Original article

Maturity Assessment model for Patient Blood Management to assist hospitals in improving patients' safety and outcomes. The MAPBM project

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Background - Patient blood management (PBM) is an evidence-based care bundle with proven ability to improve patients' outcomes by managing and preserving the patient's own blood. Since 2010, the World Health Organisation has urged member states to implement PBM. However, there has been limited progress in developing PBM programmes in hospitals due to the implicit challenges of implementing them. To address these challenges, we developed a Maturity Assessment Model (MAPBM) to assist healthcare organisations to measure, benchmark, assess in PBM, and communicate the results of their PBM programmes. We describe the MAPBM model, its benchmarking programme, and the feasibility of implementing it nationwide in Spain.

Materials and methods - The MAPBM considers the three dimensions of a transformation effort (structure, process and outcomes) and grades these within a maturity scale matrix. Each dimension includes the various drivers of a PBM programme, and their corresponding measures and key performance indicators. The structure measures are qualitative, and obtained using a survey and structured self-assessment checklist. The key performance indicators for process and outcomes are quantitative, and based on clinical data from the hospitals' electronic medical records. Key performance indicators for process address major clinical recommendations in each PBM pillar, and are applied to six common procedures characterised by significant blood loss.

Results - In its first 5 years, the MAPBM was deployed in 59 hospitals and used to analyse 181,826 hospital episodes, which proves the feasibility of implementing a sustainable model to measure and compare PBM clinical practice and outcomes across hospitals in Spain.

Conclusion - The MAPBM initiative aims to become a useful tool for healthcare organisations to implement PBM programmes and improve patients' safety and outcomes.

Keywords: *Patient Blood Management, patient safety, transfusion, maturity assessment, benchmarking.*

INTRODUCTION

Reducing inappropriate clinical interventions and incorporating high-value practices are major goals for any health organisation. These objectives can be connected via patient blood management (PBM), an evidence-based bundle of care to improve a patient's outcomes by managing and preserving the patient's own blood[1].

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Several studies have reported that blood transfusion is overused in clinical practice[2-5], and is an independent, dose-dependent risk factor for longer hospital stays, and higher risks of death and infection[6]. Similarly, pre-operative anaemia is an important and highly prevalent independent risk factor for peri-operative mortality and morbidity, and is thought to be present in approximately one-third of individuals undergoing major surgery[7-9]. Pre-operative anaemia is also the main risk factor for red blood cell (RBC) transfusion[7,10]. Overuse of blood transfusions and performing elective surgery normally associated with substantial bleeding in patients with uncorrected anaemia are listed by several professional societies and "Right Care" associations as practices that should be avoided[5,11,12].

The PBM concept is based on three pillars: (i) optimising erythropoiesis (treatment of anaemia), (ii) minimising bleeding and blood loss, and (iii) improving the patient's condition to allow the use of a more restrictive transfusion threshold[13-15] and has demonstrated its ability to address overuse and to improve patients' safety, outcomes and quality of care across many different populations[1,16-18].

Since 2010, the World Health Organisation (WHO) has officially been urging member states to implement PBM (WHA63.12)[19], and the European Commission also recently published PBM implementation guidelines for health authorities and hospitals[20, 21]. With the current shortage of donors and impediments to blood supply due to the Covid-19 pandemic, a "call for action" to implement PBM has been released by a group of experts[22].

In Spain, since 2006 we have had a comprehensive set of clinical guidelines on blood transfusion alternatives, known as the Seville Document (currently in its 3rd edition, with a more PBM-centred perspective), which is endorsed by seven important national scientific societies[23].

Despite the known benefits of PBM, and the existence of clinical guidelines and institutional recommendations, it remains challenging to implement PBM effectively across healthcare organisations[24,25]. The main challenges are: (i) the broad scope of PBM programmes (multidisciplinary, multimodal, and applicable to many clinical procedures), requiring a transversal strategy throughout the organisation and a concerted change-management effort by clinicians, managers, and regulators[20,21,26]; (ii) the need to implement long-lasting attitudinal changes among healthcare professionals in dealing with blood transfusions during a hospitalisation[27]; and (iii) the lack of a widely accepted practical framework to implement, target, and monitor a PBM programme in a given hospital or healthcare organisation, although some general recommendations have been published[28].

To address these challenges and improve patients' safety, we developed a maturity assessment model to allow healthcare organisations to measure, benchmark, assess, and communicate the results of their PBM programmes. The model is implemented in Spain as the "Maturity Assessment Model in Patient Blood Management (MAPBM), *www.mapbm.org*".

In this paper we describe the MAPBM, its benchmarking programme, and the feasibility of implementing it nationwide in 59 hospitals in Spain.

MATERIALS AND METHODS

MAPBM Assessment Model

In 2014, the MAPBM concept was developed by a multi-profession PBM group with experts from different fields (anaesthesiology, haematology, health economics, outcomes research, clinical management, and healthcare information systems). The concept included an assessment model and a strategy for deployment in hospitals.

The assessment model consists of a scorecard that allows a hospital to map its PBM organisation, PBM care delivery pathway, and PBM-related patient outcomes, according to a set of key performance indicators (KPI). Thus, the hospital can baseline its PBM performance, assess it over time, and benchmark itself against other hospitals.

In line with the Donabedian framework, the model considers structure, process and outcomes as the three relevant dimensions of a transformation effort towards fully establishing PBM as the new standard of care[20,29], and grades these within a maturity scale matrix. Each dimension consists of the various drivers of a PBM programme, and their corresponding measures and KPI (**Figure 1**). KPI were selected for: (i) their adequacy in measuring the structure, process or outcomes of PBM; (ii) the feasibility of having them supported/measured by information systems; and (iii) sensitivity and relevance.

The MAPBM model includes 70 measures for structure, 14 KPI for process, and 7 KPI for outcomes. Structure measures are qualitative and are obtained using a survey and a structured self-assessment checklist. The KPI for

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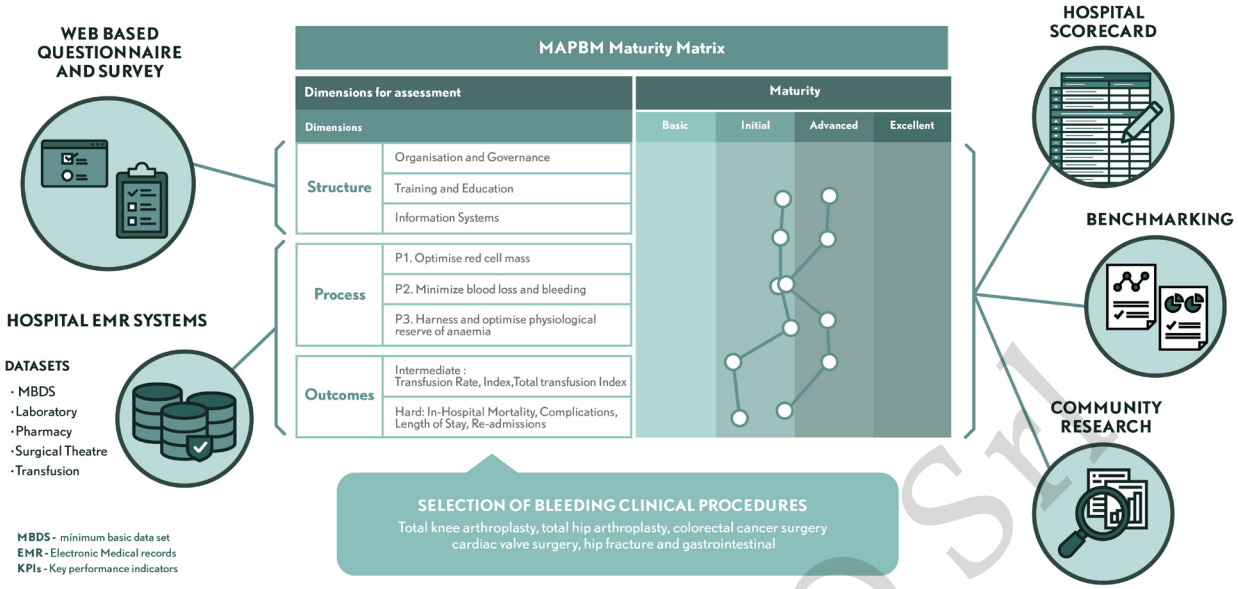

Figure 1 - Maturity Assessment for Patient Blood Management programme framework and maturity matrix

process and outcomes are quantitative and based on real-life clinical practice data gathered from the hospitals' electronic medical records (EMR).

Structure dimension

The structure dimension is rated by surveying the hospital's clinicians and having selected members of the hospital staff assess their PBM programme's governance and organisation, training and education, and information systems using a questionnaire. It considers eight major drivers: (i) PBM workgroup; (ii) clinical protocols; (iii) healthcare professionals' knowledge; (iv and v) PBM educational programmes for (iv) clinicians and (v) patients; (vi) availability of PBM-related computerised physician order-entry (CPOE) systems for prescribers; (vii) hospital data-reporting capabilities; and (viii) feedback to hospital staff on their PBM practices (**Figure 2**). The full questionnaire is shown in *Online Supplementary*, **Table SI**.

Process dimension

The process dimension is structured in line with standard PBM principles, known as the three pillars: (i) optimising red cell mass; (ii) minimising blood loss and bleeding; and (iii) optimising the physiological reserve of anaemia. Hence, this dimension includes KPI that measure and account for different aspects of optimisation of the patient's condition prior to surgery, consisting mainly on the detection of pre-operative anaemia and correction of its expected progression; strategies for minimising blood loss during an intervention, such as using different types of anaesthesia or antifibrinolytic agents; and single-unit and restrictive transfusion strategies. Process KPI are listed in **Figure 3** (see *Online Supplementary* **Table SII** for details).

Outcomes dimension

The outcomes dimension consists of: (i) intermediate outcomes, namely RBC transfusion rate, transfusion index, and total transfusion index; and (ii) hard outcomes, namely in-hospital mortality, complications, length of stay, and 30-day related readmissions (**Figure 3**). Outcomes are adjusted for age, sex, and comorbidity. (see *Online Supplementary* **Table SII** for details).

Clinical procedures assessed by the MAPBM

The process and outcomes performance measures are applied to six common procedures in which significant blood loss is anticipated: total knee arthroplasty, total hip arthroplasty, colorectal cancer surgery, cardiac valve surgery, hip fracture, and gastrointestinal bleeding. Within each hospital, all episodes of care with these diagnoses/procedures are captured (ICD-10 codes in *Online Supplementary* **Table SIII**).

MAPBM benchmarking programme

Along with the MAPBM Assessment Model, we established a MAPBM programme to support the enrolment of

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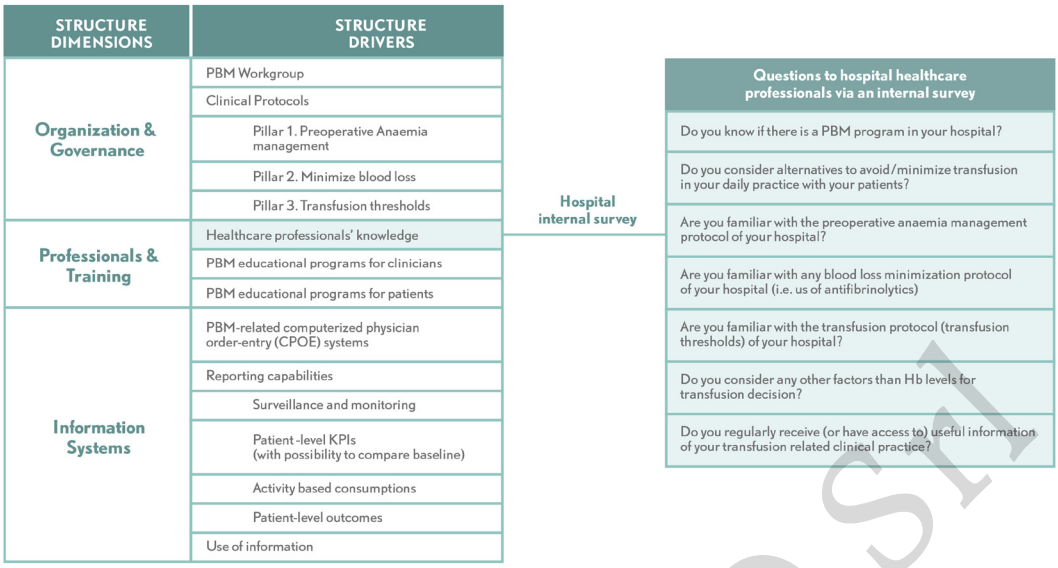

Figure 2 - Structure dimensions and drivers

hospitals into a benchmarking and PBM improvement network, and to simultaneously and continuously improve the model.

The programme has been running annually since 2015 and uses a standard data processing and measuring approach. Hospitals voluntarily participate in the programme, which is sponsored by senior management and usually led by a hospital core team, including a PBM clinician, an information systems specialist, and a quality and safety expert.

The implementation plan for the annual hospital benchmarking programme is structured in ten steps (**Table I**).

To assist enrolled hospitals with data files and questionnaires, we developed an online platform with user management features, approval workflows, and data validation algorithms. All data are anonymised and centrally aggregated, and risk-adjustment techniques are applied for benchmarking.

MAPBM data processing validations and risk-adjustments

Participating hospitals are provided with a specifications guideline for preparing their datasets, describing the required variables for the different database domains covered by the MAPBM. Data are reported at the patient level and time stamped, which allows the building of a consistent care pathway across all domains. This longitudinal, episode-level pathway is the backbone of the various process and outcomes metrics.

The domains covered are: (i) patients' diagnostics, procedures, admissions, discharge status, and basic demographics such as age and sex; (ii) laboratory tests and results related to anaemia and iron deficiency; (iii) RBC transfused (iv) surgical theatre activity, use of cell salvage, antifibrinolytics and type of anaesthesia; and (v) hospital treatments for anaemia and iron deficiency. These domains are provided for inpatient episodes classified under one of the six clinical procedures assessed by the MAPBM, except for domain (i), which is provided for every inpatient captured to allow for analysis of readmissions.

All variables are sourced from each hospital's EMR. Where a hospital's EMR structure does not allow convenient data capture for a specific domain, the hospital may opt for manual data sampling. This is somewhat common in the domain of surgical theatre activity, in which case information is recovered manually from a random sample of surgical charts.

The MAPBM Analytical Platform has two sequential parts: the Validation and Uploading Platform (VP), and the Integrated Analytics Platform (IAP). All information processed by the MAPBM is first de-identified, and patients' data privacy is secured by encryption within the bounds of the contributing hospital, before being uploaded to the VP. Every domain database is manually uploaded by

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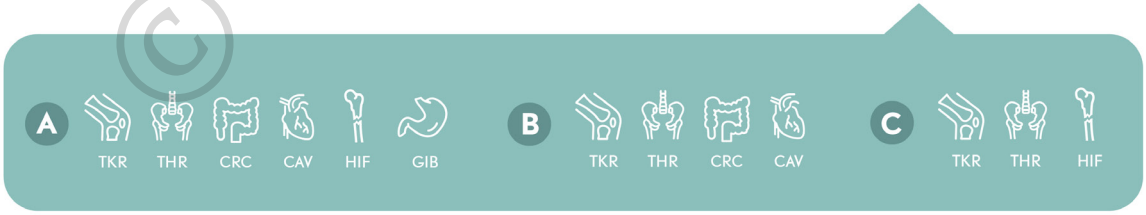
PROCESS DIMENSIONS		CLINICAL RECOMMENDATIONS	PROCESS KPIs	APPLICABLE FOR	DATA AVAILABILITY[3]
PILLAR I. Optimize red cell mass	1	Assess preoperative anaemia early enough to implement the appropriated treatment	% of patients with an Hb determination 21-90 days before surgery[1]	B	83 %
	2	Asses preoperative iron metabolism	% of patients with a Ferritin determination 21-90 days before surgery[1][2]	B	83 %
	3	Treat preoperative anaemia	% of patients treated preoperatively 7-90 days before surgery	B	75 %
	4	Preoperative anaemia is a contraindication for elective surgery	% of patients with anaemia prior to surgery	B	83 %
	5	Treat periprocedural anaemia	% of patients treated with IV iron during hospital stay	A	85 %
	6	Do not transfuse preoperatively	% of patients with preoperative transfusion	B	98 %
PILLAR II. Minimize blood loss and bleeding	7	Apply regional anaesthesia, whenever possible, to reduce blood loss	% of patients under spinal anaesthesia	C	88 %
	8	Minimize surgical bleeding with antifibrinolytics	% of patients treated with antifibrinolytics perioperatively	B	81 %
	9	Reuse own blood, whenever possible	% of patients with blood recovery systems preoperatively	B	80 %
PILLAR III. Harness and optimize physiological reserve of anaemia	10	Apply restrictive transfusion thresholds	Hb level prior to transfusion	A	81 %
	11	Apply restrictive transfusion thresholds	% of patients transfused with Hb ≥ 8 g/dl	A	81 %
	12	Single-unit red cell transfusions	% of single-unit transfused patients	A	98 %

OUTCOMES DIMENSIONS	OUTCOMES KPIs	APPLICABLE FOR	DATA AVAILABILITY[3]
INTERMEDIATE OUTCOMES	Transfusion rate	A	98 %
	Transfusion index	A	98 %
	Total transfusion index	A	98 %
HARD OUTCOMES	In-hospital mortality	A	100 %
	Complications	A	100 %
	Length of stay	A	100 %
	30-day related readmissions	A	100 %



(1) In colorectal cancer resection 14-45 days before surgery
(2) Ferritin as the determination which is always used in combination with others to assess iron metabolism
(3) Percentage of hospitals for which KPIs were obtained in sufficient quality from the hospitals' EMR

Figure 3 - Process and Outcome dimensions, drivers and key performance indicators

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Table I - *Hospital annual benchmarking programme steps*

Period (in quarters)	n.	Hospital annual benchmarking programme steps	
Q1	1	Enrolment of new hospitals	New hospitals joining the network are provided with information about the project, research protocol, technical data specifications and sign-off a participation agreement
Q2	2	Start of the annual benchmarking programme	Hospital representatives gather together in an all-hands meeting to kick-off the annual edition
Q3	3	Assessment of the hospital PBM structure	Hospital runs the internal survey to HCP and hospital project team members complete the self-assessment questionnaire about the structural elements of their PBM program
Q3	4	MBDS data extracts for selected procedures in-scope	Selection of all in-patient episodes for the given year
Q3	5	PBM clinical data extracts	Cross-extracts of laboratory, transfusions, surgery theatre and pharmacy data related to in-patient episodes
Q4	6	Benchmarking results	Hospital representatives gather together to analyse and discuss benchmarking results. Results are presented aggregated and anonymised
Q4	7	Hospital scorecard report	Hospital receives a detailed report with their scores for all MAPBM measures, in comparison with the median of the group, and evolution vs prior year
Q1 year2	8	Hospital internal communication and analysis of results	Hospital project team analyses and disseminates the year's results throughout hospital departments
Q1 year2	9	Development of PBM improvement plans	Hospital PBM teams define improvement action plans with support from hospital management
Feedback loop	10	Plan – do – check –act cycles	Deployment of PBM improvement plans and continuous re-assessment with subsequent year's results

(*) MBDS (minimum basic data set) contains patient-level data on patients' diagnostics, procedures, admissions, discharge status, and basic demographics such as age and sex

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the hospital to the VP, and undergoes a validation process that flags specific warnings to the corresponding hospital team. Once the information is accepted by the IAP, all KPI are calculated in the same way for every hospital, and feed the annual scorecard, which is then returned to the hospital.

While process KPI are calculated irrespective of the population characteristics, outcomes KPI are adjusted to account for differences in risk due to various patients' characteristics, such as age, sex and comorbidities, which are known[30] to strongly influence transfusion utilisation, mortality risk, and length of hospital stay. Thus, outcomes are reported to the hospital as the observed standardised ratio vs expected. The expected outcomes are calculated using indirect standardisation in which the main classes are procedure group, age range, sex, and comorbidity groups, based on the Elixhauser index[31].

MAPBM hospital scorecard

Each participating hospital receives an annual scorecard (see *Online Supplementary,* **Figure S1** for an example) and a reporting package with its performance for each MAPBM metric, comparison to its score against that of the previous year, and the distribution of anonymised results from all other MAPBM hospitals.

The MAPBM benchmarking programme also conducts an annual hospital ranking to recognise and publicise the results of the best performing hospitals. This ranking is based on a summary index of each hospital's results for the most relevant MAPBM metrics.

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RESULTS

MAPBM implementation. Quantitative and qualitative results

In its first 5 years, MAPBM analysed 181,826 episodes in Spanish hospitals, proving the feasibility of sustainably implementing a model to measure and compare clinical PBM practice and outcomes in a network of hospitals. This demonstrates how to (i) define meaningful quantitative process KPI to comprehensively describe PBM clinical practice according to established guidelines; (ii) measure these KPI and outcomes using available information from the hospitals' EMR; (iii) do this in a common way that facilitates benchmarking and ranking; (iv) summarise this information in a hospital scorecard, and (v) scale this model nationwide.

Translating PBM clinical guidelines into Process KPI to measure clinical practice

To measure processes across each of the three PBM pillars, we used KPI for (i) optimisation of patients' condition before surgery, such as the percentage of patients screened for pre-operative anaemia; (ii) strategies to minimise blood loss during interventions, such as the percentage of patients with an indication for and use of antifibrinolytics; and (iii) adequacy of transfusion approaches, such as the percentage of patients transfused with single-unit ordering (**Figure 3**). The definition of these process KPI has proven useful and they have shown the expected statistical correlation with the corresponding intermediate outcomes (Transfusion Index).

Populating KPI with data from the hospitals' EMR

Most MAPBM process and outcomes KPI were obtained in sufficient quality from the hospitals' EMR. Where the required data were not routinely available for each in-patient episode, hospitals performed manual retrospective searches of randomly selected medical records. This strategy was only necessary for two KPI, namely "Patients treated with perioperative antifibrinolytics" and "Use of blood recovery systems".

Facilitating benchmarking results between hospitals

One critical aspect of benchmarking is to work with measures that are generated in the same way for every hospital, allowing direct comparison between hospitals. This is possible in MAPBM because all data were processed centrally, with the same KPI definitions, inclusion criteria and risk-adjustment techniques to adjust for major confounders.

Providing a scorecard of hospital PBM performance

Each hospital's scorecard allows for monitoring of the hospital's annual performance for outcomes, process KPI and structure drivers, and for comparing its observed results against both expected and historic results. The scorecard provides numbers and graphs to facilitate the analysis, and to identify performance gaps and potential for improvement for each clinical procedure. Moreover, the Maturity Matrix adds valuable traceability that allows the hospital to link any improvement in outcomes (e.g. transfusion rate) to specific process KPI, which then can feed into their Plan-Do-Check-Act management paradigm, which otherwise is very challenging in multidimensional environments such as healthcare.

Scaling MAPBM nationwide

MAPBM implementation started in 2015 with the enrolment of eight hospitals, and by the end of 2019 it had reached a total of 59 hospitals. It has also had high recurrence, with 90% of enrolling hospitals continuing to participate during the following year (**Figure 4**). Participation in MAPBM is voluntary, so we did not select specific hospitals to create a nationally representative sample. Nonetheless, the current network covers diverse geographical regions, has a broad distribution of hospital size, and includes public, private, teaching, and non-teaching hospitals, all of which provides a solid picture of the hospital landscape in Spain (**Figure 5**).

DISCUSSION

Since its piloting in 2015, MAPBM has evolved as the standard framework for measuring PBM delivery in Spain, with a growing network of hospitals benchmarking their PBM performance annually. Over the past 5 years, it has helped a large number of hospitals in Spain to map the level of implementation of their PBM programmes and assess the results. As a tool for continuous improvement, it has allowed multi-professional PBM teams to identify gaps in terms of structure and processes in order to optimise outcomes across various populations of patients within hospitals. Benchmarking their performance against that of other hospitals also incentivises improvement throughout the hospital community. A further benefit is improved communication about PBM issues within and

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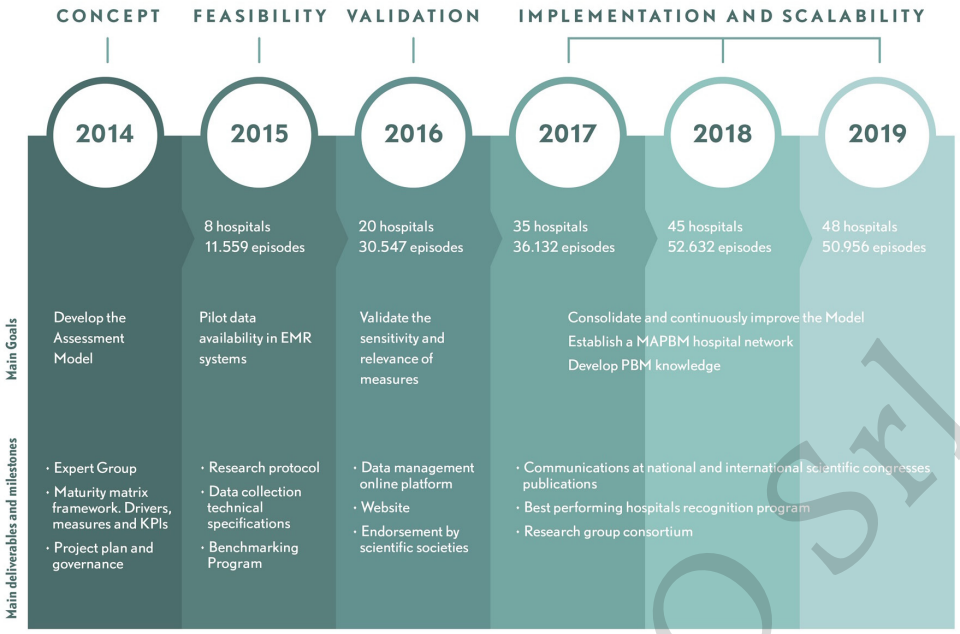

Figure 4 - Maturity Assessment for Patient Blood Management implementation roadmap

BY SIZE	
Small-size general hospital (less than 200 beds)	10
Mid-size general hospital (between 200 - 400 beds)	17
Major-size general hospital (between 400 - 600 beds)	8
Major-size general hospital and at least one reference department [1] (between 400 - 900 beds)	11
Large hospital with reference specialties (more than 900 beds)	13

[1]Reference departments consider: Neurosurgery, Cardiac Surgery, Thoracic Surgery and Transplants.

BY TEACHING SERVICE	
Teaching*	43
Non-teaching	16

BY PUBLICLY FUNDED (NHS) / PRIVATE	
Public	55
Private	4

Figure 5 - Hospitals' characteristics

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between hospitals, clinical teams and senior management. The growing number and continuous participation of hospitals highlights the increasing commitment of healthcare professionals and organisations in Spain to establishing PBM as a standard of care, and shows that they value the role of MAPBM in achieving this aim. This suggests that the number of participating hospitals that benefit from MAPBM will likely continue to grow, and even some hospitals from outside Spain have shown interest in using the MAPBM to start their own PBM network. In addition to the advantages of MAPBM for hospitals, it also provides information about the national status of Spain's healthcare system in terms of current PBM standards and variability in clinical practice, information that is not readily available from healthcare authorities or institutions.

Previous work in this area

Assessment models and standards are common in health care, and some have even led to accreditation requirements for healthcare organisations. They generally measure the capacity of a given resource (structure) or the use of a best-practice clinical pathway (process), and focus to a lesser extent on clinical measuring and benchmarking. Another increasingly accepted type of standard focuses on measuring outcomes, but does not address the structural and process-related aspects. MAPBM considers all three perspectives –health outcomes, clinical processes and structure– and benchmarks clinical real-life data. We consider this approach an advantage, as it allows one to explain variations in outcomes in relation to changes in the processes and activities that affect them.

In the field of PBM, between-hospital variability is generally assessed using transfusion rate. Few studies have also benchmarked other measures related to the use of PBM techniques[10, 32]. In 2017, the European Community published recommendations for health authorities and hospitals on how to implement a PBM programme, including a list of surveillance measures and KPI[20] However, to our knowledge, there is no established set of KPI to assess PBM performance to date. Despite its limitations, the MAPBM is the first to provide a standard set of PBM KPI that have been effectively implemented and used as a reference by a large network of hospitals.

Limitations of the MAPBM

First, the model and its KPI were initially defined by a small group of experts. To obtain wider consensus, we did not follow a specific methodology (Delphi or similar), but rather held an annual working meeting during which the clinical leaders of participating hospitals discuss and adapt KPI, where appropriate. Second, while the model could have included many more process-related KPI, we chose those that can be feasibly measured from current EMR and structured health data in Spain. Third, we initially validated the link between the process KPI and the transfusion index using only the χ^2 test, although recent rounds of analysis use multivariate regression; we will use this more powerful analysis strategy in future reports from the MAPBM. Fourth, the health outcomes in our model only consider clinical and economic outcomes, but not patient-reported outcomes (PRO) or experience (PRE). However, there is no current PBM evidence that recommends the use of PRO/PRE. Fifth, while our benchmarking methodology includes all risk-adjustments required for proper comparison, it does not account for mixed effects, which would be necessary to distinguish inter-hospital variability due to clinical practice from that due to chance. However, this is becoming less problematic as the volume of hospitals and episodes grows[33].

Challenges we have faced

The main challenge in implementing the MAPBM has been to source patient-level data in the few hospitals without comprehensive EMR systems, even though the selected KPI for the model passed an initial test of data availability for an average hospital in Spain. The data gaps mainly affect outpatient treatments; laboratory values at certain points in the clinical pathway, especially during the interval between pre-operative treatment and admission; laboratory values immediately before a transfusion decision; and where point-of-care devices were not connected to the hospital EMR.

What this will allow us to do in the future

While the MAPBM's main purpose is to assist hospitals in adopting and improving PBM and patients' outcomes, it also creates other opportunities, some of which have already become apparent in these first 5 years. First, MAPBM scores are becoming a reference in Spain for identifying the best PBM-performing hospitals. Second, MAPBM data on current PBM clinical practice is helping healthcare authorities to oversee and audit. Third, the MAPBM's large volume of homogenous PBM measures and

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outcomes for nearly 60 hospitals and >180,000 episodes to date creates opportunities for research on PBM and patients' safety.

CONCLUSIONS

The MAPBM initiative translates PBM clinical recommendations and best practices, into a set of quantifiable KPI to facilitate hospitals with measuring and benchmarking their PBM clinical pathways and outcomes. Its implementation has proven to be feasible in a large and growing number of hospitals in Spain, providing them with an ongoing scorecard to assess their PBM performance. It is hoped that the MAPBM becomes a useful tool for healthcare organisations to implement PBM programmes and improve patients' safety and outcomes.

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AUTHORSHIP CONTRIBUTIONS

EB and AGC conceived the presented idea. EB, AGC, JV and CI developed the assessment concept model and the implementation programme for hospitals. CI and LG defined and ran the analytical method. EB, McB, MJC and MB clinically validated the model. AH assessed and challenged the concept and findings of this project. All Authors discussed the results and contributed to the final manuscript.

DISCLOSURE OF CONFLICTS OF INTEREST

EB reports honoraria for lectures and/or travel support from Vifor Pharma, Sysmex, Takeda, OM Pharma and Zambon outside the submitted work. AGC was a Vifor Pharma employee at the time of starting to draft this manuscript. CI and LG are IQVIA employees. IQVIA was contracted by IMIM (Hospital del Mar Medical Research Institute) to support MAPBM project management, data processing and analytics. JV has nothing to disclose. McB reports having received travel support from Vifor Pharma España S.L. outside the submitted work. MB reports honoraria for lectures and travel support from Vifor Pharma outside the submitted work. MJC reports honoraria for lectures from Baxter, travel support and assistance to meetings from Vifor Pharma and CSL Bhering outside the submitted work.
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APPENDIX 1

*MAPBM Working Group (key hospital leaders' affiliations in order of years of participation and alphabetically)

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