gave rise to one or several independent inquiries (18).

Following those initial scandals, public confidence in hospitals and the medical profession was greatly eroded. Another scandal broke out in 2005 at the Bundaberg Hospital in Queensland. It took on such proportions that it overshadowed the previous scandals: in 2003, Dr Patel – the new head of surgery at the Bundaberg hospital – performed some 1,000 interventions, resulting in the death of 88 patients and serious complications for 14 others. After an in-depth clinical review of these cases, it was found that this doctor had directly contributed to the death of 8 patients, and that "he may have exhibited an unacceptable level of care in another eight patients who died". The report on this clinical case review mentioned that, while "In the comfortable majority of cases examined, Dr Patel's outcomes were acceptable [...] Dr Patel lacked many of the attributes of a competent surgeon". Before this scandal (2004), quality reports were produced in Queensland's public hospitals, but they were not available to the general public. The Bundaberg hospital incident highlighted the existence of these quality reports and contributed to their dissemination. Now, the government of Queensland regularly produces a certain number of indicators, including in-hospital mortality indicators for specific conditions (19).

However, the data, which are accessible via annual reports, are not institution-specific.

The national data are provided by the National Health Performance Authority (NPHA), created in 2012 in the wake of the National Health Reform of 2011[16]. This independent body produces and disseminates performance data relating to hospitals and primary care institutions throughout Australia. It will soon be publishing overall mortality indicators (hospital standardised mortality ratios) and specific in-hospital mortality rates (see Table 5).

Australian authors examined the methodological aspects of hospital mortality indicators in order to adapt them to their local context:

In 2009, Ben Tovim et al. conducted a literature review covering the methodological aspects of the analysis and public disclosure of the hospital mortality indicators measured from medico-administrative hospital data, as well as a statistical project for their introduction (19).

Scott also examined the methodological precautions to be taken for the use of the hospital standardised mortality indicator defined by Brian Jarman in Australia (21).

In 2013, the Australian Commission on Safety and Quality in Health Care conducted a literature review in the aim of presenting the usefulness and limitations of 3 types of hospital mortality indicators (20): i) standardised mortality ratio; ii) mortality in low-mortality DRGs; iii) disease-specific mortality (MI, stroke, hip fracture, pneumonia). This review examines a certain number of methodological issues (scope of the indicator, criteria for the inclusion or exclusion of specific populations, constant risk fallacy, etc.). These issues will be discussed later on in this report.

[16] The purpose of this reform was to apportion duties among ACHS, NPHA and the Independent Hospital Pricing Authority.

The indicators presented in this review are being developed by the National Health Performance Authority (NPHA) and will soon be published on the My Hospitals website (see infra).

Table 5. Overview of NPHA, whose mortality indicators will soon be disseminated to Australian institutions.

Institution	Overview	Hospital mortality indicator(s)	Data used (medico-administrative, medical, registries)	Adjustment models and variables used	Publication site(s) / method used for presenting the results
Australian Commission on Safety and Quality in Health Care (ACSQHC)	Commission created in 2011, that contributes to quality and safety of care, and better health outcomes and experiences for patients and consumers. The Commission has four main goals : i) safe delivery of health care ; ii) partnering with consumers ; iii) partnering with healthcare professionals ; iv) quality, value and outcomes. **Link :** https://www.safetyandquality.gov.au/about-us	**Among hospital performance indicators recommended by Australian Commission on Safety and Quality in Health Care, there are 3 mortality indicators :** – Hospital Standardised Mortality Ratio ; – Death in low-mortality DRGs ; – In-hospital mortality for four specified conditions : - Acute Myocardial Infarction (MI); - stroke; - fractured neck or femur ; - pneumonia. *(Quality and safety of care)* **Link :** https://www.safetyandquality.gov.au/our-work/indicators/core-hospital-based-outcome-indicators	Australian Bureau of Statistics.	**Guide for Boards and Chief Executives on Hospital Mortality Indicators :** https://www.safetyandquality.gov.au/publications-and-resources/resource-library/national-core-hospital-based-outcome-indicator-specification	**My Hospitals :** Local hospitals and hospital networks. Mortality indicators are under development and will soon be published on the My Hospitals website. **Link :** http://www.myhospitals.gov.au/about-myhospitals/overview#per formance-indicatorreporting

1.5. Germany

In Germany, quality assurance initiatives date back to 1975. The Federal Office of Quality Assurance (BQS), founded in 2001, introduced the routine compilation of some 200 indicators via the use of medico-administrative data, including disease-specific mortality indicators (stroke).

On 9 January 2015, BQS became the National Institute for Quality and Transparency (IQTIG). This institute is currently under development, with the purpose of developing and improving the quality of care.

In parallel, the AQUA institute, created in 1995, is tasked with the management of the quality of care. It develops innovative concepts to improve the quality of healthcare services. It is a pioneer in the institutionalisation of quality circles (peer review groups), the assessment of new healthcare models, the development and implementation of quality indicators, and the quality management of databases (some 400 indicators). It offers outcome indicators grouped by pathology, including mortality indicators targeting different clinical areas (see Table 6 below).

There are also private initiatives that calculate and disseminate mortality indicators: the Quality Medicine Initiative (IQM) and Quality Assurance Using Routine Data (QSR).

Table 6: Main institutions developing mortality indicators in Germany.

Institution	Overview	Hospital mortality indicator(s)	Data used (medico-administrative, medical, registries)	Adjustment models and variables used	Publication site(s) / method used for presenting the results
AQUA	Institute created in 1995, tasked with the management of the quality of care in Germany. It is a pioneer in the implementation of quality circles (peer review groups), the assessment of new healthcare models, the development and implementation of quality indicators and database quality management. **Web link:** www.aqua-institut.de	**In-hospital mortality:** – Specific in-hospital mortality rates (mainly)[17] ; – observed/expected mortality ratios[18]. **30-day procedure-specific mortality rates following:** – isolated coronary surgery, – isolated aortic valve surgery, – combined coronary and aortic valve surgery. **Neonatal care:** – mortality in high-risk newborns (with or without transfer), – observed/expected mortality ratio for high-risk newborns (with or without transfer), – mortality in premature babies with very low birth weights, without transfer at birth,	Routine-collected administrative health insurance reimbursement data. Survey data.	Logistic regression models (aortic valve surgery and cholecystectomy). **Condition-specific models:** the variables used depend on the procedure or pathology studied. The construction of the indicators is described in data sheets accessible via the following link: https://sqg.de/front_content.php?idcat=15&lang=1	The SQG – an information platform set up by AQUA – publishes Hospital Quality Reports every year. The individual Hospital Quality Reports must include the results produced by AQUA. They are used by numerous websites which provide information on hospitals and compare them. **Web link:** https://sqg.de/front_content.php?idart=293

17 **Procedures or pathological conditions concerned:** 1) Cholecystectomy; 2) Pneumonia; 3) Pacemaker: implantation; 4) Pacemaker: generator/battery replacement; 5) Pacemaker: system revision/replacement/removal; 6) Implantable defibrillator: implantation; 7) Implantable defibrillator: generator/battery replacement; 8) Implantable defibrillator: system revision/replacement/removal; 9) Coronary angiography and percutaneous coronary intervention; 10) Coronary surgery, isolated; 11) Aortic valve surgery, isolated; 12) Combined coronary and aortic valve surgery; 13) Heart transplantation; 14) Lung and heart-lung transplantation; 15) Liver transplantation; 16) Living liver donation; 17) Kidney transplantation; 18) Living kidney donation; 19) Pancreas and pancreas-kidney transplantation; 20) Femoral fracture near the hip joint (according to CAV risk and for osteosynthesis/endoprosthesis treatments); 21) Hip replacement: primary implantation; 22) Hip replacement: revision and component exchange; 23) Total knee replacement: primary implantation; 24) Knee replacement: revision and component exchange.

18 **Procedures or pathological conditions concerned:** 1) Cholecystectomy; 2) Pneumonia; 3) Pacemaker: implantation; 4) Pacemaker: system revision/replacement/removal; 5) Implantable defibrillator: implantation; 6) Implantable defibrillator: system revision/replacement/removal; 7) Coronary angiography and percutaneous coronary intervention; 8) Coronary surgery, isolated; 9) Aortic valve surgery, isolated; 10) Combined coronary and aortic valve surgery; 11) Liver transplantation; 12) Femoral fracture near the hip joint (according to CAV risk and for osteosynthesis/endoprosthesis treatments); 13) Hip replacement: primary implantation; 14) Hip replacement: revision and component exchange; 15) Total knee replacement: primary implantation; 16) Knee replacement: revision and component exchange.

		– mortality ratio for premature babies with very low birth weights, without transfer at birth.			
Quality Medicine Initiative (IQM)	Initiative founded in 2008 in charge of quality assurance with routine-collected data (DRG). Brings together 335 hospitals. **Web link:** https://www.hirslanden.ch/en/corporate/quality/quality-management-systems/quality-medicine-initiative.html	**There are 250 indicators :** – **Specific mortality indicators :** MI, pneumonia, heart failure, stroke, etc. Similar to AHRQ indicators (IQI). – **Overall mortality :** HSMR (to be published within the next 2-3 years). Calculation of standardised mortality ratios at the hospital level and national level.	Routine collection of reimbursement data by the Länders' statistics offices.	Risk adjustment/standardisation (without further details).	**IQM :** Comparison of a hospital's observed/expected mortality ratio at the national level for certain pathological conditions (MI, pneumonia, heart failure, stroke, etc.). Target to be achieved. Each hospital can compare its results with the target to be achieved at the national level.
Quality assurance using routine data (QSR)	Quality Medicine Initiative was organised in collaboration with the project entitled "Structural development and management of the quality of healthcare" in Berlin in May 2015 for quality measurement and quality assurance of routine-collected data. **Web link :** http://www.qualitaetssicherungmit-routinedaten.de/	Mortality indicators with a fixed time interval (30 days, 90 days, 1 year), e.g. 90 days after knee replacement.	Administrative data from the records of patients covered by AOK (health insurance scheme that groups together general local schemes – approximately 30% of German healthcare institutions). Further patient status information (death, post-intervention follow-up, etc.) used in the adjustment, for AQUA and QSR only. **Web link :** http://www.aokgesundheitsnavi.de/	**Risk adjustment.** ■ **Variables used in all speciality indicators**: age, gender, primary and secondary diagnoses. ■ **Pathological conditions covered by the adjustment:** hypertension, diabetes, atrial flutter, heart failure, coronary disease, neoplasia, metastases, etc. ■ No adjustment for pneumonia.	**QSR :** Longitudinal 3-year results per healthcare institution (2010-2013). **Web link :** http://www.qualitaetssicherung-mitroutinedaten.de/

2. Literature teachings concerning mortality indicators and their impact on the behaviour of healthcare system players

2.1. Research objectives and methodology

The objective of this international literature review is to provide answers to the following questions:

- What are the characteristics of the different hospital mortality indicators (types of indicators, scope, time frame, data sources and adjustment variables), and how can they be used?
- What are the consequences of the use of mortality indicators on healthcare system players? What are the virtuous or perverse effects of their use for public disclosure or financial incentive purposes?
- Is there a link between mortality indicators and the indicators used to measure the quality and safety of care?

Bibliographic search strategy and data sources

The Medline (Pubmed), Cochrane Library and CINAHL (Cumulative Index to Nursing and Allied Health Literature) databases were queried over the period running from January 1997 to October 2013. In July 2015, the search was extended to target articles published between the end of 2014 and 2015.

Only publications in English or French were used.

The following key words were used for Pubmed queries:

- *("Hospital Mortality"[Majr] OR (Hospital[title] AND Mortality[title]) OR "Hospital mortality"[title] OR "Death rate"[title] OR "Mortality rate"[title] OR "Mortality ratio"[title] OR "In-hospital death"[title] OR "Hospital death"[title])*

AND

- *("Quality Indicators, Health Care"[Mesh] OR "Performance measure"[title] OR "Performance measures"[title] OR "Quality measure"[title] OR "Quality indicator*"[title] OR "Performance indicator*"[title] OR "Performance evaluation"[title] OR "Hospital comparison*"[title] OR "Hospital rank*"[title] OR benchmark*[title] OR "Public reporting"[title] OR "Outcome and Process Assessment (Health Care)"[Mesh] OR "Outcome measure*"[title] OR "Risk Adjustment"[Mesh])*

An additional search was done for publications by authors identified following the initial search (Bottle, Aylin, Jarman, Baker, Campbell, Dimick, Epstein, Iezzoni, Lilford, Mohammed, Van Den Bosch, Wang, Werner).

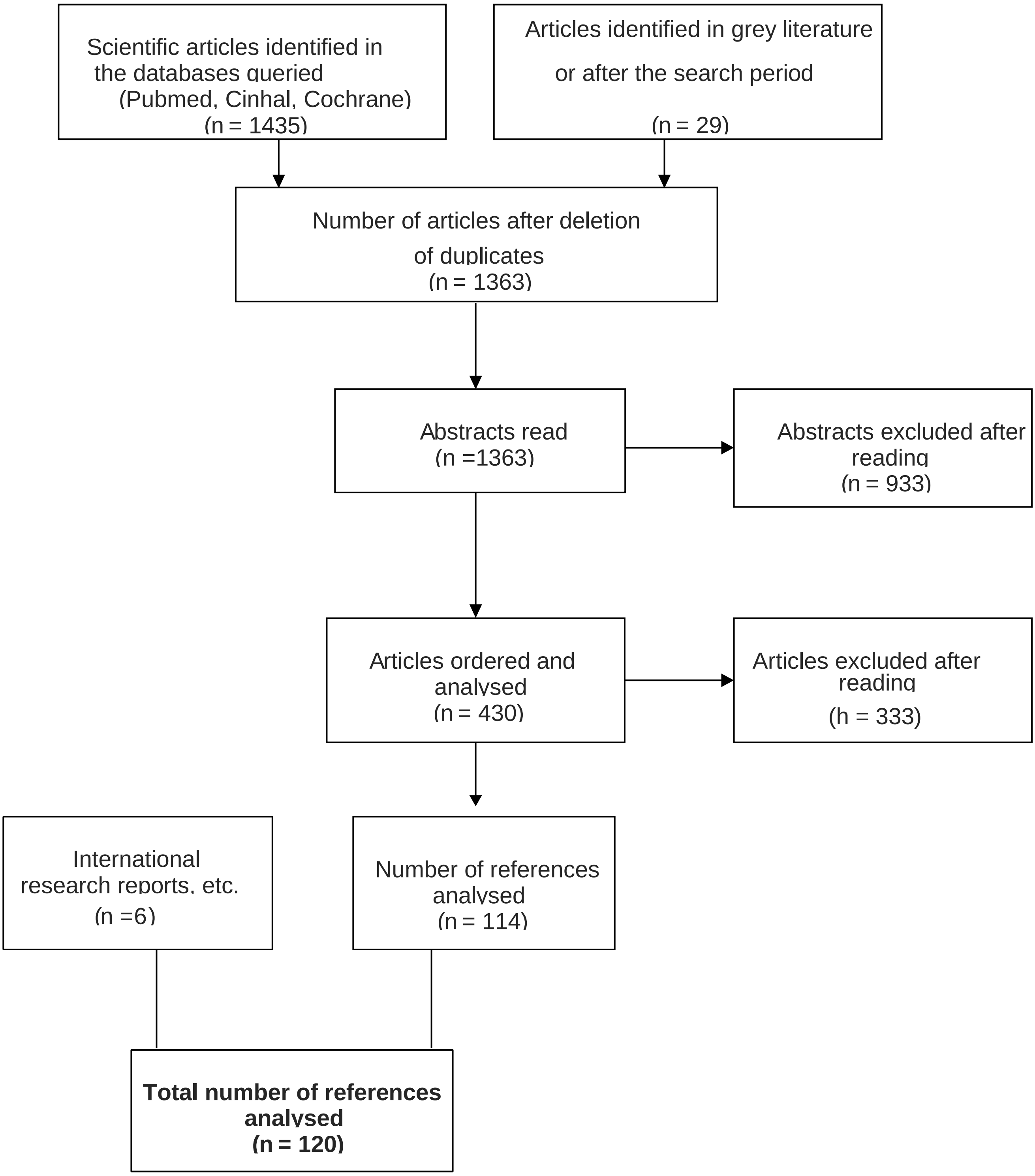
Other articles not referenced in the Medline and CINAHL databases, found in grey literature or published after the query, were included in the review.

The search in bibliographic databases identified a total of 1,363 unique publications.

Selection of scientific and grey-literature articles

The following diagram summarise the procedure used for the selection of articles, whether scientific articles, grey-literature articles, or other references.

Flowchart for the selection of scientific articles and other document sources



Studies focusing on the following topics were excluded from the scope of the review:

- Correlations between the volume of activity (medical/surgical procedures, patients, stays) and the mortality rate. This was the subject of a specific review, conducted by IRDES (the French health economy research and documentation institute), at HAS' request (22).
- Development of mortality prediction models within the framework of epidemiological studies.
- Risk adjustment models, or use of source data in the construction of risk-adjusted mortality rates.
- Mortality in developing countries, in a specific region or area.
- Other topics (political, economic, etc.).
- Correlations between mortality rates and other outcome indicators.
- Other factors explaining the variability of mortality rates (medical error, impact of carer position, nurse staffing level, socio-economic factors, etc.).
- Post-intervention impact studies on the organisation of the care system (managerial intervention, change in the organisation of a service, use of guidelines, etc.).

Method used for the analysis of the selected articles and documents

1,435 scientific articles were identified in the databases queried (Pubmed, Cinhal, Cochrane) and 29 articles were identified in grey literature or outside the search period. After deletion of duplicates, 1,363 article abstracts remained. Those 1,363 abstracts were read. Subsequently, 430 articles were read in full, out of which 114 articles were selected. A reading grid was used for the analysis of the articles – whether scientific or grey-literature articles – in order to answer a certain number of questions:

- Purpose of the indicator: overall mortality, specific mortality, combined mortality, composite score;
- Scope of the measurement: in-hospital and/or post-hospitalisation mortality;
- Measurement time frame: in-hospital mortality (during the stay), mortality within 30 days of admission or a surgical procedure, mortality within 30 days of discharge, 90-day mortality, etc.;
- Measurement aggregation level: overall or specific mortality;
- Population covered: inclusion and exclusion criteria;
- Data sources: medical, administrative, mixed, registries, other;
- Study period;
- Mortality estimation method: crude rate, adjusted rate, hospital standardised mortality rate, Standardised Mortality Ratio (SMR), Hospital Standardised Mortality Ratio (HSMR), Summary Hospital-Level Mortality Index (SHMI);
- Adjustment variables and factoring-in of the complexity or severity of cases, as well as palliative care, modes of admission and discharge (transfers), socio-economic vulnerability, the quality of coding/stratification practices;
- Associations/correlations studied: ALOS (average length of stay), cost, readmissions, satisfaction, etc.
- Statistical models and statistical validity criteria: 1) Statistical performance: C-stat value; 2) positive predictive value ; 3) Sensitivity; 4) Specificity; 5) Calibration: Hosmer-Lemeshow;
- Validation of the indicator: criteria validity, correlation with other quality measures;
- Bias: sample size, measurement objectivity, selection bias, data quality, bias linked to the use of the indicator, etc.;
- Presentation of results: national reference, regional reference;

- Use of results: internal quality improvement procedure, inter-institution benchmarking, public disclosure, financial incentives;
- Impact of the use of indicator results.

To round off the analysis, 6 reports were reviewed in addition to the 114 articles.

A total of 120 references were analysed for this literature review (see flowchart above).

2.2. What hospital mortality indicator for what use?

As already underscored by Johnson et al. in 2002, there is still no consensus as to the definition of the mortality indicator to be used to assess the quality of healthcare institutions (23): should all deaths be counted, or just those linked to a particular pathology? Should we solely consider the deaths occurring during the patient's stay or set an observation period (30, 90, 180 days, or more) ?

2.2.1. Measurement of overall mortality or specific mortality?

There are different levels of analysis of mortality indicators :

- overall mortality, which considers mortality from all pathological conditions or a majority of them;
- specific mortality which considers mortality per gender, age, socio-professional category or due to a given cause (a condition or a procedure).

The review of the mortality indicators used in 5 different countries (Part A) has shown that overall mortality indicators are calculated and disclosed in the United Kingdom, in Canada, and shortly in Australia; and that specific mortality indicators are calculated and disclosed in the USA, the United Kingdom, Canada, Germany, and shortly in Australia.

An overall mortality indicator may be based on various constructions:

- the Hospital Standardised Mortality Ratio (HSMR), an indicator developed by Jarman, Bottle and Aylin: it covers the pathological conditions responsible for 80% of in-hospital deaths. Its base value is 100;
- the Risk-Standardised Mortality Ratio (RSMR): the ratio of the number of observed deaths in a hospital to the number of expected deaths, based on age and gender. This is an indirectly standardised mortality ratio. A risk adjustment is performed according to age and gender;
- the Summary Hospital-level Mortality Index (SHMI), which covers the pathological conditions responsible for 100% of deaths (in-hospital or within 30 days of patient discharge) and includes palliative care;
- the Risk Adjusted Mortality Index (RAMI)): it covers the pathological conditions responsible for 100% of deaths, in hospitals only (base value of 100).

A specific mortality indicator may also come in different forms:

- the risk-adjusted mortality rate;
- the Risk-Standardised Mortality Ratio (RSMR);
- the mortality odds ratio, adjusted for risk.

2.2.1.1. Advantages and limitations of overall mortality indicators

Because it covers all deaths, overall mortality is a concept which is easier to understand than specific mortality. Another interest of this indicator is that it covers more causes of death than an indicator dedicated to a specific clinical condition. Its use thus mitigates the problems linked to sample size in institutions which only have a few cases per year for certain clinical conditions. In addition, this measure takes closer account of an institution's care processes and characteristics, which are not necessarily reflected in the analysis of isolated pathological conditions (24).

However, the overall mortality indicator also has conceptual and methodological problems. For numerous clinical conditions assessed via their mortality rates, it has been shown that:

- the link between mortality and quality of care is difficult to establish (25-27), particularly because of the low volumes of certain treatments (28);
- the differences in quality among healthcare institutions probably only account for a low proportion of the variation in overall hospital mortality and this variation is likely to be largely linked to differences in admission policies, the availability of acute care services, end-of-life care practices, and the quality of clinical coding practices (26, 27, 29, 33).
- In a literature review, Shahian et al. noted that the use of overall hospital mortality, compared to specific mortality for a given clinical condition or intervention (procedure), required methodological precautions (24):
- in the choice of the inclusion and exclusion criteria: this means finding the right denominator and excluding expected or unavoidable deaths (e.g. palliative care);
- in the choice of source data: administrative data should be used as a priority;
- in the choice of the right model and right adjustment variables: i) the diagnoses present on admission must be considered and set apart from those developed during the stay; ii) the risk factors must exclude socio-economic characteristics as well as hospital and geographic characteristics; iii) for individual diagnoses, it is difficult to build valid adjustment models solely using administrative data;
- in the choice of the statistical method for the aggregation of diagnoses: a proper calculation algorithm must be chosen and all sources of variations among healthcare institutions must be considered (sample size, distribution of diagnoses and respective average mortality rates).

Overall, the results of all-cause hospital mortality indicators are the reflection of a heterogeneous whole since the frequency of diagnoses, the size of samples and the severity of patient conditions vary among the institutions considered.

Overall hospital mortality results also raise questions in terms of their use by patients: to be useful to them, the indicator must enable them to choose their doctors, but the aggregation prevents the user from having the right level of detail (per pathology) and may also mask poor results.

Because of these limitations certain authors have come to consider the HSMR – which covers the pathological conditions responsible for 80% of in-hospital deaths – as a tool for monitoring in-hospital mortality over time rather than a measure to compare healthcare institutions (21, 34-37).

2.2.1.2. Advantages and drawbacks of specific mortality indicators

Shojania and Forster are advocates of specific mortality indicators (26). They consider that, for mortality indicators to provide an adequate measure of performance – whether to compare healthcare institutions or to monitor the quality of care over time – the main focus must be on simple pathological conditions or surgical procedures.

Shahian et al. worked on collecting information mortality data relating to a specific clinical condition or procedure which were of particular interest for care providers and consumers (24). For care providers, the pathological conditions or procedures are chosen with the intention of reducing mortality rates and increasing their market share. For service users, payers, or regulators, the aim is to have useful information to recommend or choose care providers for specific diagnoses.

The authors also identified a certain number of essential criteria for the use of specific mortality indicators (24):

- there must be a link with the allocated quality of care and mortality,
- the risk adjustment methods must be appropriate,
- data on risk factors must be available on a routine basis.

As an example, Shahian et al. stated that coronary bypass was a surgical procedure displaying ideal conditions for the reporting of mortality data (24): a sufficient sample size for inter-institution comparisons, the systematic routine collection of data, robust adjustment models, along with the stakeholders' general acceptance of short-term mortality as a valid quality indicator.

The coronary bypass example was further supported by Dimick et al. who showed that, among specific mortality indicators, only those based on sufficient volumes could be used as quality indicators (28). The authors thus studied the surgical mortality indicators produced by AHRQ (see Part A) and concluded that, out of the seven interventions considered[19], only coronary bypass involved enough stays to be able to reveal a possible link between mortality rate and quality of care. Thus, while specific mortality indicators are more useful for the comparison of institutions, caution must be taken not to draw conclusions on too small of volumes. It is thus necessary to define a minimal volume for the relevance of the mortality analysis.

In the United States, CMS decided a few years ago to calculate and disseminate mortality results linked to 3 pathological conditions: myocardial infarction, heart failure and pneumonia, following studies by Krumholz (38-40), which showed that these three conditions had characteristics that were as favourable to those of coronary bypass for public disclosure purposes (see Part A).

Conclusion:

The literature indicates that overall mortality (taking all deaths into account) is a concept which is easy to understand. Moreover, it does away with the problems of sample size and allows better consideration of an institution's care processes and characteristics. However, it requires numerous methodological precautions (the exclusion of expected and inevitable deaths, choosing the right source data and the right adjustment model, etc.).

By definition, specific mortality indicators concern fewer deaths. In order to obtain an adequate measure of performance, studies must focus on simple pathological conditions or essential surgical procedures occurring in sufficient volumes.

[19] 1) total hip replacement; 2) craniotomy; 3) oesophageal resection; 4) pancreatic resection; 5) paediatric heart surgery; 6) coronary bypass; 7) abdominal aortic aneurysm repair.

2.2.2. What scope is to be considered for mortality? Solely in-hospital mortality indicators? 30-day mortality indicators? 60-day mortality indicators? After the intervention or after discharge?

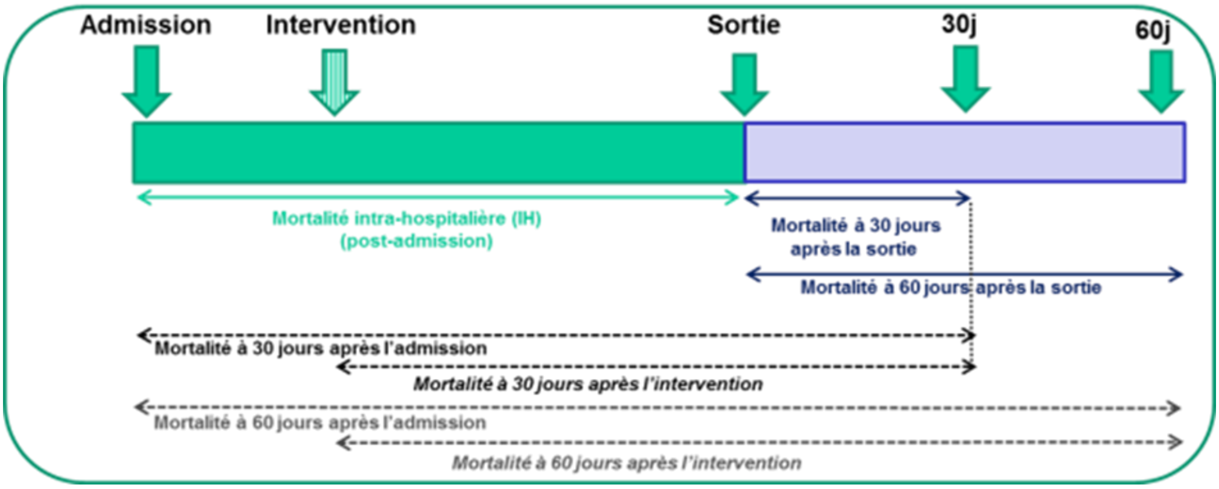


Diagram 1. Illustration of the scope of hospital mortality indicators.

The three possible measures to express hospital mortality are:

- in-hospital mortality, which considers the deaths taking place at the hospital between the patient's admission and their discharge;
- mortality occurring within a fixed time frame (30 days or 60 days) following admission or the surgical intervention. This measure takes account of the deaths taking place inside and outside the hospital;
- early post-hospital mortality, i.e. deaths taking place within 30 days of the patient's discharge from the hospital. It only includes deaths taking place after the hospitalisation. In literature, it is less frequently encountered than the first two measures.

2.2.2.1. Advantages and drawbacks of in-hospital mortality indicators

The rate of in-hospital mortality after an intervention is the easiest to measure as this measure does not require any chaining with post-hospital data. However, it has two drawbacks (41):

- patients may die at the hospital up to several months after an intervention for reasons not attributable to the surgical intervention considered;
- mortality rates preceding the patient's discharge may be under-estimated if the institution has a policy of early discharge (transfer then death in another institution or at home). Strict in-hospital mortality indicators can thus be seen as biased if the institutions being compared have different practices regarding lengths of hospital stays and discharge ("transfer bias") (41-47).

A healthcare institution's in-hospital mortality result thus depends on its discharge policy (24) and, conversely, on the "hostage" effect described by Jarman et al. (45): patients die in certain hospitals because they are too ill to be transferred to another institution due to the lack of an available downstream facility; in other hospitals, these patients could have been discharged earlier and died elsewhere. Pouw et al. also showed a negative link between the in-hospital HSMR and the early post-hospital mortality rate within 30 days of patient discharge, which means that a lower in-hospital mortality rate may in fact be mirrored by a higher post-hospital mortality rate, instead of reflecting a high quality of care (44).

For specific mortality indicators (2004-2006 data), Drye et al. have shown that in-hospitals standardised mortality ratios (SMRs) compared to 30-day SMRs varied according to the pathological conditions treated, and consequently the length of stay (43):

- from 10.8% to 16.1% for 3,135 healthcare institutions treating MI;
- from 5.2% to 11.2% for 4,209 healthcare institutions treating heart failure;
- from 6.4% to 12.2% for 4,498 healthcare institutions treating pneumonia.

It thus seems that the measurement of in-hospital mortality provides a measure which is different to that of 30-day mortality as it is dependent on the healthcare institution's discharge policy and biased in favour of healthcare institutions with the shortest stays.

2.2.2.2. Advantages and drawbacks of 30-day mortality indicators (after admission, intervention, or discharge)

The choice of a fixed observation period (30 days after admission or an intervention) is preferable to in-hospital mortality as it limits the biases linked to the different discharge policies for a particular diagnosis (24).

As previously mentioned, the interest of considering 30-day mortality resides in the fact that this fixed duration applies to all patients and to all hospitals, irrespective of their discharge policy. It also seems that 30-day mortality provides a more valid measure of hospital performance (34, 35, 46).

The choice of a period of 30 days after an intervention is also appropriate as this is the usual period of time considered for the measurement of post-operative complications (7). However, this measure also has several drawbacks:

- it is more difficult to measure as it requires the follow-up of patients after their hospital discharge (41, 47)[20];
- the 30-day interval may seem too short to cover the early mortality phase (41). For this reason, it may be appropriate to extend the data collection period to 60 days (47);

- an institution is not always able to actually "choose" the downstream institution, or the non-hospital medical care; and the longer the period between the patient's discharge and their death,

[20] Within the framework of the AMPHI project, the match between the PMSI-MCO/SNIIR-AM/ INSERM-CépiDC databases was considered excellent (96.7% match rate for persons hospitalised in the year preceding their death) but only concerned beneficiaries of the general health insurance scheme (at the time of the study, it covered 70% of the French population and 66% of deaths). In the future, matching with all RSI and Mutuelle Sociale Agricole (MSA) databases would be desirable to avoid leaving out part of the persons covered.

the higher the likelihood of the impact of other carers' treatments, and thus the more complicated it is to link the death to a shortcoming in the quality of care at the hospital in question.

2.2.2.3. Consequences of the choice of the measurement scope on the institutions' rating and/or outlier status

Concerning overall mortality, a study by Pouw et al. on 6 Dutch healthcare institutions showed that applying different mortality periods to standardised mortality ratios (SMRs) led to different results and a different distribution of outlier institutions (44): with in-hospital SMRs, 17 healthcare institutions had ratios below the expected value [100] and were qualified as "low outliers", 26 healthcare institutions were at the expected "standard" level, while 9 healthcare institutions were above 100 and qualified as "high outliers". With 30-day post-admission SMRs, 20 healthcare institutions (33%) changed levels in relation to in-hospital SMRs, and with 30-day post-discharge SMRs, 13 healthcare institutions (22%) changed levels in relation to in-hospital SMRs.

Concerning specific mortality, certain studies also showed that the scope of the measurement (in-hospital, 30-day) had a significant impact on the healthcare institutions' rating and/or outlier status:

- Rosenthal et al. demonstrated this on a population of 13,384 patients suffering from heart failure, cared for in 30 healthcare institutions in north-eastern Ohio (participating in the Cleveland Health Quality Choice (CHQC) initiative): by switching from the in-hospital SMR to the 30-day SMR, 7 healthcare institutions out of 30 had changed their status (48).
- Drye et al. also demonstrated this on three populations (43):
  - In 3,135 healthcare institutions treating MI, the switch from in-hospital SMRs to 30-day SMRs changed the rating of 257 healthcare institutions (8.2%);
  - In 4,209 healthcare institutions treating heart failure, the rating was modified for 456 healthcare institutions (10.8%);
  - In 4,498 healthcare institutions treating pneumonia, the rating was modified for 662 healthcare institutions (14.7%).
- Kristoffersen et al. showed this on a population of 144,190 patients cared for in 66 Norwegian healthcare institutions. The study examined 30-day mortality (in-hospital if the stay exceeded 30 days, or post-hospital if the stay was less than 30 days) for patients with MI, stroke and hip fractures, by comparing 30-day mortality, excluding transfers, with 30-day mortality including transfers: for MI 14.6% of healthcare institutions no longer had an outlier status, along with 15.3% for stroke and 36.2% for hip fracture (49).

Borzecki et al. studied the impact of the measurement scope (in-hospital mortality rate versus 30-day mortality rate) from the point of view of the correlation between observed and expected rates and from the point of view of the outlier rating for 119 Veterans institutions and 6 pathological conditions covered by AHRQ indicators[21] (50). The coefficients of the correlations between observed and expected in-hospital mortality ratios versus 30-day ratios were high – median: r = 0.78. The rates of concordance between outlier statuses were also high (median = 84.7%) and the kappa coefficients showed moderate concordance (kappa>0.40) for most of the diagnoses studied, except for stroke and hip fracture for which the concordance was qualified as "light" (kappa ≤ 0.22).

[21] 1) myocardial infarction (MI), 2) congestive heart failure, 3) stroke, 4) gastrointestinal haemorrhage, 5) hip fracture, 6) pneumonia.

Johnson et al. showed that the method used for the calculation of the post-operative mortality rate after 30 days or between 30 days and 6 months had a significant impact on the rating or outlier status of 43 Veterans hospitals caring for patients undergoing coronary bypass surgery (23). High correlations were observed between "observed mortality/expected mortality" ratios (r = 0.96) but the author highlighted the discordances between the healthcare institutions' outlier statuses (Kappa = 0.71).

The choice of the indicator used to express mortality has a clear impact on the institutions' rating and, in some cases, their outlier status.

Conclusions:

- The two most widely used measures are in-hospital mortality rates and 30-day mortality rates, whether the patient is still hospitalised or has been discharged.
- The rate of in-hospital mortality after an intervention is easier to measure as this measure does not require any chaining with post-hospital data. However, mortality rates may be underestimated if the healthcare institution has a policy of early discharge.
- The choice of a fixed observation period (30 days) after an admission, an intervention or a discharge is preferable to in-hospital mortality as it limits the biases linked to differences in discharge policies.
- The choice of the mortality rate measurement scope (in-hospital or 30-day) has a major impact on an institution's rating or outlier status.

2.3. What data source(s) should be used?

In a literature review, Shahian et al. stated that adjustment models for certain diseases or procedures (coronary bypass) should ideally be based on clinical data (24). Westaby et al. confirmed this point by stating that the information in clinical databases was more precise, more detailed and more reliable than that in administrative databases, in particular for risk adjustment, but that it was also more difficult to use (51).

In their opinion, administrative databases are certainly less exhaustive than clinical databases, but easier to obtain, as they are less costly in terms of the human resources required for the collection and validation of data. The deficiencies in the quality of administrative data mainly concern the following: incorrect coding of diagnoses, difficulties in distinguishing comorbidities from the complications arising during the stay, imprecise coding, incorrect coding of chronic conditions or secondary diagnoses (24, 52).

Moreover, data from registries did not prove superior in published literature and there is still a lack of available data from computerised patient records at the nation level (53). Using medico-administrative data, while being aware of the limitations, seems to be the wisest choice.

2.4. What variables should be considered for the adjustment of the data?

2.4.1. Risk adjustment method and severity indices

A literature review thoroughly describes the major theoretical principles behind hospital mortality measurement methods and adjustment models (2). It confirms the complexity of the adjustment of hospital mortality indicators to assess quality of care based on comparisons among institutions (risk of rating errors, choice of the population to show the link between hospital mortality and quality of care). Thus, no perfect statistical model for the adjustment of hospital mortality can be found in published literature, and precautions should be taken before blaming insufficient quality of care for an excessively high adjusted mortality rate.

The second part of this review provides a descriptive analysis (data sources: clinical, medico-administrative, registries) and a comparative analysis of the different patient severity scores/indices used for the adjustment of hospital mortality assessment models. It examines the performance of the adjustment models based on the risk of death through two concepts:

- The calibration of the models, generally assessed through the Hosmer-Lemeshow test. This consists of the model's ability to predict the observed vital status of patients in different subgroups having comparable predicted probabilities of death.
- The discrimination of the models, generally assessed through the c-statistic or the area under the curve. This consists of the model's ability to correctly discriminate between living patients and deceased patients. The c-statistic value is the proportion of pairs of patients with common characteristics for which the probability of dying is higher in patients who have actually died than in patients who have survived.

Focus on the Charlson severity index and the Elixhauser severity index

The review of adjustment methods in hospital mortality assessment models has identified 40 patient severity scores or indices in published literature (not counting the different versions or revisions of a particular score or index). Among the severity indices developed using medico-administrative data, we frequently encounter the Charlson index and the Elixhauser index.

- **The Charlson index** is a severity score that was developed in 1987 on a population of 600 patients with breast cancer. The Charlson comorbidity index forecasts the ten-year mortality rate for a patient who can have a range of 22 comorbidities such as heart disease, AIDS or cancer. For each condition, a score of 1, 2, 3 or 6 is allocated, depending on the associated risk of death. The scores are added up to obtain a total score to predict mortality (54).

  The clinical conditions (comorbidities) and the associated scores are the following:

  - **1 point:** myocardial infarction, congestive heart failure, peripheral vascular disease, dementia, cerebrovascular diseases, chronic pulmonary disease, conjunctive tissue disease, ulcers, chronic liver disease, diabetes.
  - **2 points:** hemiplegia, moderate or severe kidney disease, diabetes affecting the limbs, tumour, leukaemia, lymphoma.
  - **3 points**: moderate or severe liver disease.
  - **6 points:** malignant tumour, metastases, AIDS.

It can take the form of an aggregate score for the prediction of in-hospital mortality (score ranging from 0 to 37) or a non-aggregate score (with each medical condition considered independently (0/1)). There are numerous variants of the Charlson comorbidity index. In particular, a recent update was published by Quan et al. showing that, among all of the variables, 17 had a link with 1-year mortality, while only 12 were maintained in this new validated score (55).

For a doctor, this score is useful to decide how to care for a patient.

- **The Elixhauser index** was developed to classify comorbidities in hospitalised patients in order to predict hospital mortality (56). It was built using a database of CD-9[22] coded administrative data concerning 1,779,167 patients hospitalised in California. It takes account of 30 variables (comorbidities) relative to 10 pathological conditions[23], based on the ICD-9 manual. It can take the form of an aggregate score for the prediction of in-hospital mortality (score ranging from 0 to 31) or a non-aggregate score (with each medical condition considered independently (0/1)). In this score, each comorbidity has the same weight (1 point).

  The 30 clinical conditions (comorbidities) are the following: cardiac arrhythmia, congestive heart failure, peripheral vascular disease, pulmonary vascular disease, cardiac valve disease, stroke, other neurological diseases, arterial hypertension, chronic pulmonary disease, paralysis/hemiplegia, rheumatic disease, non-haemorrhagic gastric ulcer, liver disease, diabetes without chronic complication, diabetes with chronic complication, kidney disease, hypothyroidism, lymphoma/leukaemia, solid tumour without metastases, cancer with metastases, AIDS, blood-loss anaemia, deficiency anaemia, coagulopathy, electrolyte disorders, weight loss, obesity, drug abuse, psychosis, depression.

The Charlson and Elixhauser scores, produced under ICD-9, can both be adapted to ICD-10.

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[22] ICD-9: International Classification of Diseases, 9th revision.

[23] Breast cancer, myocardial infarction, asthma, appendectomy, abdominal hernia, diverticulitis, biliary duct disease, lower back pain, pneumonia, diabetes with complications.

2.4.2. Adjustment-related biases: the HSMR example

HSMRs not only reflect the quality of care, but also the severity of diseases, admission/discharge policies, the place of death, the impact of readmissions, the inclusion of the complications present on admission in the adjustment variables, the quality of coding practices, etc.

a) Severity of diseases

The HSMR risk adjustment models take account of the Charlson index to correct the presence of comorbidities associated with the clinical conditions. However, for certain pathological conditions, the severity of the current illness is not always properly accounted for in the RNMH[24] calculation: patients at a more advanced stage of a disease have a higher risk of dying than those at an earlier stage. This can lead to confusion biases and an incorrect estimation of expected mortality. In fact, the severity of the clinical conditions handled can vary from one hospital to another (e.g. cancer), hence the need for precise risk adjustment to compare outcomes (57).

b) Admission policy

The adjustment of HSMRs according to the place of provenance (hospital, patient's home, retirement home) is not enough to overcome the biases linked to the origin of the admission. Indeed, most adjustment models only take account of the patient's last place of provenance, not the previous places. Since a large number of patients return home, the place of provenance coded will be the patient's home, without any consideration for the fact that the patient was previously cared for in one or more institutions. This may lead to adjustment biases and impact the construction and interpretation of HSMRs (57).

The publication of high HSMRs can also prompt changes in a healthcare institution's admission policy rather than a modification in the quality of care (30). A healthcare institution with high HSMRs will be reluctant to admit severely ill patients and may tend to rapidly discharge patients in critical states. Thus, HSMRs do not solely reflect the healthcare institutions' discharge policy (see supra), but are also dependent on their admission policy.

c) Place of death and palliative care

While patients generally prefer to die at home, a large number of them die in the hospital for several reasons. According to Van Gestel et al. the reasons that influence the place of death should be considered in the adjustment model (57):

- the need to receive palliative care only available at the hospital, and sometimes only in certain hospitals[25]. It is thus necessary to properly identify whether patients are admitted to receive palliative care. The author also raises the question of whether patients whose care has become palliative during their stay should be considered in the adjustment model;
- the need for highly specific care in connection with a complex situation (e.g. haematological or colorectal cancers);
- availability in end-of-life care facilities;
- the fact that, in certain cases, the death of the patient at the hospital is difficult to predict;

[24] Examples: chronic pulmonary disease, kidney failure, heart failure, cancer.
[25] Example: hospitals caring for very ill patients (end-of-life care) have more palliative care units (and thus higher HSMRs) than those caring for fewer patients in palliative care.

- religious, cultural, and local socio-economic factors;
- the hospitals' admission and discharge policies.

In actual practice, depending on the countries, palliative care may or may not be considered in the calculation of HSMRs:

- In the United Kingdom, HSMRs include palliative care, while the SHMI does not (7);
- In Canada, palliative care stays are excluded from the calculation of HSMRs as they cover a large part of the population (46);
- In Australia, HSMRs systematically exclude patient stays in palliative care, and do not take account of stays in acute care comprising a palliative care episode (secondary diagnosis) (19, 21, 58).

d) Impact of readmissions

The introduction of a variable concerning the frequency of readmissions in adjustment models may improve the metrological characteristics of a risk adjustment model. It has been shown that the factoring-in of the frequency of readmissions in the adjustment of HSMRs is subject to the fallacy that the risk of death is constant (the "constant risk fallacy") and reduces the HSMRs of healthcare institutions caring for a large number of frequently readmitted patients, while increasing the HSMRs of healthcare institutions caring for only a small number of frequently readmitted patients (59).

e) Inclusion of the complications present on admission in the adjustment variables

Identifying comorbidities through the use of medico-economic databases may lead to the factoring-in of the comorbidities present on admission and the complications linked to the hospitalisation in an undifferentiated manner (60, 61).

Studies have shown that the use of a variable for present-on-admission (POA) diagnoses improves the performance of risk-adjusted mortality models and their ability to identify Medicare institutions with significantly better or worse than expected mortality rates (outliers) (61-63).

f) Coding quality and case-mix

Case-mix and coding variations are partly responsible for the unexplained variance in hospital mortality outcomes (25, 26, 42, 57, 64).

For a case-mix adjustment to be valid, the relationship between case-mix variables and the mortality rate must be constant in all hospitals. Otherwise, the case-mix adjustment could accentuate biases instead of reducing them as expected. Indeed, the relationship considered as constant actually varies according to the populations and over time. Nicholl uses the example of blood pressure, which is a direct and objective measure of the risk of stroke (65). An observational study aimed at comparing the incidence of stroke in two populations for the purpose of comparing the effectiveness of the care provided in two services may wish to adjust for the difference in blood pressure distribution. However, blood pressure measurement results depend on the way in which it is measured. If these factors differ from one institution to another, the measures may "signify" different things. Ignoring this phenomenon creates what has been termed the "constant risk fallacy". This has been described by Mohammed and Lilford (25, 33) and corresponds to the fact that correlations between case-mix variables and mortality outcomes are not constant across all healthcare institutions: there is no interaction (statistical analysis) between case-mix variables and hospital mortality. The comparison of adjusted mortality rates among institutions based on variables whose association with mortality is not constant may induce more error than the comparison of crude mortality rates.

- Inconsistent mortality risk measures are linked to variations in admission practices and may be obtained even without any HSMR measurement error (33). For example, patients admitted in A&E services are generally seriously ill, but if an institution admits patients who are not seriously ill in A&E, the mortality risk associated with A&E admissions will be reduced. This practice variation gives rise to a non-constant relationship between A&E admission and the associated mortality risk, and a reduction of the adjustment of HSMRs according to case-mix.
- Differences in the values of HSMRs are linked to differences in the quality of coding practices among healthcare institutions. The variability of comorbidity coding among healthcare institutions puts a bias on inter-institution comparisons based on the risk-adjusted mortality indicator. Thus, a healthcare institution that systematically "over-codes" will have a higher number of deaths than other institutions with the same profile in terms of case-mix, mortality and quality of care, but which code comorbidities correctly. Such an institution's patients will seem more severely ill than those of other institutions. That institution's "observed deaths/expected deaths" ratio will then be unduly reduced. This phenomenon may lead to the undue classification of an institution with an extremely high mortality ratio into a "low outlier". Likewise, an institution that systematically "under-codes" will see its mortality ratio unduly increased. This could wrongfully penalise it.

To illustrate the "constant risk fallacy", Bottle conducted sensitivity analyses on the impact of coding on the quality of HSMR adjustment (42) by calculating the correlations between "regular" HSMRs, taking account of all adjustment variables, and 8 types of "variant" HSMRs, each of which excluded one of the adjustment variables[26]. The exclusion of stays for which the average length of stay (ALOS) was equal to 0 had the lowest impact: the correlations between HSMRs not adjusted for 0-day stays and "regular" HSMRs was 0.99. For the 7 other types of variant HSMRs, differences of up to 9 points between "regular" HSMRs and "variant" HSMRs are frequently encountered.

2.4.3. Impact of the adjustment method on the rating of healthcare institutions

In published literature, there are inconsistencies in healthcare institutions' rating and outlier status, depending on the model, method and adjustment variables used.

a) Use (or not) of an adjustment method

Dimick and Birkmeyer have shown that risk adjustment does not necessarily have an impact on the healthcare institutions' rating. In a study, the two authors used the mortality data from the last two reports on heart surgery (coronary bypass) in the states of New York and Pennsylvania (66). In each state, there was a strong correlation between crude mortality and adjusted mortality rates, and in the two states, the ratings based on adjusted and non-adjusted mortality rates were just as effective in predicting the next year's mortality rates. The distribution of healthcare institutions with mortality rates

[26] The eight types of variant HSMRs are the following: 1) no adjustment for the Charlson index, 2) no adjustment for palliative care stays, 3) no adjustment for zero-ALOS stays , 4) no adjustment for the combined 3 previous criteria, 5) no 30-day mortality adjustment, 6) no adjustment for using 100% of admissions, 7) no adjustment for using 5 diagnosis-related groups, 8) adjustment using only 5 diagnosis-related groups.

lower-than-expected, higher-than-expected and in the norm (previous year's results) was the same in the two states' ratings, whether for crude or adjusted mortality rates.

b) Impact of the inclusion of a severity scale in the adjustment model

Fonarow et al. (67) assessed the degree of change in the rating of 782 Medicare hospitals (127,950 patients over the age of 65) and eligibility for financial incentives, by examining the 30-day risk-adjusted hospital mortality rates following a stroke, using two adjustment models – one with a score on the National Institutes of Health Stroke Scale (NIHSS[27]) for assessing initial stroke severity and the other without that score. The model including the NIHSS score had a significantly higher discriminant power than the model without the NIHSS score (p<0.001) and allowed a better rating of the healthcare institutions. The analysis of the correlations between the ratings obtained with the models showed distribution inconsistencies among the top healthcare institutions (20%), those in the middle (60%) and the lowest-rated ones (20%): weighted Kappa coefficient = 0.585 (unweighted = 0.530). 26.3% of the healthcare institutions obtained a different rating with the model using the NIHSS score. Among the healthcare institutions initially rated as being below the expected average, 57.7% were reclassified into the expected level by adding the NIHSS score.

c) Impact of the adjustment model used

Shahian et al. (68) compared the mortality outcomes obtained by simulation using four different adjustment models: (a) UHC-Premier, (b) 3M® (APR-DRG), (c) Thomson Reuters, (d) Dr Foster, using the data of 83 healthcare institutions in Massachusetts (Oct 2004 – Sept 2007). The use of the 4 adjustment methods led to different HSMR values and a change in the classification of outlier institutions. Overall in-hospital mortality thus varied from 2% (3M) to 5.9% (UHC-Premier). The correlations between the HSMRs compared using two methods (by pairs) depended on the weighting of the measures according to the number of discharges analysed and ranged from 0.32

(Thomson Reuters vs Dr Foster) to 0.74 (UHC-Premier vs 3M). The percentages of outlier institutions also varied according to the method used: in 2006, 12 hospitals out of the 28 displaying higher-than expected mortality rates had lower-than-expected mortality rates with at least one of the other methods (6 with one method, 3 with 2 methods, and 3 with 3 methods). Shahian explained that these differences were due to the following: the lack of standardisation of the different HSMR calculation methods, differences in the inclusion and exclusion criteria used in the calculation algorithms, differences in statistical adjustment methods, and fundamental biases concerning the assumption of a link between hospital mortality and quality of care.

d) Impact of the adjustment technique used

In Canada, Austin et al. tried to develop a mortality risk adjustment technique using logistic regression models to allow the most accurate rating of healthcare institutions according to 30-day mortality rates after MI, through 3 studies conducted over different periods (31, 69, 70):

- The first study compared the ability of "fixed-effect" and "random-effect" models to correctly identify the healthcare institutions with higher-than-expected mortality rates (April 1996 to end-of-March 1997) (69). When the distribution of mortality log-odds was normal, the random-effect models had a greater specificity and a better positive predictive value than fixed-effect models.

[27]NIHSS score: neurological score composed of 15 items, to measure the degree of deficiency linked to stroke (conscience, language, etc.) in the adjustment factors.

On the other hand, fixed-effect models had a better sensitivity than random-effect models. The conclusion is that it is necessary to consider the balance between false positives and false negatives when choosing statistical models to identify the healthcare institutions whose observed mortality rates are higher than expected (69).

- The second study compared 2 hospital rating methods (April 1997 to end-of-March 1998): a "frequentist statistical approach" (unknown fixed-effect parameters) versus a "Bayesian hierarchical approach" (random-effect parameters) (31). There was good concordance (kappa > 0.40) in the classification of healthcare institutions in only 5 comparisons out of 27, and marginal concordance (kappa ≤ 0.40) in the other 22 comparisons.
- The third study compared the hospital ratings obtained using 4 Bayesian methods (April 1998 to end-of-March 1999) (70). There was good concordance (0.40 ≤ Kappa ≤ 0.75) in only 4 comparisons out of 19, and marginal concordance in the comparisons of the 15 other healthcare institutions.

Hashmi et al. (71) studied the impact of the reliability of an adjustment technique, aimed at eliminating the bias introduced by small volumes, on ratings based on adjusted mortality rates in a population of 278,558 patients hospitalised in 557 trauma centres for contusion or deep wounds (severity score of at least 9) (National Data Trauma Bank, 2010). Once the adjustment technique had been applied, the healthcare institutions' ratings and outlier statuses – based on observed/expected mortality ratios – varied considerably. The 68 top-ranking healthcare institutions and the 18 lowest-ranking were reclassified after application of the risk adjustment technique.

Conclusions:

- A literature review thoroughly described the major theoretical principles behind the hospital mortality adjustment methods and models, and a comparative analysis of the different patient severity scores/scales used in the adjustment methods.
- **Numerous variables affect the results of hospital standardised mortality ratios (HSMRs):** the severity of the diseases, the admission/discharge policies, the place of death, the impact of readmissions, the complications present on admission, the coding and case-mix quality, etc.
- Moreover, all of these variables can constitute biases in the adjustment aimed at ensuring the comparability of institutions.
- Literature findings show that the institutions' ratings and outlier statuses are closely linked to the model, adjustment technique and variables used to make the adjustment.

2.5. What are the consequences of the publication of mortality indicator results on healthcare system players?

2.5.1. Expected effects of indicator publication

2.5.1.1. Impact of the public disclosure of mortality indicators on user choice

To improve quality, a standard approach is to publish reports on the institutions' performance, in order to encourage care providers to improve the quality of care and guide patients in their choice.

Nevertheless, Schneider and Epstein (72) have shown that in 4 Pennsylvania healthcare institutions, using the example of the "Pennsylvania Consumer Guide to Coronary Artery Bypass Graft", very few patients were interested in the "quality" reports published, even when they were free and could guide them in their choice. Some 20% of patients were informed of this guide, and 12% of them stated that they had read it before their intervention. In the author's opinion, guides are chiefly used by employers and insurers for the drafting of contracts, by institutions to select practitioners, and by care providers to identify possible improvements.

Marshall et al. conducted a literature review (1986-1999), published in 2000, to examine how published indicators were used in 7 American systems (CHQC, HCFA, etc.) and the impact of the publication of the indicators (including mortality indicators). He concluded that patients rarely look for information, do not understand it, or do not trust the information (73).

2.5.1.2. Impact of the public disclosure of mortality indicators on mortality rates

The public release of mortality reports most often leads to a significant drop in mortality, but opposite trends are also observed.

Baker et al. (74) measured the impact of the public release of quality reports comprising results on mortality outcomes, risk-adjusted ALOS, satisfaction with market share trends, and 30-day risk-adjusted mortality rates. This covered all patients hospitalised for 6 pathological conditions[28] in 30 non-federal hospitals in north-eastern Ohio having participated the Cleveland Health Quality Choice (CHQC) initiative between 1991 and 1997.

The results showed that a hospital's outlier status[29] was not significantly linked to changes in market share for the 6 pathological conditions studied, nor to changes in 30-day risk-adjusted mortality rates. Thus, it has not been demonstrated that healthcare institutions with high mortality rates tended to lose market share or that those with low mortality rates tended to win some. Mortality dropped slightly in healthcare institutions ranking below average and those with the worst results. On the basis of these findings, the author concluded that this may be due to consumers' lack of interest in CHQC reports, their difficulty in understanding the results, the refusal of financial incentives, or the healthcare institutions' inability to develop quality improvement programmes.

A study by Ryan et al. (2000-2008) showed that the public disclosure of mortality outcomes did not lead to a reduction in 30 day-mortality following heart attack, heart failure or pneumonia (75).

In Marshall's literature review (see above), the measure of the impact of the public disclosure of indicators (including mortality indicators) on the change in care outcomes (process and mortality) showed an improvement in mortality outcomes in a limited number of studies (73).

2.5.1.3. Perverse effects of public disclosure

Epstein conducted a literature review (1990-2005) to examine the mechanisms used to reduce hospital mortality after coronary bypass following the public release of quality reports comparing the performance of hospitals and surgeons (risk-adjusted mortality outcomes following coronary bypass) in three states – New Jersey, New York and Pennsylvania (76). The review showed that the public release of mortality reports was associated with drops in mortality in cardiac surgery. Based on that finding, the

[28] MI, heart failure, gastrointestinal haemorrhage, chronic obstructive pulmonary disease, pneumonia, and stroke.
[29] Tendency to have a mortality rate that is higher than expected (high outlier) or lower than expected (low outlier).

author put forward a theoretical model comprising three main risk adaptation mechanisms used by institutions:

- **selective admission:** public reporting incites surgeons to conduct their own selection of patients according to their mortality risk (avoiding high-risk patients):
  - better factoring-in of the severity of the clinical condition of patients in coding in order to increase expected mortality and reduce risk-adjusted mortality, independently from the surgeons' actual performance (observed mortality);
  - diversification of their surgical activity; it is more difficult to detect non-conformities in the case of diverse procedures;
  - introduction of an early discharge or transfer policy in other facilities;
  - selective admission of patients to avoid patients with a high mortality risk.
- **changes in the surgeon population** (selection or training of professionals): the public release of quality reports in certain states may lead to changes in the composition of the surgeon population:
  - departure of surgeons: migration to another state, change in surgical activity, stoppage of a particular activity (e.g. thoracic cardiac surgery), change in the profile of the patients treated;
  - attraction of surgeons with good mortality outcomes to the states releasing reports: the release of quality reports constitutes an entry barrier for the least qualified surgeons;
  - incentive for surgeons to improve their skills and produce good results to reduce patient mortality;
  - incentive for the least qualified surgeons to abandon their activity.
- **adaptation of surgeons to patients' risk profiles:** patients with a high risk of mortality are treated by more qualified surgeons. Studies have shown that the public release of mortality reports can prompt changes in doctor-patient combinations, following reactions concerning patient demand or patient selection:
  - concerning demand: patients can get help from their GPs or health insurance professionals to select a surgeon on the basis of the results published in cardiac surgery quality reports;
  - concerning the selection of patients: surgeons can change their minds on the selection of patients after having examined their own performance in the quality reports (avoidance of high-risk patients by less competent surgeons).

Joynt et al. sought to determine whether the public disclosure of mortality outcomes after percutaneous coronary intervention was associated with lower intervention rates or higher mortality rates in the population (77). A retrospective study was conducted with 49,660 Medicare beneficiaries hospitalised in three states publishing performance reports[30] after percutaneous coronary intervention (New York, Massachusetts and Pennsylvania) and in a control group of 48,142 Medicare beneficiaries hospitalised in 7 states that did not publish performance reports (Maine, Vermont, New Hampshire, Connecticut, Rhode Island, Maryland, and Delaware). The results showed that the use of percutaneous coronary intervention was significantly lower in the patients treated for MI in 3 of the states publishing mortality outcomes after coronary intervention, than in the patients treated in the 7 control states with no public reporting. However, the differences in overall mortality after MI between the states publishing mortality outcomes and those that did not were small but not significant. A first assumption put forward was that the decision to perform a percutaneous coronary intervention may or may not have been taken in an

[30] Performance reports: mortality outcomes after percutaneous coronary intervention.

appropriate way in the states publishing mortality outcomes or not. Another explanation is that the doctors working in states publishing mortality outcomes may have changed their coding practices. This may have given the impression that the patients seemed in worst condition than they actually were, and may have biased the analyses aimed at looking for a link between the public disclosure of mortality outcomes and poorer results.

2.5.2. Use of mortality indicators in financial incentive programmes

2.5.2.1. Effects of public reporting and Medicare pay-for-performance programmes

Ryan showed that the introduction of a programme of quality reporting (composite score concerning the quality of care for 5 pathological conditions (MI, heart failure, pneumonia, coronary bypass, hip or knee replacement) and pay-for-performance had no significant effect on 30-day mortality rates, nor on 60-day risk-adjusted costs for MI, heart failure, pneumonia and coronary bypass, in patients covered by Medicare (2000-2006). On the other hand, the programme improved the classification of outliers in a small but significant way for heart failure and pneumonia (78).

Jha et al. measured the long-term effects of a pay-for-performance programme – Medicare's Premier Hospital Quality Incentive Demonstration (Medicare Premier HQID) – comprising specific 30-day mortality outcomes for three pathological conditions (MI, heart failure, pneumonia) and one surgical procedure (coronary bypass), on 30-day mortality outcomes (79). At the beginning of the programme, 30-day mortality for the 3 conditions and the coronary bypass were similar for the 252 hospitals participating in Medicare's Premier HQID programme and the 3,363 non-participating hospitals (12.33% versus 12.40%; CI95% = [-0.4 to 0.26]). The drop in the quarterly mortality rate was similar in the two categories of hospitals (0.04% in both cases) and mortality remained similar for six years after the introduction of Medicare's PHQID programme (11.82% for hospitals participating in Medicare's PHQID versus 11.74% for the other hospitals; CI95% = [-0.30 to 0.46]). If we consider the 3 pathological conditions, there was no difference in 30-day mortality between hospitals participating in Medicare's Premier HQID and other hospitals at the beginning of the programme, nor any difference in the quarterly drop in mortality, nor any difference six years after the introduction of the programme. The results are similar, even for the hospitals with the poorest results.

2.5.2.2. Spill-over effect of a financial incentive programme

Kristensen et al. analysed the impact of the introduction of a pay-for-performance programme (Hospital Quality Incentive Demonstration (HQID)) covering 30-day mortality indicators for 5 pathological conditions[31] in healthcare institutions in the northwest of the United Kingdom over a period of 18 months (short term) and 24 additional months (long term), i.e. 42 months (80). Mortality within 30 days of admission was examined for 8 pathological conditions[32], three of which were part of the five pathological conditions covered by the HQID programme (MI, heart failure, pneumonia). The study compared 24 hospitals located in the northwest region and participating in the HQID programme to 137 non-participating healthcare institutions located in the rest of United Kingdom (control). Between 18 and 42

[31]The HQID pay-for-performance programme targeted five pathological conditions: MI, heart failure, pneumonia, coronary bypass, knee and hip surgery.

[32] Three of the five pathological conditions included in the HQID programme: MI, heart failure, pneumonia; and five other pathological conditions not covered by the programme: kidney failure, alcoholic liver disease, intracranial lesion, paralytic ileus and intestinal obstruction without hernia, duodenal ulcer.

months, the results showed a constant reduction in mortality for the three pathological conditions covered by the HQID and this reduction was significantly higher in the 137 control institutions (-2.3 points) than in the 24 institutions participating in the HQID programme (-1.6 points). The greatest reduction observed in the control region concerned mortality after pneumonia.

At the end of the follow-up period (42 months), there was no longer any significant difference in the reduction of mortality after MI, heart failure or pneumonia between the institutions participating in the HQID programme (-3.3 points) and those in the control group (-3.1 points).

Between the short term (18 months) and the long term (42 months), mortality from the pathological conditions not covered by the programme dropped more for participating hospitals (-2.9 points) than for control institutions (-1.7 points).

To explain those results, the author put forward the assumption that there was a spill-over effect between the hospitals participating in the quality improvement programme and non-participating hospitals, as well as a spill-over effect between the diseases covered by the HQID programme and those that were not.

2.5.3. Moral aspects of using mortality indicators in financial incentive programmes

Certain authors examined the adverse effects of the use of mortality indicators in financial incentive programmes:

- Kupfer examined how healthcare institutions financially responsible for 30-day mortality would react (81):
  - The healthcare institutions' initial reflex would be to look into their coding practices. The goal is then not to improve the quality of practices, but to reduce the mortality rates allocated to the institution. Thus, in Canada and the United Kingdom, the lowering of mortality rates took place in parallel with an increase in palliative care coding. In the absence of clinical data on the relevance of the coding, it is difficult to know whether the observed drops in mortality rates are linked to an improvement in the quality of care or whether they are linked to institutions' learning how to manage the funding of the healthcare system.
  - Another option will be to rapidly transfer patients with a high risk of death (based on the probability of survival estimated during the first clinical examination) from the hospital to hospices or palliative care facilities where patients are excluded from the mortality indicator calculation.
  - The inclusion of this mortality indicator in the financial incentive will push doctors to drastically select the patients to be admitted to the hospital beds, based on an admittance assessment and on whether they are more or less at risk of dying within 30 days.
  - Kupfer also mentioned the study by Joynt et al. (see supra) concerning the states in which the public reporting of mortality indicators already exists and where patients covered by Medicare are less likely to have a percutaneous coronary intervention (77).
- Linking healthcare reimbursements to mortality rates may disproportionately penalise hospitals that provide care to patients who are extremely ill or have complex conditions. While risk adjustment methods for mortality rates are intended to take account of these differences in care, their limitations have been demonstrated (25, 32, 68).
- Hospitals having participated in a limited way in the care of a deceased patient will be penalised regardless of the extent of the care they provided to the patient (82). This may be the case for

institutions providing care after a patient's discharge, in particular for 30-day readmissions, and which have minimal control over the care.

- A corollary of this link between reimbursement and mortality is to imply that all deaths are preventable and that something must have gone wrong when a patient has died. The idea that all deaths can be considered as "preventable" was qualified as "extreme" by Pronovost (83). This has negative consequences on hospitals' safety culture.
- The assumption that a lower mortality rate is always associated with a higher quality of care is erroneous, as numerous deaths are not preventable. With nearly one third of deaths having taken place in hospitals in 2000 and in 2010 and with 30% of Medicare expenditures dedicated to end-of-life care (84), the fact of linking financial incentives to measures based on hospital mortality could lead to excessively aggressive end-of-life care (last 6 months of life) and considerably increase the cost of care. Riley thus showed that the proportion of Medicare reimbursements linked to end-of-life care dropped slightly over a 30-year period, going from 28.3% to 25.1% in 2006 ($p<0.01$). After adjustment for age, gender and mortality rates, there was no longer a significant reduction. Technical progress has thus increased the proportion of expenditures for end-of-life care.
- The creation of financial sanctions based on mortality rates for deaths that are not clinically preventable can generate frustration and opposition on the part of clinicians, and ultimately be detrimental to the perception of the value of mortality and quality indicators.

Conclusions:

- The public reporting of mortality indicator results has a low impact on the choices made by service users. It has a non-constant effect on mortality trends and generates adaptations on the part of institutions and professionals. This adaptation stems from three main mechanisms: i) the selective admission of patients; ii) changes in the surgeon population; iii) an adaptation of surgeons to patients' risk profiles.
- The use of mortality indicators in financial incentive programmes has various impacts on the behaviour of healthcare system players:
  1. It has an impact on the institutions' mortality trends and their outlier status ;
  2. It can have a spill-over effect and improve the quality of care for pathological conditions not covered by these programmes ;
  3. It can have major perverse effects such as: the modification of coding practices, the rapid transfer of patients with a high death risk, the selective admission of patients, the penalising of hospitals that care for patients who are very ill or have complex conditions, which can in turn lead to overtreatment to avoid death and thus generate needless expenses. Furthermore, it gives the impression that all deaths are preventable while the preventable death rate is below 6% (see infra).

2.6. Is there a link between mortality indicators and other indicators of the quality and safety of care?

In 1966, Donabedian put forward an evaluation model based on 3 categories of indicators (structure, process and outcome). This model is now widely accepted internationally (85, 86).

- Structure indicators evaluate the conditions under which the care is provided. They measure aspects such as the organisational structures put in place to provide care to patients (management system, logistics, IT system, administrative rules, etc.) and the availability of material and human resources.
- Process indicators evaluate the way in which the care is provided and its consistency with evidence-based practices. They measure the following: the quality of the information collected during patient care and its traceability; the relevance of the diagnosis/treatment and compliance with time-to-treatment guidelines; technical efficiency in the execution of diagnostic and therapeutic procedures (including surgery) and their compliance with good professional practices and standards; evidence of the implementation of preventive measures in terms of health and illness; the coordination and continuity of care; patient acceptance of the treatments, etc.
- Lastly, outcome indicators evaluate the effects of the care on the health state of patients (as defined by the World Health Organisation) and populations. They can be broken down into intermediate results (outputs) which are indirect measures, and final results (outcomes) which reflect the improvement in the patients' physical state (healing, functional recovery, survival, etc.), their health behaviours and their information. Outcome indicators assess aspects such as quality of life, the patients' experience and satisfaction with the healthcare system, and mortality.

2.6.1. Correlation between mortality indicators and process indicators

A certain number of publications have examined the link between mortality indicators and the quality of care measured by process indicators. The following analysis examines the correlations between process indicators linked to the treatment of one or several pathological conditions or surgical procedures, and the associated mortality outcomes. The studies found in published literature generally reveal non-constant correlations between quality of care and mortality:

- A few studies reveal weak but significant correlations between care process indicators linked to the treatment of one or several pathological conditions (heart failure, pneumonia, myocardial infarction, stroke) or surgical procedures (peripheral vascular surgery) and the associated mortality outcomes:
  - Unroe et al. observed these results in 13,619 Medicare nursing facilities (patients over the age of 65) caring for patients suffering from heart failure: there were significant correlations between the quality of the nursing care and 90-day risk-adjusted mortality rates after discharge, according to the type of facility (public, private for-profit and private non-profit) (87).
  - Meehan et al. obtained these results from 3,555 Medicare healthcare institutions by examining the correlations between 4 process indicators relative to the treatment of pneumonia[33] and 30-day risk-adjusted mortality outcomes (logistic regression). A drop in 30-day mortality was significantly associated with the administering of antibiotics within 8 hours

[33] Four process indicators: (1) initial administering of antibiotics within 8 hours of hospital admission; (2) haemoculture before the administering of antibiotics; (3) haemoculture within 24 hours of hospital admission; (4) oxygenation evaluation within 24 hours of hospital admission.

of hospital admission (OR = 0.85; CI95% = [0.76 - 0.95]) and haemoculture within 24 hours of hospital admission (OR = 0.90; CI95% = [0.81 -1.0]) (88).

- Popescu et al. confirmed these results in 2,761 Medicare hospitals by showing that the crude mortality rates and 30-day risk-adjusted mortality rates of institutions showing poor performance through a composite score of 5 process indicators relative to the treatment of MI (CMS) were significantly higher than those of hospitals with an intermediate or high performance level (89).
- Bradley et al. also confirmed these results in 962 Medicare hospitals: correlations between process indicators relative to the treatment of MI and 30-day risk-adjusted mortality rates were moderate (correlations ≥ 0.4; p<0.001) or low (correlations <0.4; P<0.001) but significant, explaining 0.1% to 3.3% of the variation in the hospitals' mortality rates (90).
- Werner et al. observed these results for patients treated for MI, heart failure or pneumonia. The results showed that there were weak but significant correlations[34] between 10 specific process measures for the treatment of MI, heart failure and pneumonia, and associated mortality outcomes in 3,657 Medicine/Surgery/Obstetrics hospitals participating in the Medicare Hospital Compare programme (96).
- In comparison to Werner (79), the study by Jha et al. revealed greater correlations between the results of the specific process indicators relative to the treatment of MI, heart failure and pneumonia, and risk-adjusted hospital mortality rates: better performance in the treatment of the three pathological conditions was associated with lower risk-adjusted mortality rates.
- Lastly, in 11 hospitals in the Netherlands, Hoeks et al. showed that a substantial proportion of the variation in 30-day mortality after peripheral vascular surgery could be explained by differences in patient characteristics such as age and gender, the Lee index (cardiac risk score), as well as variations in care processes (91).

– We also find studies that show non-significant correlations between care process indicators and the associated mortality outcomes:
  - Shafi et al. did not show any significant correlations between the results of 22 CMS process indicators (dedicated to the treatment of MI, congestive heart failure, pneumonia and post-surgical infections) and risk-adjusted hospital mortality rates in patients from 112 healthcare institutions (p>0.05) (92).
  - Nicholas et al. did not show any difference in the compliance rates of surgical care processes between healthcare institutions with high or low 30-day risk-adjusted mortality rates for 6 high-risk surgical interventions in the NSQIP[35], across 2,000 Medicare hospitals (93).
  - Ingraham et al. did not show any significant correlation between 4 process indicators in the Surgical Care Improvement Project and 30-day risk-adjusted mortality rates based on data from 200 ACS NSQIP hospitals (94).
  - Kernisan et al. showed that there was no significant link between the Leapfrog safety practice scores (SPS) for surgical procedures and adjusted hospital mortality rates in 155 hospitals of the Nationwide Inpatient Sample (95). In-hospital mortality rates remained

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[34] The variations in risk-adjusted mortality rates (in-hospital, 30-day, and 1-year) among healthcare institutions whose performance measures were between the 25th and the 75th percentile were calculated for each pathological condition using 2 methods: 1) Composite score: aggregation of all process measures for each pathological condition and 2) "All or none": satisfaction or not with all performance measures.

[35] 1) repair of ruptured abdominal aneurysm, 2) repair of ruptured aortic aneurysm, 3) coronary bypass, 4) oesophageal resection, 5) mitral valve repair, 6) pancreatic resection.

the same from the lowest to the highest SPS quartile, i.e. 1.97%, 2.04%, 1.96% and 2%, respectively.

- We also find studies showing variable results in terms of correlations between process and mortality indicators, when several different treatments or pathological conditions are considered:
  - Shahian et al. showed that better compliance with care processes in the treatment of MI and pneumonia is associated with an improvement in long-term survival and mortality outcomes, while the correlations are reversed, and even paradoxical for heart failure (97). For MI and pneumonia, better compliance with care processes (compliance rate between 50% and 99% or equal to 100%) is associated with a higher 1-year survival probability and a lower readmission rate, while lower compliance with care processes (under 50%) is associated with a lower 1-year survival probability and a higher readmission rate. For heart failure, the links are contradictory, even paradoxical, even though a few process measures were linked to an improvement in mortality outcomes (e.g. conversion enzyme inhibitor).
  - Maeda and Lo Sasso showed that a high rate of compliance with the processes recommended by the Joint Commission for heart failure was not associated with lower mortality rates (whether adjusted or not), in a population of 3,011 accredited acute-care hospitals (98). Conversely, better compliance with processes concerning patient discharge instructions and the evaluation of the left ventricular ejection fraction function was associated with lower mortality rates for healthcare institutions ranking, respectively, in the 80th and 90th percentiles of the mortality rate distribution.

More broadly on that topic, a literature review conducted by Pitches et al. showed that the notion that the healthcare institutions with the highest risk-adjusted mortality rates provided a low quality of care was neither consistent nor reliable (27). Irrespective of the type of association, positive correlations (association between high quality of care and low mortality rate) never exceeded 50% for the 51 associations analysed through 36 studies.

Prior studies conducted by Hofer and Hayward (99) and Zaldkind and Eastaugh (29) had shown that, even when using a "perfect" risk adjustment method by simulation, mortality rates only marginally identified institutions providing poor quality of care (11).

Moran and Solomon showed that global indices reflecting the quality of care processes (proxies related to care processes: ALOS scores and cost-effectiveness scores) were not correlated to mortality outcomes in 99 intensive care units, from the Australian and New Zealand Intensive Care Society Adult Patient Database (1993-2003) (100). This is the first official demonstration of a lack of correlation between process measures and associated mortality outcomes, in line with the conclusions of the review by Pitches et al. (27) and the studies conducted by Hofer and Hayward (99) and Zalkind et Eastaugh (29), despite the methodological limits mentioned (confusion factors, heterogeneity of process measures and mortality measures).

The studies examining correlations between quality-of-process measures (process indicators) and mortality measures finally seem rather inconclusive. The authors showed that the weakness of the correlations between process indicators and mortality indicators could be due to two main factors:

1. **Limitations linked to the construction of the mortality indicator:**

- the mortality measure used (27, 79, 96, 101);
- the adjustment method used (27, 79, 88, 93, 96, 97, 101);

- the size of the sample and the choice of the patient inclusion/exclusion criteria (90, 93-96, 98, 101);
- the lack of patient follow-up after their discharge (97);
- problems with the quality of the data (79, 88, 89, 92, 93, 96, 98,101).

2. **Limitations linked to the choice of process indicators:**

- the type of process indicator(s): this may correspond to small variations in mortality among institutions if most of the healthcare institutions have satisfactory results for a given process, masking any correlation between better performance (upper quartile of the Safe Practice Score) and lower risk-adjusted mortality (95); or conversely, if most of the healthcare institutions have high mortality outcomes irrespective of the results of surgical care processes (high or low), in the case of surgical procedures with a high mortality risk (93);
- the combination of process indicators: it is not always representative enough of the processes that can be linked to mortality in a healthcare institution (79, 96, 101);
- the type of measure used to calculate a performance score relative to several pathological conditions (MI, heart failure, pneumonia): there may be an under-estimation of the correlations between the process measures and short-term mortality outcomes, mainly when the quality processes studied have long-term benefits (e.g. secondary prevention for myocardial infarction) (79).

Lastly, there may be non-observed differences in patient characteristics, or between institutions, that could explain the low correlations between quality of process and mortality (88, 90, 101).

Werner et al. showed that the observed mortality differences among all healthcare institutions were greater than the expected mortality differences and were not solely linked to the direct effects of the care processes implemented in the treatment of MI, heart failure and pneumonia, but also to non-measured effects that were sometimes more significant (101).

In the study mentioned earlier, Bradley et al. put forward the assumption that low correlations between process indicators and mortality rates may also be due to other factors not linked to the processes measured (90) such as patient safety, staffing levels, the handling of emergencies, and clinical strategies that may have an impact on the institution's performance, and that these factors – which are not currently measured – could explain some of the variations observed among institutions.

In the study by Meehan et al, a pneumonia-specific mortality risk index was used, but did not allow perfect adjustment, that would make it possible to control all mortality risk differences among patients (88).

The previously mentioned literature review by Pitches et al. examined a certain number of the above mentioned methodological limitations, such as the problem of the calculation of the mortality rate, the risk adjustment methods used, the poor quality of the data, and the low representativeness of the samples studied (27).

2.6.2. Correlation between mortality indicators and structure indicators

Other studies examined the correlations between structure indicators (nurse staffing levels, competition elements) and mortality outcomes.

Three studies evaluated the correlations between indicators of **nurse staffing levels** and the associated 30-day mortality rates (in-hospital or post-hospital mortality). They revealed:

- **either significant correlations**: Person et al. and subsequently Schilling et al. showed that an increase in nurse staffing levels had a positive impact on hospital mortality outcomes (102, 103).
- **or the absence of significant correlations**: Staiger et al. showed that, for seven cardiac surgery interventions[36], the nurse staffing level was not correlated to mortality and that it did not explain a significant proportion of the observed mortality rates (104).

Four studies evaluating the impact of **different competition strategies** (market penetration rate, competition on prices or on the quality of care) on mortality trends relative to certain pathological conditions were generally non-conclusive (17, 105-107):

- The study by Mukamel et al. (17), targeting a population of 1,927 healthcare institutions (134 regions), looked for associations between the market penetration (market share) of Health Maintenance Organisations (HMOs), the competition between hospitals and HMOs, and adjusted hospital mortality rates for six specific pathological conditions[37]. The results showed:
  - A positive and statistically significant association between an increase in market share and an increase in the quality of care (and thus a negative association between an increase in market share and mortality);
  - There was a marginal association between an increase in competition and an increase in quality.
- In the study by Gozvrisankaran and Town (105), the relations between competition strategies and in-hospital mortality after an MI or pneumonia were evaluated in two insurance systems: HMOs and Medicare facilities:
  - **in HMOs**: it was shown that an increase in competition was associated with a reduction in risk-adjusted mortality rates.
  - **conversely, in Medicare facilities:** it was shown that an increase in competition was associated with an increase in risk-adjusted mortality rates. In keeping with another study, the author explained that these results showed that an increase in competition between HMOs led to a reduction in the hospital prices paid by HMOs and better hospital quality (108). Conversely, the results suggest that competition among hospitals whose costs are government-controlled (Medicare) leads to a reduction in hospital quality.

- The study by Bian et al. (106) looked for a link between HMO penetration and stroke mortality outcomes in a population of 1,327 healthcare institutions treating elderly people for ischaemic stroke (1993-1998). Irrespective of the measure used, the analyses showed that HMO penetration was not correlated to in-hospital mortality rates, nor to the overall mortality rates of a county (a potential Medicare HMO market). However, HMO penetration was significantly associated with the transfer of the patients who died after a stroke, from acute care to geriatric-type facilities (transfer of the place of death).
- Volpp et al. studied the effect of a change in inter-institution competition strategies on mortality trends (107). They thus compared mortality relative to the care provided to a population of patients over the age of 65 admitted in the hospitals of New Jersey (undergoing a funding reform)

[36] Percutaneous coronary intervention, coronary bypass, mitral valve replacement, aortic aneurysm repair, aortic endarterectomy, esophagectomy, pancreatic resection.

[37] Myocardial infarction, heart failure, pneumonia, stroke, coronary artery bypass, and total hip replacement.

[38] Stroke, hip fracture, pneumonia, pulmonary embolism, heart failure, MI, gastro-intestinal bleeding.

and New York (control area) for 7 pathological conditions[38]. The authors showed that the shift from a hospital payment system where competition is based on quality-of-care and where prices are contingent on the cost of the services produced, to a price-based competition system, in which quality is the variable that can be downgraded to offer a better price, had a negative impact on mortality trends.

2.6.3. Correlation between mortality indicators and preventable mortality

The end-goal of mortality indicators is to improve quality of care and reduce mortality rates. However, studies have shown that the proportion of "preventable" deaths, i.e. those for which deficient quality of care can be proven, is far from being preponderant.

The mortality review conducted by Keogh in 2013 sought to determine the level of care in 14 healthcare institutions identified as outliers for 2 consecutive years, according to one of the two most widely used measures (HSMR or SHMI) (6). He showed that over 90% of in-hospital deaths concerned patients hospitalised for emergencies (in particular elderly people), due to staffing problems, organisational problems or the lack of professional references, or the fact that the admissions took place on a week-end or at night.

In July 2013, one of the main recommendations of this review was to study the relationship between excess mortality rates (HSMR or SHMI measure) and the rate of "truly preventable" deaths, obtained through a retrospective case record review by experienced clinicians.

Hogan et al. sought to determine the proportion of preventable deaths in NHS short-stay healthcare institutions in the United Kingdom (109) and they studied their association with HSMR and SHMI measures. A retrospective case record review was conducted over two periods with 34 healthcare institutions selected at random: 10 healthcare institutions in 2009 (110) and 24 healthcare institutions in 2012 (109). In each healthcare institution, 100 deaths were chosen at random and examined in a case record review. The results showed that, over the two periods studied, the proportion of preventable deaths was equivalent to 3.6% (IC95% = [3.0% - 4%]). This proportion was lower in 2012/2013 (3%; [2.4% - 3.7%]) than in 2009 (5.2%; [3.8% - 6.6%]), and could be explained by several factors, such as the surveyors' knowledge, the phrasing of the questions, etc. These "truly preventable" death rates are consistent with those of other studies: 6,0% in the USA in 2011, 3.4% in New Zealand in 2006, and 4.1% in the Netherlands in 2009.

Hogan et al. also demonstrated a long, non-significant association between HSMRs and the proportion of preventable deaths. Similar results were demonstrated between SHMI measures and the proportion of preventable deaths. For the authors, the lack of association between the proportion of preventable deaths and HSMRs partly reflects methodological shortcomings in both measures. Hogan recommends giving priority to the use of morbidity-mortality reviews to find ways of improving the quality of care and to only use standardised mortality ratios such as HSMRs to identify high mortality rates in pathological conditions for which we already have high-quality clinical data.

Authors commenting on this article advised against the use of HSMRs. In one of these comments, Wise quoted Nick Black (Professor at the London School of Hygiene and Tropical Medicine) on the fact that it was better to support and help hospitals achieve quality standards rather than criticise and punish them, on the basis of approximate measures such as HSMRs (111). Nick Black further added, "Given the complexity of hospitals, with many different clinical departments and activities, it is more helpful for the public, patients, staff, and politicians to use a variety of specific measures of quality, such as adherence to good practice guidelines; outcomes for specific pathological conditions or procedures; patient surveys of their experiences; infection rates; and staff surveys." (111). In another article, Doran et al. were more categorical. Based on the principle that a rationalisation of the indicators to be developed was necessary, he stated that all evidence showed that there was no future for overall mortality rates. He further added that, no matter how carefully these rates are risk-adjusted, they do not take account of coding errors, variation across hospitals, variation in performance within hospitals and the availability of alternative places where patients can die, and in addition, they are not correlated with avoidable deaths (112).

2.6.4. Integration of quality indicators in a composite score

Certain authors discuss the use of mortality indicators in multidimensional composite scores combining outcome indicators (death, complications, morbidity), process indicators, and structure indicators (volume) for given diagnoses (24, 26, 113).

This was the subject of specific studies by Dimick et al. and Staiger et al. (University of Michigan) on surgical mortality indicators in the Leapfrog Group (104, 114):

- Dimick et al. showed that a composite score combining mortality and procedure volume for 6 surgical operations[39] was a better model to predict mortality over the following year than volume or mortality considered individually (114).
- Staiger et al. developed another composite score corresponding to a weighted average of several quality indicators available for 8 surgical procedures[40]: mortality rate and complication rate for each procedure, as well as all of the hospitals' structural characteristics that can be linked to mortality (hospital volume, nurse staffing level and teaching status), in a population of 53,120 patients having undergone aortic valve replacement (Medicare 2000-2001 data) (104). They particularly examined aortic valve replacement and showed that the composite score explained 78% of the mortality rate variation for this intervention (2000-2001); the most important variables were hospital volume, mortality after an aortic valve replacement and mortality associated with other surgical procedures. The composite score predicted 70% of the future variation of the in-hospital mortality rate for the 2002-2003 period. Compared to single indicators (process, outcome, structure) of surgical performance, composite scores are better able to explain the variation of in-hospital mortality rates and predict future performance.

Conclusions:

The classification of quality indicators put forward by Donabedian in 1966 remains the international benchmark. It involves 3 categories of indicators: structure indicators, process indicators and outcome indicators (including mortality indicators).

[39]**Six surgical procedures:** 1) coronary bypass; 2) aortic valve replacement; 3) repair of abdominal aortic aneurysm; 4) percutaneous coronary intervention; 5) pancreatic cancer resection; 6) oesophageal cancer resection.

[40] **Eight procedures studied:** 1) aortic valve replacement; 2) percutaneous coronary intervention; 3) coronary bypass; 4) mitral valve replacement; 5) aortic aneurysm repair; 6) aortic endarterectomy; 7) esophagectomy; 8) pancreatic resection.

- A literature review shows non-constant correlations between a high quality of care measured through process indicators, and low mortality, and vice versa. In particular, a literature review conducted by Pitches et al. showed that the notion that the healthcare institutions with the highest risk-adjusted mortality rates delivered a low quality of care was neither consistent nor reliable.

The weakness of the correlations between process indicators and mortality indicators may be due to two main limitations: limitations linked to the construction of the mortality indicators and limitations linked to the choice of the process indicators.

- The literature review shows weak correlations between overall mortality rates (such as HSMRs) and the proportion of preventable deaths.

Hogan et al. estimated that the proportion of preventable deaths was between 3% and 5.2%. These results were consistent with those of other studies: 6% in the USA in 2011, 3.4 % in New Zealand in 2006 and 4.1% in the Netherlands in 2009.

3. Guidelines on how to choose and use all-cause mortality indicators in France

Since 2006, HAS has been promoting quality through the general rollout of healthcare quality and safety indicators (IQSSs) in healthcare institutions. The IQSS policy has three objectives, jointly pursued by HAS and the DGOS:

- Providing tools and methods to oversee and manage healthcare quality and safety;
- Supporting the reporting and oversight of intervention policies at regional and national levels;
- Fulfilling users' transparency requirements concerning the quality of the care provided in healthcare institutions.

This indicator mechanism is associated with HAS' certification of healthcare institutions – a procedure that pursues the same objectives.

To enhance the IQSS mechanism with hospital mortality indicators, while taking account of the information provided by the analysis of literature data and by what is being done in other countries, HAS recommends the development of 30-day condition-specific mortality indicators (all causes).

3.1. Specific mortality indicators for inter-institution comparison and public disclosure

3.1.1. Choice of the mortality indicator

For the comparison of institutions, the data stemming from published literature and foreign experiences are favourable to the use of specific mortality indicators.

Concerning the scope of the indicator, preference should be given to indicators that evaluate mortality at a distance from patient admission for pathological conditions or at a distance from a surgical, interventional or obstetric procedure. Indeed, the shortening of average lengths of stays (ALOS) and their variation make it impossible to solely consider the in-hospital period. In other countries, the most frequently used time limit, for both readmissions and mortality, is 30 days following the admission or surgical procedure.

For the choice of the pathological conditions and procedures to be studied, it is important to concentrate on procedures involving a sufficient number of stays. The analysis of published literature prompts us to **primarily consider pathological conditions and procedures for which internationally validated indicators already exist:** mortality within 30 days of admission for myocardial infarction, heart failure, ischaemic stroke, pneumonia, COPD exacerbation or within 30 days of a diagnostic or therapeutic procedure for coronary bypass, aortic or mitral valve replacement, open surgery or endovascular treatment of an abdominal aorta aneurysm; lower extremity bypass; percutaneous coronary interventions; surgical treatment of a cancerous tumour (pancreas, colon, etc.).

The countries that have developed specific mortality indicators have developed a number of them. France should follow in their footsteps.

In order to be measurable and allow comparisons among institutions, the chosen clinical conditions and procedures, along with the associated deaths, will need to be sufficiently frequent.

The choice of the indicators and their development will need to involve clinical experts (clinically relevant condition or procedure, relevant time frame for the observation of deaths, choice of relevant adjustment variables, validation of the clinical relationship with the quality of the underlying processes and structures). Health authorities, patients and service users should be consulted on the choice of the indicators, in order to provide them with information which is meaningful to them. The choice of the pathological conditions and procedures for which mortality indicators will be developed will also need to take account of the fact that, overall, preventable hospital mortality is marginal. Priority should thus be given to frequent pathological conditions and procedures for which the preventable mortality rate is high, in the aim of reducing it.

Their coding must be reliable and they must already be covered by stable good-practice guidelines. The recommended data sources for the production of specific mortality indicators at a distance from patient admission or a surgical procedure are the medico-administrative data of the national PMSI-MCO database paired with SNIIRAM data since deaths taking place outside healthcare institutions are coded in the DCIR[41] database. At present, mortality indicators can be calculated for 75% of the French population (the list would need to be updated with the CNAMTS but it mainly covers the general health insurance scheme excluding local mutual insurance sections (SLM and MSA). This limitation is not necessarily a major obstacle since the beneficiaries of those regimes are generally not treated differently from other people within a particular hospital. However, verifications would be necessary in certain very specific institutions where beneficiaries of these regimes – which do not systematically enter the date of death in the DCIR – would be highly over-represented. These population restriction limitations will soon be resolved (the new system should be operational within 18 months). Indeed, the French legislation adopted in December 2015 to reform the healthcare system provides for the set-up of the SNDS (national health data system), chain-linking the SNIIRAM-PMSI data with the causes of death (with the mention of the AMPHI project in the explanatory memorandum). With this enhancement, the dates of death will be uploaded to the DCIR for all persons having died on French territory and having a registry number (NIR) – i.e. nearly 99% of the population according to the first estimates. This upload will be done using CépiDc-INSEE information, without having to wait for the validation of the coding of the causes. For the rapid calculation of the indicators, HAS should ideally be provided with permanent access to the future IT system through the SNDS implementing decree.

The AMPHI report[42] has shown that 30-day mortality indicator results are similar whether they cover overall deaths from all causes or whether they exclude deaths due to a cause not directly linked to the reason for the hospital admission (deaths not linked to the main diagnosis of the hospital stay). These indicators can thus include all causes of death (all-cause mortality).

Another conclusion of the AMPHI report is that using the causes of death, while excluding independent deaths, is not useful for an overall mortality indicator (3). However, this data could improve specific **mortality** rates (115). The factor that limits the production of specific mortality rates is the time required for the compilation of the causes of deaths, which is currently two years. However, this time frame should gradually be shortened as this is a clear objective of CépiDc. The SNIIRAM-Causes of Death pairing, done on a routine basis in the SNDS for all deaths, should no longer pose a problem.

41 Within the framework of the AMPHI project, the match rate for the PMSI-MCO/SNIIR-AM/ INSERM-CépiDC databases was considered excellent (96.7% match for persons hospitalised in the year preceding their death), but only concerned beneficiaries of the general health insurance scheme (70% of the French population and 66% of deaths). In the future, matching with all RSI and Mutuelle Sociale Agricole (MSA) databases would be desirable to avoid leaving out part of the persons covered.

42 This report is not available on the CépiDc website.

The indicator's **numerator** is the observed number of patient deaths during or following an admission (within 30 days) for the given pathological condition or procedure, for the year considered (generally the last year of available data).

The indicator's **denominator** is the expected number of deaths over the same period and for the same condition or procedure. It is estimated for each patient by statistic modelling using aggregate data covering several consecutive years (generally the last 3 years of available data). It could thus be necessary to have data for at least 3 consecutive years to allow the estimation of expected death rates, while limiting annual fluctuations and increasing the statistical power of the model.

Certain stays should be excluded from the database of chain-linked data before any modelling of expected mortality rates:

- incomplete/missing data, stay groups entered in the PMSI by error;
- stays involving patients who are organ donors or were declared dead on arrival at the hospital;
- sessions;
- stays for which the vital status is not reliable (e.g. neonatal period).

Other aspects will need to be discussed and arbitrated by the group of experts:

- the thresholds to be set for the exclusion of institutions with too few eligible stays and deaths;
- the inclusion or not of stays in **palliative care** according to the impact of the exclusion of these stays on expected mortality rates;
- stays involving **admission through transfer** and the institution to which the death is allocated.

3.1.2. Adjustment models for specific mortality indicators

The **adjustment variables** will be specific to each of the mortality indicators measured.

They include "patient characteristics": the choice of the variables will be discussed with competent clinicians and will also depend on their availability in the database of chain-linked data, the scientific literature data on the conditions or procedures considered (2), and the results of the scientific studies conducted in France on hospital mortality indicators (HSMR project / IMER centre within HCL).

Insofar as possible, the chosen adjustment factors should represent the state of the patient on admission at the hospital, in order to be able to distinguish the patient comorbidities treated during their hospitalisation from the complications arising during that stay (Part 2.2 : What hospital mortality indicator for what use ?).

For inter-institution comparison purposes, the modelling of the expected mortality rate at a distance from the hospital admission or surgical/interventional procedure should preferably be based on a simple logistic regression model, adjusted for patient characteristics.

An adjustment based on institution-specific variables may be examined: activity volume for the condition/procedure considered, legal status, rural or urban status, university status, availability of specialised care units, medical/nurse staffing levels, medical density of the geographic area, etc. These factors may improve the performance of the death rate adjustment model. Some of them may also allow the estimation of the bias associated with the measurement of certain patient characteristics used in the adjustment model.

To represent the variability among institutions, for external evaluation or regulation purposes, a caterpillar plot or funnel plot may be used. This will make it possible to compare institutions, as well as identify outliers. Moreover, a temporal chart of the institutions' mortality rate over the last 3 available years (the years used for the modelling of the expected mortality rates) should be provided.

For outliers, control charts such as Shewhart charts, as presented by Duclos (116), may be envisaged, as well as Cumulative Sum Charts (CUSUM), as described by numerous authors (117).

3.1.3. Modalities for using mortality indicators

The validated indicator results will be transmitted to the institutions to help them improve the safety and quality of care. Moreover, if the outcome indicator(s) have sufficient metrological properties, in other words if the events identified via the PMSI are confirmed in patient records more than 9 times out of 10, they may be disclosed to the public. The public disclosure of a hospital mortality indicator should be preceded by one or two years of indicator production, with dissemination being restricted to the institutions concerned and to the national and regional health authorities. During those two years, the transmission of the indicator results to the institutions could be backed by structured dialogue between the supervisory authority (and/or HAS) and the institutions in order to identify aspects that can be improved based on the indicator results.

For public disclosure purposes, the reporting of performance-based classifications (see Veterans Affairs Hospital Compare –Table 1 Part A - 1) seems preferable. The institution can be ranked in relation to the national average by comparing its 95% confidence interval to 1 (or 100 if you opt for an Observed/Expected ratio*100). This will produce 3 grades of institutions: "those significantly lower than the national average", "those significantly higher than the national average", and "those within the national average". The institution may also be rated according to its position in the funnel plot. Since the upper and lower limits of the funnel plot are generally set at 2 and 3 standard deviations, the institutions can be classified into 3 to 5 performance categories in relation to the national average.

Insofar as possible, mortality indicators linked to specific procedures or pathological conditions should be published at the same time as the results of existing process indicators on the same topic, so as to evaluate the quality of the hospital care using the two types of indicators.

Published literature has shown that financial incentives to improve quality using mortality indicators do not seem appropriate, notably because of the adverse effects that this measure could have on professional practices (such as the modification of coding practices by healthcare institutions to improve mortality rates without improving the quality of care, and the rapid transfer of patients with a high death risk from the hospital to another healthcare institution in order to exclude them from the mortality indicator). Financial incentives taking account of mortality indicators could also encourage doctors to drastically select the patients admitted to the hospital beds, according to whether they are more or less at risk of dying within 30 days.

3.2. Other mortality-based tools may be used to improve the quality of care in healthcare institutions

3.2.1. Overall mortality indicator exclusively used for internal management

The work done by the IMER centre within Hospices Civils de Lyon on the development in France of an overall hospital standardised mortality ratio (overall HSMR for Medicine/Surgery/Obstetrics institutions) has shown that it is currently inappropriate to use an overall mortality indicator built from PMSI data to compare the results of institutions and even more so, for the public disclosure of results[4].

However, as underscored by the authors of the studies, and in keeping with the literature analysed, HSMRs can effectively be used as tools to monitor mortality trends in a healthcare institution. Indeed, for the internal management of the quality of care, the monitoring of mortality is quite useful. In healthcare, Statistical Process Control (SPC) is a method used for the continuous improvement of the quality of care based on the chronological monitoring of pre-established indicators, allowing the follow-up and identification of the indicator's behaviour by analysing its variations (118). These variations may be due to:

- special/irregular/unusual causes for which an aetiology can be found: the indicator's behaviour is then not predictable;
- common/frequent/random/structural causes inherent to the process studied. A system or process that is only subject to common causes is said to be "controlled", it is then predictable and can be modelled.

Monitoring through control charts such as Shewhart charts is recommended, along with the set-up of a quality improvement process based on indicator monitoring (119).

3.2.2. Systematic morbidity-mortality reviews for the detailed study of the causes of death

In addition to the indicators allowing the identification of atypia, institutions could make broader use of morbidity-mortality reviews (MMRs).

An MMR is a collective, retrospective, systemic analysis of cases involving death, a complication, or an event that could have caused harm to the patient. Its purpose is the implementation and follow-up of actions to improve the quality and safety of patient care.

The systemic analysis conducted as part of the MMR is a general analysis of the situation, taking account of all interacting aspects (organisational, technical and human) involved in patient care.

MMRs are important tools to implement in order to increase knowledge by drawing on the experience gained. HAS has developed a certain number of tools to support the set-up and structuring of MMRs (120) (defining of quality criteria, methodological guidance, continuous professional development (CPD), etc.).

MMRs are mandatory in certain activity sectors within healthcare institution (see criterion 28.a of the certification guide) – i.e. surgery, anaesthesia-resuscitation and oncology – as well as for the accreditation of doctors and medical teams working in a high-risk speciality area (surgery, obstetrics, anaesthesia, etc.). These procedures must be part and parcel of day-to-day activity in all other sectors.

Thanks to the forethought given to the consequences of the procedures, their permanent integration and regular implementation in an activity sector has positive effects on the professionals' safety culture and on the service provided to the patients. Cross-evaluations between professionals from different services or institutions should be encouraged.

4. Conclusion

- The review of the mortality indicators used in five countries (United States, United Kingdom, Canada, Australia and Germany) has shown that most of the countries, excluding the United States, use all-cause mortality indicators (use of the Hospital Standardised Mortality Ratio (HSMR) in the United Kingdom, Canada and Germany). All countries also use specific mortality indicators and most publish the results of these indicators.
- The international literature review has shown that overall mortality is a concept which is easier to grasp than specific mortality, and that it eliminates sample size issues. However, for overall mortality, a few methodological precautions must be taken: exclusion of expected or unavoidable deaths, choice of appropriate source data and the right adjustment model.

Specific mortality indicators constitute a more precise and more medical measure than overall mortality. By definition, they concern fewer deaths. In order to obtain an adequate measure of performance, studies must focus on simple pathological conditions (e.g. stroke) or essential surgical procedures (e.g. coronary bypass) performed in sufficient numbers and presenting inter-institution variability.

The two most widely used measures are in-hospital (IH) mortality rates and 30-day mortality rates (following admission or an intervention), whether the patient is still hospitalised or has been discharged. In-hospital mortality indicators are dependent on an institution's patient discharge policy, while 30-day mortality indicators (following admission or an intervention) are most often used and are not dependent on the discharge policy. However, they are more difficult to measure as they require patient follow-up after their discharge from the hospital. It should be noted that a 30-day interval may be too short to cover the early mortality phase. It could be wise to extend the follow-up phase to 60 days.

It should also be noted that the choice of the mortality rate measurement scope (in-hospital or 30-day) has an impact on the institution's rating and/or outlier status.

The studies published on that subject have shown that patients rarely seek information on published mortality results, do not understand them, or have no trust in such information. The studies suggest that such guides and reports are chiefly used by employers and insurers for the drafting of contracts, by institutions to select practitioners, and by care providers to identify possible improvements. The public reporting of mortality indicator results has a low impact on the choices made by service users. It has a non-constant effect on mortality trends and generates adaptations on the part of institutions and professionals. This adaptation stems from three main mechanisms: i) the selective admission of patients; ii) changes in the surgeon population; iii) an adaptation of surgeons to patients' risk profiles. The use of mortality indicators in financial incentive programmes can spur improvements in the quality of care but can also have numerous adverse effects such as: the modification of coding practices, the rapid transfer of patients with a high death risk from the hospital to another healthcare institution in order to exclude them from the calculation of the mortality indicator, the selective admission of patients based on their risk of dying within 30 days, the undue sanctioning of healthcare institutions that have a minor role in the care of patients (post-acute care), the penalising of hospitals caring for patients who are very ill or have complex conditions, which can in turn lead to overtreatment to avoid death, and thus generate needless expenses.

The literature review also revealed non-constant correlations between high quality of care measured through process indicators and low mortality, and vice versa.

Lastly, the studies showed weak correlations between overall mortality rates (such as HSMRs) and the proportion of preventable deaths, i.e. linked to shortcomings in the care provided. According to those studies, the proportion of preventable deaths is between 3% and 6%.

– For the development of hospital mortality indicators in France, preference should be given to **specific indicators of mortality within 30 days of admission** (pathological conditions) **or a procedure** (surgery, intervention or obstetrics). These indicators can be put in place if the volume of procedures or pathological conditions is sufficient. As a priority, the conditions and procedures for which indicators have already been validated internationally (e.g. CMS) should be considered. The data sources to be used should be medico-administrative data (from the SNIIRAM database in particular since it includes the PMSI data, as well as death data). First of all, the validated indicator results will be transmitted to the healthcare institutions. If the validation allows it, the indicator results may be disclosed to the public. In that case, the reporting should focus on performance-based ratings in relation to the national average (higher than expected, lower than expected, or in the norm). The use of these indicators in a financial incentive programme to improve quality is not envisaged, in order to avoid the development of a patient-selection phenomenon.

HSMRs have a certain number of methodological limitations that prompt us to consider them as tools to provide early warning and monitor mortality within institutions, but which should not be used for the comparison of institutions or for public disclosure purposes.

– **Work undertaken for the development of mortality indicators in France**

The AMPHI report confirmed that the strictly in-hospital (IH) mortality indicator does not identify the same institutions as having excess mortality as the indicator measuring mortality within 30 days of admission (deaths at the hospital or outside the hospital). It also showed that 30-day mortality indicator results are similar whether they cover overall deaths from all causes or whether they exclude deaths due to a cause not directly linked to the reason for the hospital admission (deaths not linked to the main diagnosis of the hospital stay).

It also confirmed the results published in international literature, i.e. that in-hospital mortality indicator results depend on the institutions' mean length of stay, which in turn is linked to their "discharge policy". When we consider longer periods after admission or the intervention, the weight of the institution's independent factors is likely to be greater. The AMPHI report thus recommends the use of a short period (30 days) for the overall post-hospital mortality indicator.

The results of the RNMH4 project showed that the use of an overall in-hospital mortality indicator to assess the overall care provided by an institution is still premature, whether for public disclosure purposes or for the comparison of institutions.

Over the past few years, the OECD's Health Care Quality Indicator (HCQI) expert group – of which HAS is a member – has launched studies on hospital performance. After having defined a conceptual framework for hospital performance, the OECD launched a pilot data collection in the aim of analysing the variability of mortality within 30 days of hospital admission for acute myocardial infarction (AMI). This data should shed light on the factors responsible for the variability of post-AMI mortality in the different countries and institutions. Moreover, the OECD wished to obtain a reliable indicator to be included in its next edition of Health at a Glance in November 2017.

Fifteen countries were already taking part in this study, including Canada, Denmark, Ireland, Norway, Israel, Mexico, the USA, Australia, and Korea)[43]. At the meeting of 3-4 November 2016, France and Italy stated their wish to participate in the data collection6.

[43] Directorate for Employment, Labour and Social Affairs, Health Committee, Understanding Hospital Performance: Progress on Hospital Performance Project and Future Directions for Strategic Work. DELSA/HEA(2016)27 OECD. 21-Oct-2016.

HAS was asked by the European and International Affairs Delegation and the Health Minister's office to manage the study on behalf of France at the OECD.

HAS has three main interests in carrying out this study:

- **visibility**, as the production of healthcare quality and safety indicators lies within the scope of HAS' expertise, which gives it legitimacy to work on that subject;
- **consistency** with the national studies conducted in France (DREES, DGOS, ATIH, CépiDc, HAS) over the past 8 years and the present literature review favourable to the development of specific mortality indicators (for high-volume pathological conditions/procedures) within 30 days of admission/intervention, for which AMI is a recommended topic of interest (see supra);
- **for strategic purposes on the national and international levels:** this work involves the production of the data required for the calculation of the mortality indicators produced by the OECD, concerning in-hospital mortality (PMSI data supplied to HAS by ATIH) and post-hospital data only available in the SNIIRAM database. Closer ties will thus have to be developed between CNAMTS and HAS in order to combine HAS' expertise concerning indicators with that of CNAMTS concerning post-hospital follow-up data. CNAMTS will also need to take part in the discussions with the OECD since it will have to provide the data needed for the calculation of the indicators.

This project thus initiates a collaboration between HAS and CNAMTS, with the prospect of other work to come.

Glossary

Adjustment through logistic regression (2) :

In published literature, logistic regression is the method most often mentioned to adjust hospital mortality for risk factors concerning patients or hospital stays. This adjustment method is based on the estimation of the probability of occurrence of an event (predictive model). In this type of model, the hospitalised patients' probability of dying is represented by a logarithmic function of their exposure (or not) to the factors to which they could have been exposed, according to equation (1) below:

$$(1) \qquad \text{Log}\,(Y) = \text{Log}\,\frac{(P_i)}{(1-P_i)} = a_0 + a_1 x\text{Factor1}_i + a_2 x\text{Factor2}_i + \ldots + a_n x\text{FactorN}_i$$

<u>Where</u>:
Log (Y) is the patients' probability of death (expressed as an odds-ratio value);
Factor1, Factor2... FactorNi are the risk factors associated with level 1 of the analysis represented by i;
and a_1, a_2...a_n are the respective regression coefficients.

Adjustment through standardisation (2) :

Standardisation is an adjustment method frequently used in literature to compare several institutions. This method takes account of patient-related factors with variables taking the form of an aggregate variable (i.e. a ratio for gender, average age, average length of patients' hospital stays) for the statistical unit made up by the hospital service/department, or the hospital. The aggregate variables defined for each patient-related factor can be expressed through an ordinal or continuous value from which can be derived a number k of categories (or strata) establishing k levels of risk for each of the variables.

There are two main standardisation methods (2) :

Direct standardisation (or the standard population method) which is based on a comparison between an observed rate (study population sample) and an expected rate (reference population), with the two populations having a comparable structure (case-mix).

The standardised mortality rate is calculated by weighting the observed mortality rate with the expected mortality rate, per category of variables representing the criteria used to characterise the case-mix (i.e. age brackets, gender, severity scale/score).

Indirect standardisation (or the standardised mortality method) which makes it possible to calculate the "Standardised Mortality Ratio" or SMR. The SMR is determined by calculating the ratio of the number of observed deaths to the number of expected deaths (the result is generally multiplied by 100). The number of expected deaths is determined by applying pre-defined variables to each patient category to describe the study's sub-populations.

An SMR above 100 indicates higher mortality in the sub-population than in the reference population (an SMR of 130 indicates excess mortality of 30%).

An SMR below 100 indicates lower mortality in the sub-population than in the reference population (an SMR of 75 indicates an under-mortality of 25%).

Odds ratio: the odds ratio (OR) is a statistical measure often used in epidemiology, expressing the degree of dependence between qualitative random variables. It is used in Bayesian inference and logistic regression, and makes it possible to measure the effect of a factor.

It is defined as the relationship between the odds of an event (such as a disease) occurring in a group A of individuals, and the odds of the same event occurring in a group B of individuals. The odds can be compared to those of a race horse winning a Grand Prix. A horse with odds of 1 to 3 has 1 chance in 4 of winning.

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Bibliographic references

1. Agence technique de l'information sur l'hospitalisation. Rapport de synthèse des travaux de l'ATIH sur les méthodes d'ajustement des RNMH. Paris: ATIH; 2011.
2. Direction de la recherche des études de l'évaluation et des statistiques, Haute Autorité de Santé, Januel JM. Les méthodes d'ajustement dans les modèles d'évaluation de la mortalité hospitalière. Partie 1 – Étude descriptive. Série études et recherche n°112. Paris: DRESS; 2011. http://drees.social-sante.gouv.fr/IMG/pdf/serieetud112-4.pdf
3. Institut national de la santé et de la recherche médicale, Centre d'épidémiologie sur les causes médicales de décès, Lamarche-Vadel A, Ngantcha M, Jougla E, Rey G. AMPHI. Analyse de la Mortalité Post-Hospitalisation en France en 2008-2010 recherche d'Indicateurs par établissement. Paris: Inserm; 2014.
4. Street A. The resurrection of hospital mortality statistics in England. J Health Serv Res Policy 2002;7(2):104-10.
5. Mid Staffordshire NHS Foundation Trust, Francis R. Report of the Mid Staffordshire NHS Foundation Trust Public Inquiry. Volume 1: Analysis of evidence and lessons learned (part 1). London: Stationery Office; 2013. http://www.midstaffspublicinquiry.com/sites/default/files/report/Volume%201.pdf
6. Keogh B. Review into the quality of care and treatment provided by 14 hospital trusts in England: overview report London: NHS; 2013. http://www.nhs.uk/nhsengland/bruce-keoghreview/documents/outcomes/keogh-review-finalreport.pdf
7. Campbell MJ, Jacques RM, Fotheringham J, Maheswaran R, Nicholl J. Developing a summary hospital mortality index: retrospective analysis in English hospitals over five years. BMJ 2012;344:e1001.
8. Organisation de coopération et de développement économiques. Etre à la hauteur. Mesurer et améliorer la performance des systèmes de santé dans les pays de l'OCDE. Paris: OECD Publishing; 2002.
9. Spiegelhalter DJ. Surgical audit: statistical lessons from Nightingale and Codman. J R Statistical Soc 1999;162(1):45-58.
10. Gross PA, Braun BI, Kritchevsky SB, Simmons BP. Comparison of clinical indicators for performance measurement of health care quality: a cautionary note. Clin Perform Qual Health Care 2000;8(4):202-11.
11. Krauss J, Maclean R. Inpatient mortality: a reflection of quality care? Outcomes Manag 2002;6(4):169-73.
12. Hannan EL, Kilburn H, Racz M, Shields E, Chassin MR. Improving the outcomes of coronary artery bypass surgery in New York State. JAMA 1994;271(10):761-6.
13. Krakauer H, Bailey RC, Skellan KJ, Stewart JD, Hartz AJ, Kuhn EM, et al. Evaluation of the HCFA model for the analysis of mortality following hospitalization. Health Serv Res 1992;27(3):317-35.
14. Hannan EL, Kilburn H, Lindsey ML, Lewis R. Clinical versus administrative data bases for CABG surgery. Does it matter? Med Care 1992;30(10):892-907.
15. Hannan EL, Racz MJ, Jollis JG, Peterson ED. Using Medicare claims data to assess provider quality for CABG surgery: does it work well enough?Health Serv Res 1997;31(6):659-78.
16. Dziuban SW, McIlduff JB, Miller SJ, Dal Col RH. How a New York cardiac surgery program uses outcomes data. Ann Thorac Surg 1994;58(6):1871-6
17. Mukamel DB, Zwanziger J, Tomaszewski KJ. HMO penetration, competition, and

risk-adjusted hospital mortality. Health Serv Res 2001;36(6 Pt 1):1019-35.
18. Van der Weyden MB. The Bundaberg Hospital scandal: the need for reform in Queensland and beyond. Med J Aust 2005;183(6):284-5.
19. Australian Institute of Health and Welfare, BenTovim D, Woodman R, Harrison JE, Pointer S, Hakendorf P, et al. Measuring and reporting mortality in hospital patients. Canberra: AIHW; 2009. http://www.aihw.gov.au/publicationdetail/?id=6442468221
20. Melbourne EpiCentre, Landgren F, Staley C. Hospital mortality indicator (HMI). Review. Parkville: Melbourne EpiCentre; 2013. http://www.safetyandquality.gov.au/wpcontent/uploads/2014/09/Hospital-MortalityIndicator-Literature-Review.pdf
21. Scott IA, Brand CA, Phelps GE, Barker AL, Cameron PA. Using hospital standardised mortality ratios to assess quality of care: proceed with extreme caution. Med J Aust 2011;194(12):645-8.
22. Institut de recherche et documentation en économie de la santé, Com-Ruelle L, Or Z, Renaud T. Volume d'activité et qualité des soins dans les établissements de santé : enseignements de la littérature. Rapport n°545. Paris: IRDES; 2008. http://www.irdes.fr/Publications/Rapports2008/rap1734.pdf
23. Johnson ML, Gordon HS, Petersen NJ, Wray NP, Shroyer AL, Grover FL, et al. Effect of definition of mortality on hospital profiles. Med Care 2002;40(1):7-16.
24. Shahian DM, Iezzoni LI, Meyer GS, Kirle L, Normand SL. Hospital-wide mortality as a quality metric: conceptual and methodological challenges. Am J Med Qual 2012;27(2):112-23.
25. Lilford R, Pronovost P. Using hospital mortality rates to judge hospital performance: a bad idea that just won't go away. BMJ 2010;340:955-7.
26. Shojania KG, Forster AJ. Hospital mortality: when failure is not a good measure of success. CMAJ 2008;179(2):153-7.
27. Pitches DW, Mohammed MA, Lilford RJ. What is the empirical evidence that hospitals with higher-risk-adjusted mortality rates provide poorer quality care? A systematic review of the literature. BMC Health Serv Res 2007;7(91).
28. Dimick JB, Welch HG, Birkmeyer JD. Surgical mortality as an indicator of hospital quality: the problem with small sample size. JAMA 2004;292(7):847-51.
29. Zalkind DL, Eastaugh SR. Mortality rates as an indicator of hospital quality. Hosp Health Serv Adm 1997;42(1):3-15.
30. Lilford R, Mohammed MA, Spiegelhalter D, Thomson R. Use and misuse of process and outcome data in managing performance of acute medical care: avoiding institutional stigma. Lancet 2004;363(9415):1147-54.
31. Austin PC. A comparison of Bayesian methods for profiling hospital performance. Med Decis Making 2002;22(2):163-72.
32. Iezzoni LI. The risks of risk adjustment. JAMA 1997;278(19):1600-7.
33. Mohammed MA, Deeks JJ, Girling A, Rudge G, Carmalt M, Stevens AJ, et al. Evidence of methodological bias in hospital standardised mortality ratios: retrospective database study of English hospitals. BMJ 2009;338:b780.
34. Sheps SB. Measure for measure? The challenge of new thinking about patient safety. Healthc Pap 2008;8(4):62-7.
35. McKinley J, Gibson D, Ardal S. Hospital standardized mortality ratio: the way forward in Ontario. Healthc Pap 2008;8(4):43-9.
36. Taylor P. Standardized mortality ratios. Int J Epidemiol 2013;42(6):1882-90.
37. Bottle A, Jarman B, Aylin P. Strengths and weaknesses of hospital standardised mortality ratios. BMJ 2011;342:749-53.

38. Krumholz HM, Wang Y, Mattera JA, Wang Y, Han LF, Ingber MJ, et al. An administrative claims model suitable for profiling hospital performance based on 30-day mortality rates among patients with an acute myocardial infarction. Circulation 2006;113(13):1683-92.
39. Krumholz HM, Wang Y, Mattera JA, Wang Y, Han LF, Ingber MJ, et al. An administrative claims model suitable for profiling hospital performance based on 30-day mortality rates among patients with heart failure. Circulation 2006;113(13):1693-701.
40. American Heart Association, American College of Cardiology Foundation, Krumholz HM, Brindis RG, Brush JE, Cohen DJ, et al. Standards for statistical models used for public reporting of health outcomes. Circulation 2006;113(3):456-62.
41. Jacobs JP, Mavroudis C, Jacobs ML, Maruszewski B, Tchervenkov CI, Lacour-Gayet FG, et al. What is operative mortality? Defining death in a surgical registry database: a report of the STS Congenital Database Taskforce and the Joint EACTS-STS Congenital Database Committee. Ann Thorac Surg 2006;81(5):1937-41.
42. Bottle A, Jarman B, Aylin P. Hospital standardized mortality ratios: sensitivity analyses on the impact of coding. Health Serv Res 2011;46(6pt1):1741-61.
43. Drye E, Normand SL, Wang Y, Ross JS, Schreiner GC, Han L, et al. Comparison of hospital risk-standardized mortality rates using in-hospital and 30-day models: implications for hospital profiling. Ann Intern Med 2012;156(1 Pt 1):19-26.
44. Pouw ME, Peelen LM, Moons KG, Kalkman CJ, Lingsma HF. Including post-discharge mortality in calculation of hospital standardised mortality ratios: retrospective analysis of hospital episode statistics. BMJ 2013;347:f5913.
45. Jarman B, Bottle A, Aylin P, Taylor R. Mortality rates. Dead confusing. Health Serv J 2002;112(5831):26-7.
46. Penfold RB, Dean S, Flemons W, Moffatt M. Do hospital standardized mortality ratios measure patient safety? HSMRs in the Winnipeg Regional Health Authority. Healthc Pap 2008;8(4):8-24.
47. Osswald BR, Tochtermann U, Schweiger P, Göhring D, Thomas G, Vahl CF, et al. Minimal early mortality in CABG: simply a question of surgical quality? Thorac Cardiovasc Surg 2002;50(5):27680.
48. Rosenthal GE, Baker DW, Norris DG, Way LE, Harper DL, Snow RJ. Relationships between inhospital and 30-day standardized hospital mortality: implications for profiling hospitals. Health Serv Res 2000;34(7):1449-68.
49. Kristoffersen DT, Helgeland J, Clench-Aas J, Laake P, Veierod MB. Comparing hospital mortality: how to count does matter for patients hospitalized for acute myocardial infarction (AMI), stroke and hip fracture. BMC Health Serv Res 2012;12(1):364.
50. Borzecki AM, Christiansen CL, Chew P, Loveland S, Rosen AK. Comparison of in-hospital versus 30-day mortality assessments for selected medical conditions. Med Care 2010;48(12):1117-21.
51. Westaby S, Archer N, Manning N, Adwani S, Grebenik C, Ormerod O, et al. Comparison of hospital episode statistics and central cardiac audit database in public reporting of congenital heart surgery mortality. BMJ 2007;335(7623):759.
52. Iezzoni LI. Assessing quality using administrative data. Ann Intern Med 1997;127(8 Pt 2):666-74.
53. Almoudaris AM, Burns EM, Bottle A, Aylin P, Darzi A, Faiz O. A colorectal perspective on voluntary submission of outcome data to clinical registries. Br J Surg 2011;98(1):132-9.
54. Charlson ME, Pompei P, Ales KL, MacKenzie CR. A new method of classifying prognostic comorbidity in longitudinal

studies: development and validation. J Chronic Dis 1987;40(5):373-83.

55. Quan H, Li B, Couris CM, Fushimi K, Graham P, Hider P, et al. Updating and validating the Charlson comorbidity index and score for risk adjustment in hospital discharge abstracts using data from 6 countries. Am J Epidemiol 2011;173(6):676-82.
56. Elixhauser A, Steiner C, Harris DR, Coffey RM. Comorbidity measures for use with administrative data. Med Care 1998;36(1):8-27.
57. Van Gestel YR, Lemmens VE, Lingsma HF, de Hingh I, Rutten HJ, Coebergh JW. The hospital standardized mortality ratio fallacy: a narrative review. Med Care 2012;50(8):662-7.
58. Ben-Tovim DI, Pointer SC, Woodman R, Hakendorf PH, Harrison JE. Routine use of administrative data for safety and quality purposes: hospital mortality. Med J Aust 2010;193(8 Suppl):S100-S3.
59. Van den Bosch WF, Kelder JC, Wagner C. Predicting hospital mortality among frequently readmitted patients: HSMR biased by readmission. BMC Health Serv Res 2011;11:57.
60. Shine D. Risk-adjusted mortality: problems and possibilities. Comput Math Methods Med 2012;2012:829465.
61. Glance LG, Osler TM, Mukamel DB, Dick AW. Impact of the present-on-admission indicator on hospital quality measurement: experience with the Agency for Healthcare Research and Quality (AHRQ) Inpatient Quality Indicators. Med Care 2008;46(2):112-9.
62. Stukenborg GJ, Wagner DP, Harrell FE, Oliver MN, Heim SW, Price AL, et al. Which hospitals have significantly better or worse than expected mortality rates for acute myocardial infarction patients? Improved risk adjustment with present-at-admission diagnoses. Circulation 2007;116(25):2960-8.
63. Stukenborg GJ. Hospital mortality risk adjustment for heart failure patients using present on admission diagnoses: improved classification and calibration. Med Care 2011;49(8):744-51.
64. Society for Cardiothoracic Surgery in Great Britain and Ireland, National Institute for Clinical Outcomes Research, Bridgewater B, Hickey GL, Cooper G, Deanfield J, et al. Publishing cardiac surgery mortality rates: lessons for other specialties. BMJ 2013;346:f1139.
65. Nicholl J. Case-mix adjustment in non-randomised observational evaluations: the constant risk fallacy. J Epidemiol Community Health 2007;61(11):1010-3.
66. Dimick JB, Birkmeyer JD. Ranking hospitals on surgical quality: does risk-adjustment always matter? J Am Coll Surg 2008;207(3):347-51.
67. Fonarow GC, Pan W, Saver JL, Smith EE, Reeves MJ, Broderick JP, et al. Comparison of 30-day mortality models for profiling hospital performance in acute ischemic stroke with vs without adjustment for stroke severity. JAMA 2012;308(3):257-64.
68. Shahian DM, Wolf RE, Iezzoni LI, Kirle L, Normand SL. Variability in the measurement of hospital-wide mortality rates. N Engl J Med 2010;363(26):2530-9.
69. Austin PC, Naylor CD, Tu JV. A comparison of a Bayesian vs. a frequentist method for profiling hospital performance. J Eval Clin Pract 2001;7(1):35-45.
70. Austin PC, Alter DA, Tu JV. The use of fixed- and random-effects models for classifying hospitals as mortality outliers: a Monte Carlo assessment. Med Decis Making 2003;23(6):526-39.
71. Hashmi ZG, Dimick JB, Efron DT, Haut ER, Schneider EB, Zafar SN, et al. Reliability adjustment: a necessity for trauma center ranking and benchmarking. J Trauma Acute Care Surg 2013;75(1):166-72.

72. Schneider EC, Epstein AM. Use of public performance reports: a survey of patients undergoing cardiac surgery. JAMA 1998;279(20):1638-42.
73. Marshall MN, Shekelle PG, Leatherman S, Brook RH. The public release of performance data: what do we expect to gain? A review of the evidence. Jama 2000;283(14):1866-74.
74. Baker DW, Einstadter D, Thomas C, Husak S, Gordon NH, Cebul RD. The effect of publicly reporting hospital performance on market share and risk-adjusted mortality at high-mortality hospitals. Med Care 2003;41(6):729-40.
75. Ryan AM, Nallamothu BK, Dimick JB. Medicare's public reporting initiative on hospital quality had modest or no impact on mortality from three key conditions. Health Aff 2012;31(3):585-92.
76. Epstein AJ. Do cardiac surgery report cards reduce mortality? Assessing the evidence. Med Care Res Rev 2006;63(4):403-26.
77. Joynt KE, Blumenthal DM, Orav EJ, Resnic FS, Jha AK. Association of public reporting for percutaneous coronary intervention with utilization and outcomes among Medicare beneficiaries with acute myocardial infarction. JAMA 2012;308(14):1460-8.
78. Ryan AM. Effects of the premier hospital quality incentive demonstration on medicare patient mortality and cost. Health Serv Res 2009;44(3):82142.
79. Jha AK, Joynt KE, Orav EJ, Epstein AM. The long-term effect of premier pay for performance on patient outcomes. N Engl J Med 2012;366(17):1606-15.
80. Kristensen SR, Meacock R, Turner AJ, Boaden R, McDonald R, Roland M, et al. Long-term effect of hospital pay for performance on mortality in England. N Engl J Med 2014;371(6):540-8.
81. Kupfer JM. The morality of using mortality as a financial incentive: unintended consequences and implications for acute hospital care. JAMA 2013;309(21):2213-4.
82. Joynt KE, Jha AK. Thirty-day readmissions: truth and consequences. N Engl J Med 2012;366(15):1366-9.
83. Pronovost PJ, Colantuoni E. Measuring preventable harm: helping science keep pace with policy. JAMA 2009;301(12):1273-5.
84. Riley GF, Lubitz JD. Long-term trends in Medicare payments in the last year of life. Health Serv Res 2010;45(2):565-76.
85. Donabedian A. Evaluating the quality of medical care. 1966. Milbank Q 2005;83(4):691-729.
86. Donabedian A. The quality of care. How can it be assessed? JAMA 1988;260(12):1743-8.
87. Unroe KT, Greiner MA, Colon-Emeric C, Peterson ED, Curtis LH. Associations between published quality ratings of skilled nursing facilities and outcomes of medicare beneficiaries with heart failure. J Am Med Dir Assoc 2012;13(2):188-6.
88. Meehan TP, Fine MJ, Krumholz HM, Scinto JD, Galusha DH, Mockalis JT, et al. Quality of care, process, and outcomes in elderly patients with pneumonia. JAMA 1997;278(23):2080-4.
89. Popescu I, Werner RM, Vaughan-Sarrazin MS, Cram P. Characteristics and outcomes of America's lowest-performing hospitals: an analysis of acute myocardial infarction hospital care in the United States. Circ Cardiovasc Qual Outcomes 2009;2(3):221-7.
90. Bradley EH, Herrin J, Elbel B, McNamara RL, Magid DJ, Nallamothu BK, et al. Hospital quality for acute myocardial infarction: correlation among process measures and relationship with short-term mortality. JAMA 2006;296(1):72-8.

91. Hoeks SE, Scholte op Reimer WJ, Lingsma HF, van Gestel Y, van Urk H, Bax JJ, et al. Process of care partly explains the variation in mortality between hospitals after peripheral vascular surgery. Eur J Vasc Endovasc Surg 2010;40(2):147-54.
92. Shafi S, Parks J, Ahn C, Gentilello LM, Nathens AB, Hemmila MR, et al. Centers for Medicare and Medicaid services quality indicators do not correlate with risk-adjusted mortality at trauma centers. J Trauma 2010;68(4):771-7.
93. Nicholas LH, Osborne NH, Birkmeyer JD, Dimick JB. Hospital process compliance and surgical outcomes in medicare beneficiaries. Arch Surg 2010;145(10):999-1004.
94. Ingraham AM, Cohen ME, Bilimoria KY, Dimick JB, Richards KE, Raval MV, et al. Association of surgical care improvement project infection-related process measure compliance with risk-adjusted outcomes: implications for quality measurement. J Am Coll Surg 2010;211(6):705-14.
95. Kernisan LP, Lee SJ, Boscardin WJ, Landefeld CS, Dudley RA. Association between hospital-reported Leapfrog Safe Practices Scores and inpatient mortality. JAMA 2009;301(13):1341-8.
96. Werner RM, Bradlow ET. Relationship between Medicare's hospital compare performance measures and mortality rates. JAMA 2006;296(22):2694-702.
97. Shahian DM, Meyer GS, Mort E, Atamian S, Liu X, Karson AS, et al. Association of National Hospital Quality Measure adherence with long-term mortality and readmissions. BMJ Qual Saf 2012;21:325-36.
98. Maeda JL, Lo Sasso AT. The relationship between hospital market competition, evidence-based performance measures, and mortality for chronic heart failure. Inquiry 2012;49(2):164-75.
99. Hofer TP, Hayward RA. Identifying poor-quality hospitals. Can hospital mortality rates detect quality problems for medical diagnoses? Med Care 1996;34(8):737-53.
100. Australian and New Zealand Intensive Care Society, Moran JL, Solomon PJ. Global quantitative indices reflecting provider process-of-care: database derivation. BMC Med Res Methodol 2010;10:32.
101. Werner RM, Bradlow ET, Asch DA. Does hospital performance on process measures directly measure high quality care or is it a marker of unmeasured care? Health Serv Res 2008;43(5 Pt 1):1464-84.
102. Person SD, Allison JJ, Kiefe CI, Weaver MT, Williams OD, Centor RM, et al. Nurse staffing and mortality for Medicare patients with acute myocardial infarction. Med Care 2004;42(1):4-12.
103. Schilling P, Goulet JA, Dougherty PJ. Do higher hospital-wide nurse staffing levels reduce inhospital mortality in elderly patients with hip fractures: a pilot study. Clin Orthop Relat Res 2011;469(10):2932-40.
104. Staiger DO, Dimick JB, Baser O, Fan Z, Birkmeyer JD. Empirically derived composite measures of surgical performance. Med Care 2009;47(2):226-33.
105. Gozvrisankaran G, Town RJ. Competition, payers, and hospital quality. Health Serv Res 2003;38(6 Pt 1):1403-21.
106. Bian J, Dow WH, Matchar DB. Medicare HMO penetration and mortality outcomes of ischemic stroke. Am J Manag Care 2006;12(1):58-64.
107. Volpp KG, Ketcham JD, Epstein AJ, Williams SV. The effects of price competition and reduced subsidies for uncompensated care on hospital mortality. Health Serv Res 2005;40(4):1056-77.
108. Town R, Vistnes G. Hospital competition in HMO networks. J Health Econ 2001;20(5):733-53.
109. Hogan H, Zipfel R, Neuburger J, Hutchings A, Darzi A, Black N. Avoidability of hospital deaths and association with hospital-wide mortality ratios:

retrospective case record review and regression analysis. BMJ 2015;351:h3239.

110. Hogan H, Healey F, Neale G, Thomson R, Vincent C, Black N. Preventable deaths due to problems in care in English acute hospitals: a retrospective case record review study. BMJ Qual Saf 2012;21(9):737-45.

111. Wise J. Standardised mortality ratios should not be used to benchmark hospitals, study concludes. BMJ 2015;351:h3829.

112. Doran T, Bloor K, Maynard A. The death of death rates? BMJ 2015;351:h3466.

113. Chua CL, Palangkaraya A, Yong J. A two-stage estimation of hospital quality using mortality outcome measures: an application using hospital administrative data. Health Econ 2010;19(12):140424.

114. Dimick JB, Staiger DO, Baser O, Birkmeyer JD. Composite measures for predicting surgical mortality in the hospital. Health Aff 2009;28(4):118998.

115. Mechinaud Lamarche-Vadel A. Elaboration d'indicateurs de mortalité post-hospitalière à différents délais avec prise en compte des causes médicales de décès [Doctorat en Santé Publique Epidémiologie]. Paris: Université Paris Sud; 2014. https://tel.archives-ouvertes.fr/tel01165007/document

116. Duclos A, Polazzi S, Lipsitz SR, Couray-Targe S, Gawande AA, Colin C, et al. Temporal variation in surgical mortality within French hospitals. Med Care 2013;51(12):1085-93.

117. Noyez L. Control charts, Cusum techniques and funnel plots. A review of methods for monitoring performance in healthcare. Interact Cardiovasc Thorac Surg 2009;9(3):494-9.

118. Haute Autorité de Santé. Maîtrise statistique des processus en santé. Comprendre et expérimenter. Saint-Denis La Plaine: HAS; 2004. http://www.has-sante.fr/portail/jcms/c_457150

119. Shewhart WA, Deming WE. Statistical method from the viewpoint of quality control. New York: Dover Publications; 1986.

120. Haute Autorité de Santé. Repères – Les revues de morbi-mortalité (RMM) [En ligne]. SaintDenis La Plaine: HAS; 2015. http://www.has-sante.fr/portail/jcms/c_2568478/fr/reperes-lesrevues-de-morbi-mortalite-rmm

Abbreviations and acronyms

HAS	Haute Autorité de santé
ACS NSQIP	American College of Surgeons National Surgical Quality Improvement Program
IQM	Association Initiative Médecine de Qualité (Quality Medicine Initiative).
AHRQ	Agency for Healthcare Research and Quality.
AMPHI	Analyse de la mortalité post-hospitalière : recherche d'indicateurs par établissement. (Analysis of post-hospital mortality: search for institution-specific indicators.)
ATIH	Agence Technique de l'Information sur l'Hospitalisation (French technical agency for information on hospital care).
CépiDc	Centre d'épidémiologie sur les causes médicales de décès (Epidemiology centre for the medical causes of death).
CMS	Center for Medicare and Medicaid Services.
CNAMTS	Caisse Nationale d'Assurance Maladie des Travailleurs Salariés (National health insurance fund for salaried workers).
CQC	Care Quality Commission
DREES	Direction de la Recherche, des Etudes, de l'Evaluation et des Statistiques du Ministère en charge de la santé (French Health Ministry's Directorate for Research, Surveys, Assessment and Statistics).
DGOS	Direction générale de l'offre de soins (French Directorate General of Health Care Provision).
ES	Etablissement de santé (healthcare institution).
HCFA	Health Care Financing Administration
HSMR	Hospital Standardised Mortality Ratio
CIHI	Canadian Institute for Health Information
IQM	Association Initiative Médecine de Qualité (Quality Medicine Initiative).
NHS	National Health Service
NPHA	National Health Performance Authority
QSR	Quality assurance using routine data
MMR	Morbidity-Mortality Review
RSMR	Risk-Standardised Mortality Ratio
SMR	Standardised Mortality Ratio
HSMR	Hospital Standardised Mortality Ratio
SNIIRAM	Système national d'information inter-régime de l'assurance maladie (French health insurance inter-scheme IT system).
SHMI	Summary Hospital-Level Mortality Index
VHA	Veterans Health Affairs

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