Challenge Brief

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List of Abbreviations

AMR	Antimicrobial Resistance
BPMN	Business Process Modelling and Notation
CET	Central European Time
EHR	Electronic Health Record
EU	European Union
GDPR	General Data Protection Regulation
GP	General Practitioner
GPA	Government Procurement Agreement
ICF	International Classification of Functioning, Disability and Health
ICT	Information and communication technology
IPR	Intellectual Property Rights
LMG	Local Modelling Group
OMC	Open Market Consultation
PCP	Pre-Commercial Procurement
PIN	Prior Information Notice
PPI	Public procurement of innovative solutions
Q&A	Questions and answers
R&D	Research and Development
SAAS	Software-As-A-Service
TDx	Tender Document x
UML	Unified Modelling Language™
VPN	Virtual Private Network
WTO	World Trade Organisation

1 Executive Summary

Health and care systems worldwide face challenges from disruptive threats such as pandemics, natural disasters, and economic crises, among other short-term crises. Resilience of health and care systems characterised by their ability to adapt and maintain services is crucial for coping with these threats.

Delivering high-quality health and care is inherently complex, requiring multi-disciplinary collaboration and coordination. The Covid-19 pandemic exposed weaknesses in existing health and care infrastructures emphasising the need for an adaptable and flexible solution for care pathway planning during crises.

DYNAMO is an innovative solution aimed at enabling the use of data from various organisational IT systems and other databases or records, to promote evidence-supported care pathway planning adaptable to disruptive care situations.

The primary users of DYNAMO will be senior representatives from health and care delivery organisations, alongside stakeholders specific to each crisis scenario. This includes emergency services, local authorities, the military, and others. Together, these senior representatives will form the 'crisis response planning group' using DYNAMO for strategic planning and overseeing the implementation of re-designed care pathways during a crisis and thus aiding health and care systems in becoming more resilient and responsive.

The difficulty in modifying health and care processes to address immediate disruptions and long-term shifts is not due to the absence of pathway design methods. Instead, it is because of the lack of tools that allow diverse stakeholders to collaborate flexibly across organisational boundaries and service domains. Moreover, there is a deficit of tools that support evidence-based pathway design with quick evaluations of potential impacts during the planning phase.

To address this, DYNAMO's procurers are in search of a digital tool that can facilitate evidence-based planning and modelling of adaptable, non-proprietary care pathways. This tool should aid in swiftly adjusting to changing conditions during crises, promoting faster response times, and enhancing the quality of reactions during systemic disruptions. It should also help in designing temporary service pathways activated during a crisis and deactivated post-crisis.

The envisioned crisis care pathway tool will consist of three primary functional components:

- Dynamic pathway modelling
- Task planning and skills matching
- Impact assessment re alternative pathways

As the DYNAMO solution is intended to be a socio-technical system, interlinking human action with computational algorithms its processes will service three purposes:

1) Assist the regions represented in the buyers' group of the to focus and fact check their initial ideas and, via co-design with regional stakeholders, tailor them to regional requirements.
2) To inform and guide the pre-commercial procurement (PCP) through all its three phases, providing a realistic reference for suppliers in terms of functional requirements and overall system design.
3) After being tested and evaluated during the PCP phases, become the usual mode of operation for the DYNAMO solution in real-life implementations.

The process model consists of five sequential steps taking each Local Modelling Group (LMG) through setting up, planning, modelling, testing and operations and finally scenario sharing.

Alongside this model, sits the functional architecture which has a business intelligence, workflow engine and comms engine as its three distinct but inter-connected components.

The final section of this DYNAMO Challenge Brief gives the initial details of a number of high-pressure scenarios and use cases relating to antimicrobial resistance (AMR), a sustained heatwave, cyberattack and a pandemic that the procurers are requiring the DYNAMO solution to address.

2 Introduction to DYNAMO

Disruptive threats to health systems such as pandemics, natural disasters, or economic crises, as well as short-term crises such as heatwaves or prolonged cold weather, have profound impact upon and implications for population health, economic progress, and social cohesion. These unexpected, systemic shocks challenge the absorptive capacity of a health and care system to maintain the same level (quantity, quality, and equity) of service provision and protection of the population despite adverse impacts on available resources. Health system resilience – the ability to adjust to both expected and unexpected conditions while maintaining services, their functionality, and their performance– is key to coping with such threats. Trends like ageing populations and the increase of chronic diseases evoke further challenges to the transformative capacity and capability of the health and care system to adjust to these shocks.

Providing high- quality healthcare tends to be a complex process which is difficult to manage even under normal conditions. The delivery of efficient and effective healthcare services involves health and care staff from different professions and institutions and sectors needing to work together in a flexible and coordinated way. Multi-disciplinary care pathways are seen as one instrument to develop and communicate collaborative health and care service delivery processes. They describe the operational process of interdependent events, tasks and activities in the sense of a "patient journey" through the health and care system, either for individuals or for patient groups.

A pressing need exists for a streamlined, versatile solution capable of managing, connecting, and analysing data from diverse organisational IT systems, including external databases and even paper records when required, coupled with information relating to existing care pathways for specific population groups. Based on all the data and information entered, the solution needs to generate re-designed care pathways, especially for those with complex requirements, that should address the procurers' challenging crisis scenarios. The recent Covid-19 pandemic highlighted the shortcomings of current health and care IT infrastructures, which fall short in effectively automating the design and deployment of these response strategies for various crisis situations.

2.1 How are users involved in DYNAMO?

The primary users of the DYNAMO solution will be senior representatives and planners from health and care delivery organisations together with a variety of other key stakeholders according to each procurer's crisis scenario focus. For many scenarios, the emergency services such as police and fire services, third sector representing individuals and communities, water companies, local authorities and potentially the military would be necessary.

These senior representatives would become the crisis response planning group (the term Gold Command is used in some regions) responsible for using the DYNAMO solution to strategic plan re-designed care pathways and operationally oversee their implementation in the event of a crisis situation occurring. As a strategic planning tool, such a solution needs to be able to effectively re-design non or partially automated pathways to be implemented within and across different health sectors and adjacent public service domains. The DYNAMO solution will thus help health and care planners and service providers to be more responsive in terms of speed and level and quality of services in the event of a future pandemic, natural disasters, or other crises. By delivering a strategic planning tool that is able to effectively support the modelling of a range of crisis scenario care pathways for different population groups, the DYNAMO solution will support current health and care systems in becoming more resilient. To this end, the procurer sites, each of whom has identified the need for such a planning tool, will establish a dedicated crisis response planning team – the Local Modelling Group (LMG). The group will consist of selected decision makers from relevant sectors according to the crisis

scenario, health and care practitioner representatives, care managers, and IT planners/programmers. A data manager will be appointed who possesses the necessary skills in relation to data preparation and analysis as well as a knowledge of the (potential) data sources to be used. The LMG will have access to complementary expertise and capacity (legal, technical) as required. At each procurer site the LMG will apply the DYNAMO solution according to a generic response planning process comprising several subsequent work steps which will be described in more detail in Chapter 2.

The members of the LMG will be the users of the DYNAMO solution. They will use the solution to plan the adaptation of existing services delivery processes or develop new service processes at the level of strategic service planning. DYNAMO will thus not be used to support service delivery to individual patients at the point of care. During the PCP process the procurers' LMGs will co-develop and pilot the solution in relation to selected high-pressure scenarios. These scenarios may concern rather short-term health system shocks, e.g., in the case of a heatwave. But they may also concern structural changes negatively affecting the health and care system in the longer term such as staff layoffs caused by structural staff shrinkage. The DYNAMO procurers' LMGs will utilise the DYNAMO solution by simulating both types of threats in terms of selected high-pressure scenarios.

2.2 Summary of key characteristics of the expected solution

The DYNAMO solution will foster the response capacities and capabilities of existing health and care ecosystems when a systemic crisis occurs. As mentioned earlier, multi-disciplinary care pathways are one instrument to enable care continuity and facilitate communication to ensure coordinated response processes as they are able to bundle interdependent tasks and activities organising care and support on the individual and population (group) level. Existing care pathways tend to be static and unable to be adapted to fit a dynamic environment and patient and system outcomes are then suboptimal. During the Covid-19 pandemic, we have also learned that such pathways need to be aligned to structural conditions prevailing, such as staffing resource availability nationally, regionally, and even locally to be practically implementable. This makes it difficult to transfer existing health and care pathways from one implementation context to another without adapting and tailoring them to a different environment and constraints accordingly, whether during an exceptional health system crisis or in normal times.

As a result, adapting existing health and care delivery processes to short-term shocks and long-term structural developments has remained a challenge to established health and care ecosystems. This is not so much due to lacking methodologies and approaches for care pathway design in general, but due to the lack of supportive tools enabling a diverse range of stakeholders to flexibly collaborate in pathways design across established organisational boundaries and service domains. There is also a lack of tools enabling evidence-supported pathway design and their associated workflows and care planning at the individual and population levels at the service planning stage which allows for a swift assessment of desired and undesired impacts of alternative pathway options already during the design phase.

The DYNAMO procurers therefore seek a digital solution that enables evidence-supported planning and modelling of sharable multi-disciplinary, non-proprietary care pathways. Such a pathway planning tool is required to support flexible adaptation to changing conditions during crises. In this sense, the solution is expected to effectively support a dynamic adaptation of routine care pathways across hitherto disconnected service silos, with a view to significantly accelerating the response time for re-planning of health and care delivery processes and improve the quality of the resulting response when a systemic crisis occurs. It should also support the design of, and resources required for new service pathways which can be temporarily provided while a system crisis occurs and closed again once the crisis ends.

As graphically summarised by Figure 1, the envisaged crisis care pathway planning tool is envisaged to integrate three functional core building blocks for dynamic utilisation by the LMGs. These are presented in more detail in the following subsections.

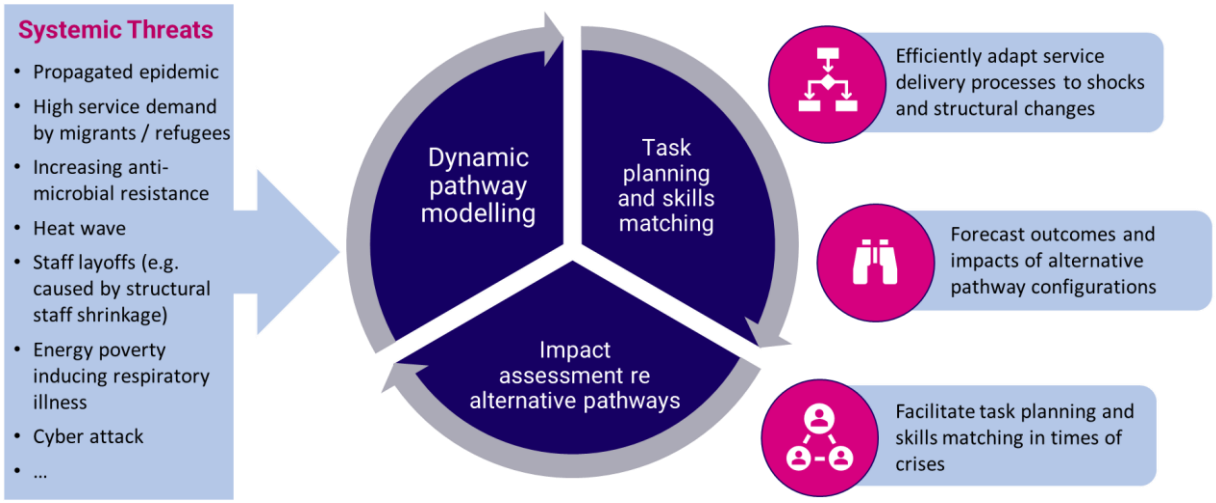

Figure 1 – Core functional building blocks of the envisaged DYNAMO crisis care pathway planning tool

Dynamic crises care pathway modelling

The DYNAMO solution is expected to support service providers and planners in designing multidisciplinary service delivery pathways to enable care teams to develop people's care plans which will provide the basis for a coordinated joint service response to a diverse range of health system crises. To this end, the resulting crisis response care pathways need to be shareable, be it in electronic format or on paper, amongst and applicable by a diverse range of stakeholders beyond the clinical health care environment, Therefore, to be useful as a basis for implementing cross-sectoral health and care workflows they need to be made explicit with formal, repeatable semantics, i.e., they must be truly shareable. Based on relevant modelling standards, e.g., Business Process Modelling and Notation (BPMN), Unified Modelling Language™ (UML©) 27 or ISO 5807:198528, the DYNAMO solutions should enable the modelling of different types of workflow models. Depending on whether structured or unstructured workflows must be modelled, these may include process (BPMN) models, case (CMMN) models and decision models (DMN). To be useful as a basis for implementing cross-sectoral health and care workflows, they need to be made explicit with formal, repeatable semantics, i.e., they must be truly shareable.

Impact assessment re alternative pathways

Beyond mere pathway design, the DYNAMO procurers are to be enabled to use data available from existing health IT infrastructures (EHR, HIS, etc.) and other data with relevance to the design and/or monitoring of crisis care pathways (e.g. data held by the local authority concerning transport or social care) that are available to the LMG, to assess alternative service pathway options in advance for possible impacts when it comes to their practical feasibility and expected outcomes. However, not all data potentially required for such an ex-ante pathway impact assessment may be available from existing electronic data repositories when a systemic crisis occurs. It may thus be required to manually enter relevant data into the DYNAMO solution, e.g., official statistics, expert estimations, and other types of data. It may also be required to import data available in diverse document formats, whether they may be machine readable or not.

Procurers may need to assess a variety of impact assessment dimensions such as staff and resource availability, staff qualifications, cost implications as well as patient-related

information. This requires the DYNAMO solution to be able to collect potentially large volumes of data (from e.g., existing EHRs), and the organisations involved in the LMG will be responsible for ensuring that the required data is easily accessible and interpretable by different parties. The existing outcome and process impact measures used to assess the effectiveness of care pathways will be required to minimise these being compromised as much as is possible in a crisis situation. Data sources to be used in practice, beyond the modelling exercise within the project, may also not be pre-defined for every crisis care pathway but may become necessary / available only on short notice, e.g., when a given crisis care pathway becomes operational. Similarly, data holding systems may be varied in terms of formats, interfaces, and performance, as well as being subject to different forms of governance. Machine learning and other ontology-based (rules-based) techniques will likely be needed to interpret the datasets and potentially link data items.

Under such circumstances, the DYNAMO solution is to provide ex-ante pathway impact assessment that includes a potentially wide range of parameters. The latter are to be defined by the LMGs on a case-by-case basis, with a view to enabling the development of an appropriate service response to different scenarios where health and care system operations and functioning is threatened. Flexibly definable pathway impact assessment parameters will allow health and care provider organisations to assess alternative crisis-related care pathways in advance for possible impacts in terms of their practical feasibility and expected outcomes under given crisis conditions. Therefore, the DYNAMO solution is expected to provide intelligent decision support in relation to alternative crisis pathway options, including risk assessment and stratification capabilities for affected population groups.

Monitoring of crisis care pathway implementation by means of selected parameters is to be supported, with a view to enabling a dynamic re-assessment of care pathways through an easy-to-use interface, e.g., a dashboard.

Task planning and skills matching

Current health and care practitioners and organisational providers are likely to have a requirement to enable workforce tasks, roles, and responsibilities to be re-configured and potentially redistributed and substituted within the workforce available in a crisis situation. A mapping/inventory exercise of available resources and assets will be required to be undertaken by suppliers for each of the procurer sites and their crisis scenarios. Existing staff planning solutions are either not based around task and skills, or not designed for situations where health and care system functions are threatened. Task-based staff planning, and skills matching capabilities are to be provided that are appropriate to health system threats to allow for modelling of multi-disciplinary care pathways around task allocations instead of job titles. This is expected to be more flexible and allow to apply task shifting, so that professionals from care and community can more easily substitute each other for specific tasks. The inclusion of clinical representatives on the LMGs will be an important aspect of the membership as this will facilitate discussions on clinical and information governance issues relating to emergency changes to workforce roles and responsibilities.

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3 DYNAMO Socio-technical Process Model and Functional Architecture

The DYNAMO solution is intended to be a socio-technical system, interlinking human action with computational algorithms. Developing the underlying socio-technical DYNAMO process is one first key objective of the PCP project. As such, the DYNAMO process serves three purposes:

- The DYNAMO process helps the regions represented in the buyers' group of the DYNAMO PCP project to focus and fact check their initial ideas and – via co-design with regional stakeholders – tailor them to regional requirements.
- The DYNAMO process informs and guides the pre-commercial procurement through all its three phases, providing a realistic reference for suppliers in terms of functional requirements and overall system design.
- The DYNAMO process will – after being tested and evaluated during the PCP phases – become the usual mode of operation for the DYNAMO solution in real-life implementations.

In general terms, the DYNAMO solution will be used by the members of the procurer site LMGs (the "social half" of the socio-technical process) to plan the adaptation of existing health and care service delivery processes to structural health and care threats.

Such threats can take the form of short-term shocks, e.g., a heatwave or a pandemic, posing health risks for certain groups. But they can also take the form of long-term changes affecting the health and care system in a negative way such as staff layoffs caused by structural staff shrinkage. The DYNAMO solution must be capable of dealing with both systemic short-term shocks and long-term threats in a way that allows a given health and care ecosystems to:

a. sustain required operations,

b. resume optimal performance as quickly as possible,

c. transform its structure and functions to strengthen the system,

d. reduce its vulnerability to similar shocks and structural changes in the future.

At each procurer site, the LMG will apply the DYNAMO solution according to a generic process model. This model was developed in co-operation with all members of the buyers' group and represents a common view of DYNAMO that was abstracted from the specific requirements of each high-pressure scenario proposed.

The process model consists of five steps to be followed in chronological order from start to finish of a full DYNAMO operation cycle:

Step I: In the set-up phase, the LMG is constituted, and its operational capacity is established, with the roles and responsibilities of the individual members being defined in a binding manner. Each member of the LMG registers with their own account to the DYNAMO system.

Step II: The planning phase focuses on identifying and documenting alternative pathways in the DYNAMO system for distinguishable population groups and/or subgroups affected by a particular crisis scenario in terms of their health and care needs. This step also includes the specification of data that may be needed for a meaningful ex-ante impact assessment according to key parameters which are to be operationally modelled in the subsequent work step. Moreover, data sources that are available to the LMG are identified, as well as information gathering methods available for closing any data/information gaps.

Step III: In the modelling phase, work of the LMG concentrates on data-supported - impact modelling for the pathway options developed at the previous stage with help of the DYNAMO solution. Indicators for impact monitoring are defined by the LMG and documented in the DYNAMO solution. Indicator calculation models for pathway alternatives and pathway implementation monitoring are defined by the LMG in the DYNAMO solution.

Step IV: The testing / operation phase focuses on instantiating the pathway and feeding real life data into the model defined in the previous work step, with a view to assessing alternative crisis pathways developed in Step II. The indicators defined in Step III are populated with data.

Step V: The resulting pathway is shared among the relevant stakeholders in an open format, including alternative pathways steps and calculation models.

The following diagram (Figure 2) illustrates the individual steps of the generic application process of the DYNAMO solution in more detail.

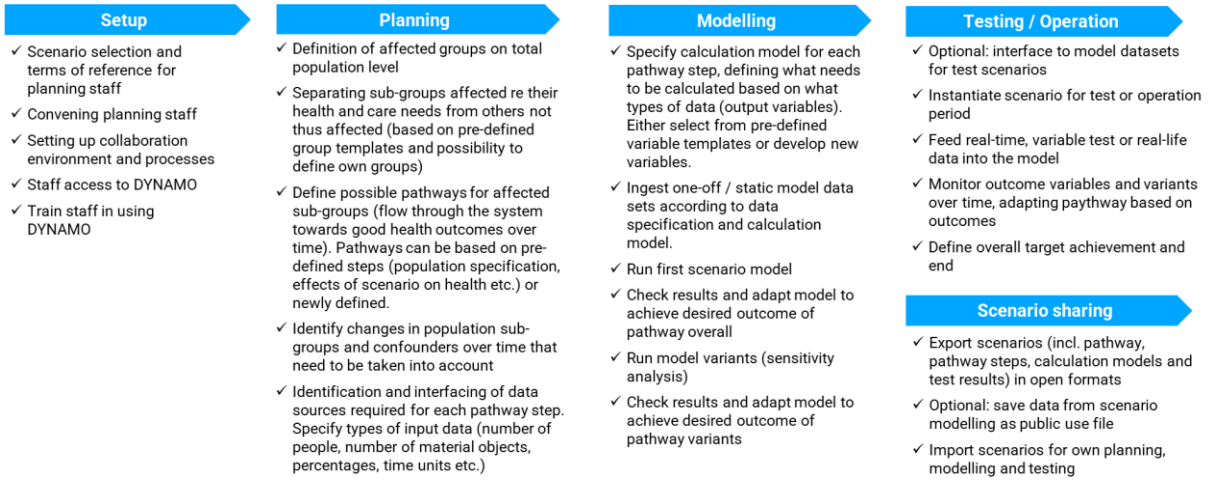

Figure 2 – DYNAMO Process Model

This process is supported and to some extent delivered by the DYNAMO solution and its components (the “technical half” of the socio-technical process), as shown in the functional architecture (Figure 3) below.

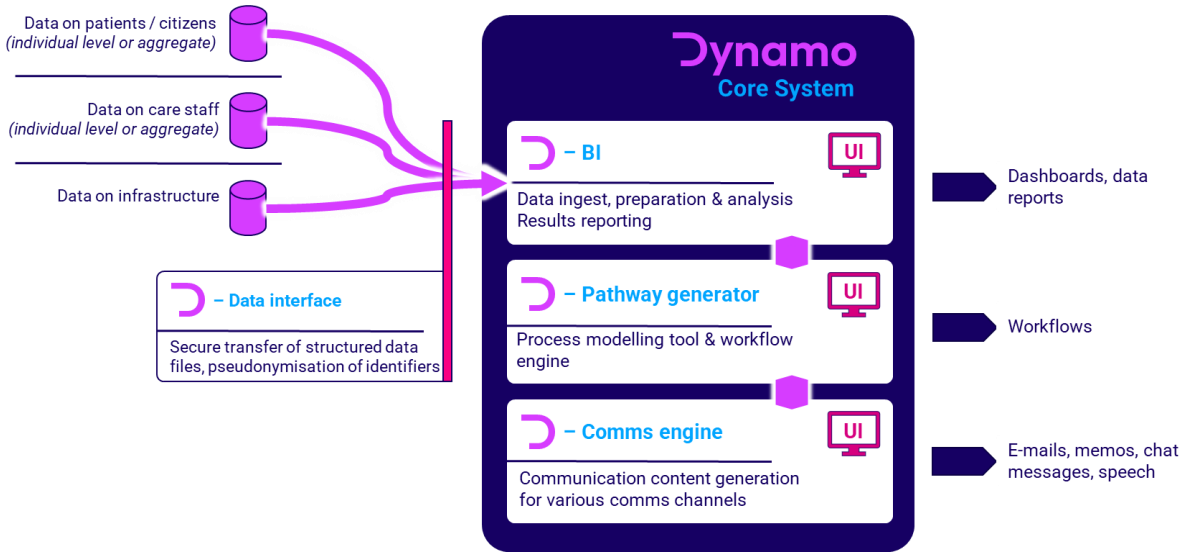

Figure 3 - The DYNAMO functional architecture

The solution will be used by the DYNAMO operations rooms, i.e., the members of the LMGs and any additional stakeholders that may need to be involved. All members of the operations room will have role-based access to those parts of the DYNAMO solution that they require for their task. Apart from general operational security this above all ensures that any sensitive data being processed is protected in accordance with regulatory and ethical requirements.

The DYNAMO solution comprises three components:

- **D-BI**: a business intelligence component used for all data handling from ingest and cleaning to analysis and results reporting. **D-BI** is intended to be used by data analysts and produces outputs channelled into dashboards and data reports. This component should use relevant data and information standards where possible.
- **D-Workflow engine**: a component that enables the design and operation of workflows (partly based on data from the **D-BI** component) together with any relevant clinical guidelines, information or other local factors, focussed on planning, resource efficiency management and triaging.
- **D-Comms engine**: an AI-based component that produces communication content that can be targeted to different recipients including the general public, health and care staff, planning staff in different organisations, suppliers and others. Communication is supported for different channels including e-mail, memos, chat messages, speech, announcement on public media and/or web pages.

As part of the **DYNAMO Core System**, these components are functionally separate but integrated on the data level, allowing **D-BI** results to be computed as part of **D-Workflow engine**, **D-Workflow engine** to tailor and send communications via **D-Comms engine** and received communications to flow back into **D-Workflow engine**.

All components have suitable user interfaces.

A fourth key component is **D-Data interface** that on the one hand connects DYNAMO to existing data (IT) systems in each organisational setting but also allows for easy entry of data that is not available in semantic form (e.g., passed on verbally from somebody, taken from a paper report, and the like). The connection to existing data systems is envisaged as a way to securely transfer data files extracted from other systems in combination with a tool allowing for the pseudonymisation of identifiers (names, insurance numbers etc.) in a way that still allows for individual level linkage of different datasets where required. Pseudonymisation is envisaged as a distributed process, with identifiers being pseudonymised or even anonymised in their respective source systems using predefined algorithms and security keys. Depending on the scenario, a trust centre might be implemented between the DYNAMO operations rooms

and the different data owners. Above all, this component will follow GDPR, and other relevant information governance guidance and procedures in the procurer sites.

Data required for the DYNAMO socio-technical process is expected to fall into three categories:

1) data on patients or clients of the services affected under the scenario;
2) data on service provider staff (including its skills and availability) and
3) data on the status or availability of services and infrastructure (including relevant estate).

A future requirement will be to have a deeper interface with existing data systems for the automatic extraction of real-time data. The requirements elicitation among the buyers' group however showed that this is currently not necessary to deliver the planned high-pressure scenarios. As a planning and management tool, DYNAMO will not be a direct part of (emergency) operations of affected organisations (such as healthcare providers). This eliminates the need to directly link into the working processes of these organisations to, for example, guide service provision for individual patients. Rather, DYNAMO supports provider organisations and others by planning, resource management and triaging on a group level. For the same reason there is also no immediate need to work with real-time data, as asynchronous dataflows that are e.g., updated every night are sufficient for the intended purposes. This also means that working with pseudonymised, anonymised or even aggregated data could be sufficient for a given task. Doing so in turn reduces the data privacy footprint of the DYANMO solution, making operations easier.

4 DYNAMO Requirements

4.1 Functional system requirements (R1-R5) and related service levels

The following tables provide details of the functional system requirements covering the DYNAMO Core System and each of the three components described above and namely:

- D-BI: a business intelligence component used for all data handling from ingest and cleaning to analysis and results reporting.
- D-Workflow engine: a component that enables the design and operation of workflows.
- D-Comms engine: an AI-based component that produces communication content.

Table 1 - Functional requirements on the DYNAMO Core System

ID	Name	Short description
R1.1	System component interfacing	The core system shall interface between all system components, allowing for seamless flow of data between them
R1.2	Central data base	The core system shall provide a central database to handle all data exchange, backup, and data archiving
R1.3	Logging function	The core system shall provide a logging function for all system components
R1.4	User roles	The core system shall support different user roles. Example roles are the administrator of the Local Modelling Group, a nominated data manager and other members of the expert group. The exact definition of roles to be enabled will have to be further specified during the PCP process.
R1.5	Access control	The core system shall provide a role-based user access control mechanism.
R1.6	Off-line outputs	The core system shall be capable of producing offline outputs (printouts) from all system components to be usable in settings where online access to the system is not possible
R1.7	Re-deployability	The core system shall be capable of taking system snapshots that can be re-deployed locally and run when online access of the system will not be possible
R1.8	Graphical interfaces	The core system shall provide graphical user interfaces for different devices, available in all procurers' languages
R1.9	Dashboard	The core system shall provide a dashboard displaying outputs from all system components (such as metrics from BI, state of different workflows, state of the communication engine etc.)
R1.10	On-premise installation and SAAS operation	The core system shall support both operation as an on-premise installation and as a software-as-a-service (SAAS) solution or a combination of both. All solutions must be fully compliant with GDPR and other applicable national regulations.
R1.11	Cybersecurity	The core system shall comply with applicable cybersecurity standards (such as ISO 27001 and others)

In relation to the DYNAMO Core System the following service levels shall be provided in a modular manner:

- Installation
- Technical maintenance
- System administration
- User training

Table 2 - Functional requirements on the DYNAMO Business Intelligence (BI) component

ID	Name	Short description
R2.1	Data workflow support	The BI component shall support a data workflow from data ingest, cleaning and plausibility checking, to analytics and results reporting
R2.2	Data formats	The BI component shall be capable of handling data in all usual formats, including semantically structured data, manual data entry, optical character recognition (OCR) of typed, handwritten or printed text scanned from documents and spreadsheets
R2.3	Scalability	The BI component shall be scalable from small to very large (high volume) datasets throughout the workflow
R2.4	Analytical support	The BI component shall support descriptive and statistical analysis, including multivariate statistics, machine learning and artificial intelligence
R2.5	Reporting formats	The BI component shall support usual reporting formats from tables to different types of graphs and figures, interactive formats etc.
R2.6	Scripting of pre-defined data workflow steps	The BI component shall be capable of scripting pre-defined work steps in a data workflow to make them usable by staff that is not specifically qualified in data analytics
R2.7	Interfacing with external databases	The BI component shall be capable of interfacing (ODBC) with existing databases, including those hosted off-premises
R2.8	Weighting mechanism	The solution shall provide a mechanism for weighting different data sources, e.g. in relation to assumed veracity or trustability.
R2.9	Skills matching	The solution shall be able to handle job descriptions for skills matching

In relation to the Service levels Business Intelligence (BI) component the following services levels shall be provided in a modular manner:

- Installation
- Technical maintenance
- System administration
- Data analytics: defining and scripting data ingest, cleaning, analytics and results reporting in collaboration with staff from the procurer for pre-defined scenarios.
- User Training

Table 3 - Functional requirements on the DYNAMO Workflow Engine (WE) component

ID	Name	Short description
R3.1	Standards based workflow definition	The WE component shall support the definition of workflows on the basis of relevant standards (e.g., BPMN, UML©, ISO 5807:198528)
R3.2	Rule-based workflow outcome monitoring	The WE component shall support monitoring of processes, decision making and forecasting of outcomes aligned with the workflows, according to predefined criteria, rules or more complex algorithms for predictions using machine learning techniques.
R3.3	Metrix based Mapping of dependencies	The WE component shall be capable of mapping complex dependencies between different data points or performance metrics (e.g., number of people to be served depending on available build infrastructure and healthcare staff with specific skills levels)
R3.4	Workflow export	The WE component shall provide a functionality to export and store workflows defined within the system in standardised formats for future use

In relation to Workflow Engine (WE) component the following service levels shall be provided in a modular manner:

- Installation
- Technical maintenance
- System administration
- User training, including training in the use of standard workflow formats.

Table 4 - Functional requirements on the DYNAMO Communications Engine (CE) component

ID	Name	Short description
R4.1	Natural language messages	The CE components shall generate natural language messages for different formats (audio, text, graphics) to communicate with different stakeholders
R4.2	Appending documents	The CE components shall be capable of appending documents (from files or generated by other system components) to messages
R4.3	Communications channels	The CE components shall send generated messages (and possible appended files) via the different channels
R4.4	Human approval workflow	The CE components shall support a workflow for checking and approving messages by human users before sending if required
R4.5	Contact information imports	The CE components shall be capable of importing contact information (names, addresses, phone numbers etc.) to send messages

In relation to the Communications Engine (CE) component the following service levels shall be provided in a modular manner:

- Installation
- Technical maintenance
- System administration
- User training

Table 5 - Functional requirements on the DYNAMO Data Interface (DI) component

ID	Name	Short description
R5.1	Safe off-site storage	The DI component shall provide safe off-site storage to allow external parties to upload data files, password-protected
R5.2	Data import	The DI component shall provide functionality to import data from off-site storage or local file system into core system database
R5.3	Interfacing with off-premises databases	The DI component shall be capable of interfacing (ODBC) with off-premises databases
R5.4	Data pseudonymisation	The DI component shall provide the ability to pseudonymize structure data items in a dataset using common keys and algorithms
R5.5	Future interfacing with external data systems	The DI component shall have future capability to interface with existing data systems (such as Electronic Health Records) using established standards

In relation to the Data Interface (DI) component the following service levels shall be provided in a modular manner:

- Installation
- Technical maintenance
- System administration
- User Training

4.2 Non-functional requirements (R6)

Table 6 - Non-functional requirements

ID	Name	Short description
R6.1	Extendibility	The DYNAMO solution shall be able to principally allow for new functionality (e.g., adding a new core component beyond pathway design, initial impact assessment of alternative pathways and skills matching) to be added.
R6.2	Modularity	The DYNAMO solution shall be developed in a modular way, to allow meaningful application of selected functional components (pathway design, initial impact assessment of alternative pathways and skills matching). Modularity and network availability and quality shall differentiate the different network states: disconnected, low bandwidth and high bandwidth. Functions available at a minimum for data collection, data presentation, interfacing with external IT infrastructures, training materials, will have to be further specified during the PCP process.
R6.3	Instantiation	The solution shall possess the capability to restore specific instances (e.g., by leveraging log files), ensuring the accurate and efficient recovery of designated states.
R6.4	Latency and response time	The DYNAMO solution's entry masks and functionalities shall lead to the expected result (e.g., registration and settings) without obstructing and hindering its use within the crisis response planning process. The DYNAMO solution shall be usable with delay no greater than 0.5 ms.
R6.5	User interfaces	The solution shall provide the necessary interfaces based on the different user levels, as a minimum: - administrator of the Local Modelling Group - nominated data manager - other members of the expert group All user interfaces should be designed in such manner that the user understands and knows what to do on each screen. All screens should include additional instructions and help text whenever needed.
R6.6	User interface languages	The DYNAMO solution shall provide user interfaces in five languages including Italian, Portuguese, Spanish, Polish and English
R6.7	Supportive material languages	All supportive materials (e.g., user manuals, example cases) shall be made available in five languages including Italian, Portuguese, Spanish, Polish and English
R6.8	Language expandability	The DYNAMO solution shall be agnostic to language, i. e. used terminology shall be easily changeable and the solution shall be developed in a way so that additional languages can be easily added.
R6.9	Customisation-Users	The DYNAMO user shall be able to set preferences (e.g., language) which are stored with the user account and / or as cookies.
R6.10	Capacity-Users	The DYNAMO solution shall support a sufficient number of simultaneous users accessing the solution.
R6.11	Capacity-Data (any)	The DYNAMO solution shall support a sufficient number of data entries of any kind without loss of data and without restrictions to any user type.

R6.12	Access via web	For a connected network state, the DYNAMO solution shall be web-based (accessible from the web on a browser), and not necessitate any software download or installation on a computer.
R6.13	Access controls time	The access controls process time shall be minimized and should not become a barrier to application entry.
R6.14	Browsers	The DYNAMO solution shall be accessible from and fully compatible with all major browsers including Google Chrome, Mozilla Firefox, Opera, Microsoft Edge, and Apple Safari.
R6.15	Secure connection	The connection used for accessing the DYNAMO solution shall be secure according to commonly applied standards for sharing sensitive data.
R6.16	Ease of use	All user interfaces of the DYNAMO solution should be designed in such a manner that the functions can be achieved with as few clicks as possible.
R6.17	Error messages	All error messages should explain how to recover from the error and propose a fallback mechanism

4.3 Legal and regulatory requirements (R7)

Table 7 - Legal and regulatory requirements

ID	Name	Short description
R7.1	GDPR	The DYNAMO solutions shall be fully GDPR compliant.
R7.2	Policy communicatio n	The DYNAMO solution shall provide the user with complete information on its privacy and security policies during registration and later through navigation in the user interface.
R7.3	Access Control	The DYNAMO solution shall govern access by username and secure password (in compliance with regional/national/European data protection legislation).
R7.4	Security Policy	The local modelling group shall develop a security policy with respect to the processing of personal data.
R7.5	Security Measures – VPN	The DYNAMO solution shall provide necessary equipment and measures to ensure user and data privacy by allowing access to data, if applicable inside and / or outside of the restricted domain, operating via a virtual private network (VPN).
R7.6	Breach Notification-User	The solution shall notify the users in case of security breaches by explaining the nature of the breach, contact information about the organisation and how the users can mitigate any possible adverse impact of the breach.
R7.7	Security Incident	The solution shall ensure a timely response to incidents reported by the national Computer Emergency Response Team (CERT)
R7.8	Security profile	The solution shall develop a security profile which can be certified according to Common Criteria for Information Technology Security Evaluation (ISO/IEC 15408)

4.4 Operational, staff and business requirements (R8)

Table 8 - List of Organisational, staff and business requirements

ID	Name	Short description
R8.1	Installation of prototypes v.1	The DYNAMO solution developer shall install the necessary prototype system alpha version at the premises of each of the four Procurers and Associated Partner for the prototype to be tested by at least 5 users at each site (Phase II).
R8.2	Installation of prototypes v.2	The DYNAMO solution developer shall install the necessary prototype system beta version at the premises of each of the four Procurers and the Associated Partner (setting-up in Phase II and operation in Phase III) for the prototype to be tested by at least 10 users at each site.
R8.3	Introduction of pilot system	The DYNAMO solution developer shall introduce the pilot system at the premises of each of the four Procurers and Associated Partner in close collaboration with their representatives in Phase III. On-site testing will be done to reveal and resolve any issues that prevent the system from working properly at the premise.
R8.4	Pilot operation maintenance	In Phase III, the DYNAMO solution developer shall keep the DYNAMO solution fully functional at all times. A team shall be available to the site management to physically and/or remotely resolve any issues and problems that prevent the system from working as desired.
R8.5	Helpdesk provision and technical maintenance	The DYNAMO solution developer shall set-up and operate a help service and maintenance response team to address problems faced by users. This service will be provided at each of the five sites during Phase II and Phase III.
R8.6	Concept for user training and capacity-building assistance	The DYNAMO solution developers shall provide a concept describing the approach to user training and capacity-building assistance the developers will follow and execute during the pilot operation phase. Appropriate materials development and where necessary events organisation shall be planned as part of the strategy.
R8.7	Business strategy	The DYNAMO solution developers shall provide a business strategy describing the approach for commercialising the solution (including market expansion plans, business models, etc).
R8.8	Total cost of ownership	DYNAMO suppliers shall deliver models to quantify total cost of ownership in relation to the services and products they are offering.
R8.9	Quality management and certification	The DYNAMO developers shall provide a quality management and certification strategy. Standards such as UNI-EN-ISO 9000 may apply.

5 DYNAMO Use Cases

In the upcoming sections, we delve into how the DYNAMO solution is applied, focusing on context-specific use cases. Each use case revolves around an intense scenario that will be tackled during the project's duration. The exploration begins with a detailed representation of this intense scenario, set to be emulated by the procurer across the tri-phase procurement process. The use case is then broken down from three perspectives:

- The exact conditions that activate the DYNAMO solution at the procurer's location (starting point).
- The steps involved in establishing the LMG at the procurer's location, as well as the stakeholders participating in this phase (LMG setup).
- A day-to-day overview of DYNAMO's functionality, in line with the generic socio-technical model discussed earlier in the text (DYNAMO's operational hub).

To complement this, a concise overview of the socio-technical workflow is provided in table form, highlighting crucial tasks to be carried out at the concerned procurer site.

Concluding this section, we present a visual representation of the data sources and formats that can be integrated into DYNAMO, keeping in mind the fundamental components of the DYNAMO solution.

5.1 Use case - Antimicrobial resistance

5.1.1 High-pressure scenario - Treviso

Anti-microbial resistance (AMR) is a significant concern worldwide and presents a high-pressure scenario for healthcare systems, including those in Treviso, Italy. AMR occurs when bacteria, viruses, fungi, and parasites evolve to resist the drugs designed to kill them, making common infections harder to treat, and increasing the risk of disease spread, severe illness, and death.

Treviso has a significant elderly population, for which the susceptibility to infections increases, thus heightening the risks associated with AMR. Furthermore, areas with high population density, like Treviso as an urban centre, can facilitate the more rapid spread of resistant infections. This creates an additional burden on healthcare facilities, which may already be grappling with the complexities of treating drug-resistant illnesses. These healthcare institutions serve as the frontline in the fight against AMR and, if inadequately equipped or understaffed, can find themselves overwhelmed.

Another pressing concern could be the overuse or misuse of antibiotics, either due to over-prescription by medical professionals or inappropriate usage in sectors like agriculture. This can contribute to the development and spread of drug-resistant strains of bacteria, exacerbating the problem, and adding further strain on healthcare services.

Tourism is another factor to consider. The region of Veneto is a popular tourist destination, and Treviso is no exception. The influx of tourists can introduce new strains of bacteria and other pathogens into the local population, complicating the efforts to manage and treat drug-resistant infections.

The economic ramifications are also significant. Extended hospital stays and more complicated treatment regimens for drug-resistant infections increase healthcare costs. These elevated costs can have a ripple effect, affecting community well-being and local businesses.

In addition, cultural attitudes towards antibiotic use and traditional medicine could influence the extent of AMR in the community. Addressing this effectively requires culturally sensitive educational initiatives to promote responsible antibiotic use.

Supply chain challenges also loom large. The need for the continual development of new antibiotics and treatments becomes even more critical as existing ones become ineffective. This is compounded by potential disruptions in supply chains, particularly in times of global crisis.

Managing AMR effectively also calls for a coordinated, multi-sectoral approach, involving not only healthcare but also public health, agriculture, and education sectors. This cross-sectoral coordination can be logistically complex, requiring robust governance structures to be effective.

Moreover, AMR is a global issue. Pathogens do not respect national borders, and this broadens the scope of the challenge, necessitating international collaboration. On a local level, this can lead to a sense of fatigue and pressure among healthcare providers and policymakers, as their efforts may seem like a drop in the ocean.

Ethical dilemmas also arise, particularly when effective treatments are in short supply. Healthcare providers may have to make difficult decisions about who receives which treatments, adding another layer of complexity to an already challenging situation.

Finally, AMR adds a layer of concern to pandemic preparedness. As we've seen with COVID-19, healthcare resources can be stretched to the limit during a health crisis. The presence of drug-resistant strains could make the containment and treatment of outbreaks much more difficult.

In summary, anti-microbial resistance presents a multifaceted and high-pressure scenario for the healthcare system in Treviso. It calls for comprehensive strategies that include rigorous surveillance, public education, antibiotic stewardship, and collaboration across sectors and borders.

5.1.2 Use case description - Treviso

Starting point

The scenario revolves around ISRAA, the largest provider of care services to older people in the wider area of Treviso. Overall, the public organization operates four residential care homes, 21 home care units throughout the region and one dementia care centre. In their daily work, ISRAA staff often interact with other health care providers, such as the regional health authority (AULSS2), several hospitals and a variety of general practitioners and specialist doctors. When it comes to internal workforce safety, since 2018 ISRAA has implemented a dedicated security management protocol based on the ISO standard "IO002 – Biological risk management procedures".

Recently, the organisation has noticed an increasing number of severe microbial infections in older people in its care facilities that could not be successfully treated only with the usual antibiotics. An internal ad-hoc assessment revealed that most of the infected care recipients have recently returned from a hospital stay.

Set up of the Local Modelling Group (LMG)

ISRAA convenes a meeting of the DYNAMO Modelling Group (LMG) which is chaired by the general director. Permanent LMG members include the chief of the security and safety service, four nursing home coordinators, 21 care unit coordinators and the coordinator of the dementia care centre. As per existing planning, the LMG sets up a virtual operations room with help of the DYNAMO solution. Beyond the permanent members of the DYNAMO LMG, further stakeholders are invited to join the temporary DYNAMO Operations Room in order to

counteract the further spread of resistant bacteria in a concerted action. They include representatives of the regional health authority, of health care centres and hospitals located in the region.

The DYNAMO Operations Room in operation

All permanent and temporary members of the LMG are granted 24/7 access to the DYNAMO solution via a secure internet connection after successful registration. Different roles and responsibilities are agreed upon, including the nomination of a Pathway Modelling Task Force and a Pathway Impact Modelling Task Force. Both task forces are chaired by ISRAA staff who had received specific training on care pathway modelling and impact modelling when the DYNAMO solution was procured.

Over several days, the Pathway Modelling Task Force investigates all known cases of infection among ISRAA clients by reviewing the respective internal client folders and interviewing the responsible internal staff. In addition, external service providers who have been involved in the clients' care chain are contacted by telephone. At this stage, the primary goal is to identify possible infection chains and to avoid other people developing the infection. It turns out that most affected ISRAA clients were treated in a particular hospital immediately before their infection was diagnosed. The hospital concerned is immediately informed about this finding indicating the type of bacteria, infection, clinical condition. Next, the pathway design task force uses the DYNAMO solution for developing a care pathway for infected patients, including mandatory screening for resistant bacteria before discharge and, in case of a positive result, referral to isolation rooms available in ISRAA facilities, taking into consideration whether a single or a shared room is needed. Patients with the same infection/bacteria can be placed in the same room, but people with other infections must be placed in different rooms. The solution should also be capable of monitoring the spread (spatial and geographical) of the pathogen/infection in the region through monitoring data from other health and care organisations in the area. The pathway is presented by a flow chart diagram which is shared with all health care facilities concerned.

Based on the newly designed care pathway for infected patients, the impact modelling task force starts identifying a set of key variables required to be included in a specifically defined pathway dashboard for monitoring the impacts of the new care pathways after its implementation within the concerned stakeholders' day-to-day operations. This includes the no. of patients diagnosed with an infection by a resistant bacterium, their current place of stay and further places they have been to after the hospital stay, the number of isolation rooms available in ISRAA facilities and the number of staff specifically trained on caring for infected patients.

Data on these variables is fed into the DYNAMO solution and regularly updated. Some data, such as the number of patients diagnosed with a resistant infection, is regularly imported into the DYNAMO solution format ISRAA's internal patient health record (Cartella Utente Web 4.0). To achieve this, the IT provider of the health record system produces daily data exports that are made available to the DYNAMO Operations Room via secure cloud servers and imported into DYNAMO. Other data, e.g., the no. of quarantine beds available, is collated from the stakeholders concerned by other means, e.g., telephone calls and paper-based reports, and manually entered into the DYNAMO solution. Based on regular data updates, the pathway dashboard also provides several alerts, e.g., when the no. of diagnosed patients exceeds the no. of available isolation rooms or when the no. of available quarantine care staff is not sufficient to staff all quarantine beds available according to a pre-defined staffing ratio. Using the DYNAMO comms engine, messages are sent to different care providers and other relevant stakeholders such as hygiene and cleaning personnel appraising them of situation updates and informing them how to intervene in a specific case or what measures must be immediately taken. In particular, an e-mail is sent to each of those stakeholders in the social and health care domain who have previously signed a legal framework agreement notifying them of the existing risk of contamination.

After several days of monitoring updated dashboard figures and specific dashboard alerts, the Pathway Modelling Task Force notices that the number of affected persons is increasing despite measures taken so far. They decide to revise the initially defined pathway by setting up a new isolation location. Data on available staff shows that there are not sufficient personnel in Treviso to staff the location. Hospitals from neighbouring regions are therefore contacted so see if suitable staff is available there. This is immediately done by telephone. After that an email/formal written request is issued through DYNAMO. The number and qualifications of the new staff members is entered into the solution, as is the upcoming availability of the new isolation location. The pathway is updated accordingly, and hospitals receive a generated message instructing them to discharge infected patients to the isolation location from the day it commences operation. The message is generated by a human and distributed through the DYNAMO solution or other communication systems.

With this last surge of infected patients and the new isolation facility and the hygiene and cleaning actions adopted, the infection subsides, and patient numbers first stabilise and then decline over the coming week. As soon as the last patient has been treated, the DYNAMO Operations Room produces a report of all its activities over the last couple of weeks and then disbands. The report is written by a member of the LMG. It summarises key information on how the crisis response was implemented such as time information on the detection of the infections, emergency management actions, time of resolution (if the case) and human resources engaged.

5.1.3 Contextualised socio-technical process flow and data input - Treviso

Setup

- ✓ Infection caused by antibiotic resistant bacteria in ISRAA (different units/sectors)
- ✓ The planning commission is convened by the General Director and it includes:
  - General director
  - Chief of the security and safety service
  - Nursing home coordinators (4)
  - Care units' coordinators (21)
  - Dementia Care Center coordinator (1)
- ✓ All receive access to DYNAMO. Access for care planners.
- ✓ All receive training on DYNAMO: coordinators of units, nurses, physicians are in charge of training other members of staff.
- ✓ Consultation with clinical team to determine which coding for the strain will be used and what treatment pathways are being established

Planning

- ✓ Affected groups are older people in ISRAA facilities, to be divided into levels of severity of their condition:
  1. Difficult to manage older people with dementia, but no physical impairments, behavioural symptoms (wandering).
  2. Medium difficulty to manage: no cognitive impairments, able to understand, but physical impairments.
  3. Easier to manage older people with physical and cognitive impairments, no self-sufficient.
- ✓ Sub-groups (Relatives and other external contacts that may have contributed involuntarily to spread the infection)

Pathway elements:

- ✓ Identification of affected people from internal records. Main aim is to avoid or limit the spread of the infection (inside ISRAA and outside)
- ✓ Mapping of available resources and units' features such as: assessment of professionals' capacity, obstacles and constraints (economic or others), levels of integration with other care services (hospitals/home care), professionals' equipment and workloads, structural conditions of the buildings (internet connection or others).
- ✓ Type and number of affected people will vary. Scenario can also affect other services connected such as: people in home care treatment, day centres, temporary hospitalisation.
- ✓ Data are collected from internal records (HR and employee data + patient data) and integrated with other database (hospital, regional data). Codes and names of bacteria must be unique.

Modelling

- ✓ Calculation models include type of patients divided into groups, creation of operative groups (who does what), identification of available resources and professionals to involve, definition of priority interventions and actions, definition of specific activities based on role, monitoring of the spread of the infection, issuing of alerts and communications among actors involved.

Testing / Operation

- ✓ For testing: interface for model datasets for test scenarios.
  1. General director and planning commission convene testing board for testing the model.
  2. Model testing run with planning commission.
  3. Results and outcomes are evaluated according to specific parameters and target achievements.

Real-life operation:

- ✓ Planning commission is convened
- ✓ Confirm use of DYNAMO and initate.
- ✓ Exchange of data and information with Ulss (local healthcare authority)
- ✓ Constant interaction with different actors of the territory, e.g. other long term care facilities, hospitals.

Figure 4 – Contextualised DYNAMO process in Treviso, IT

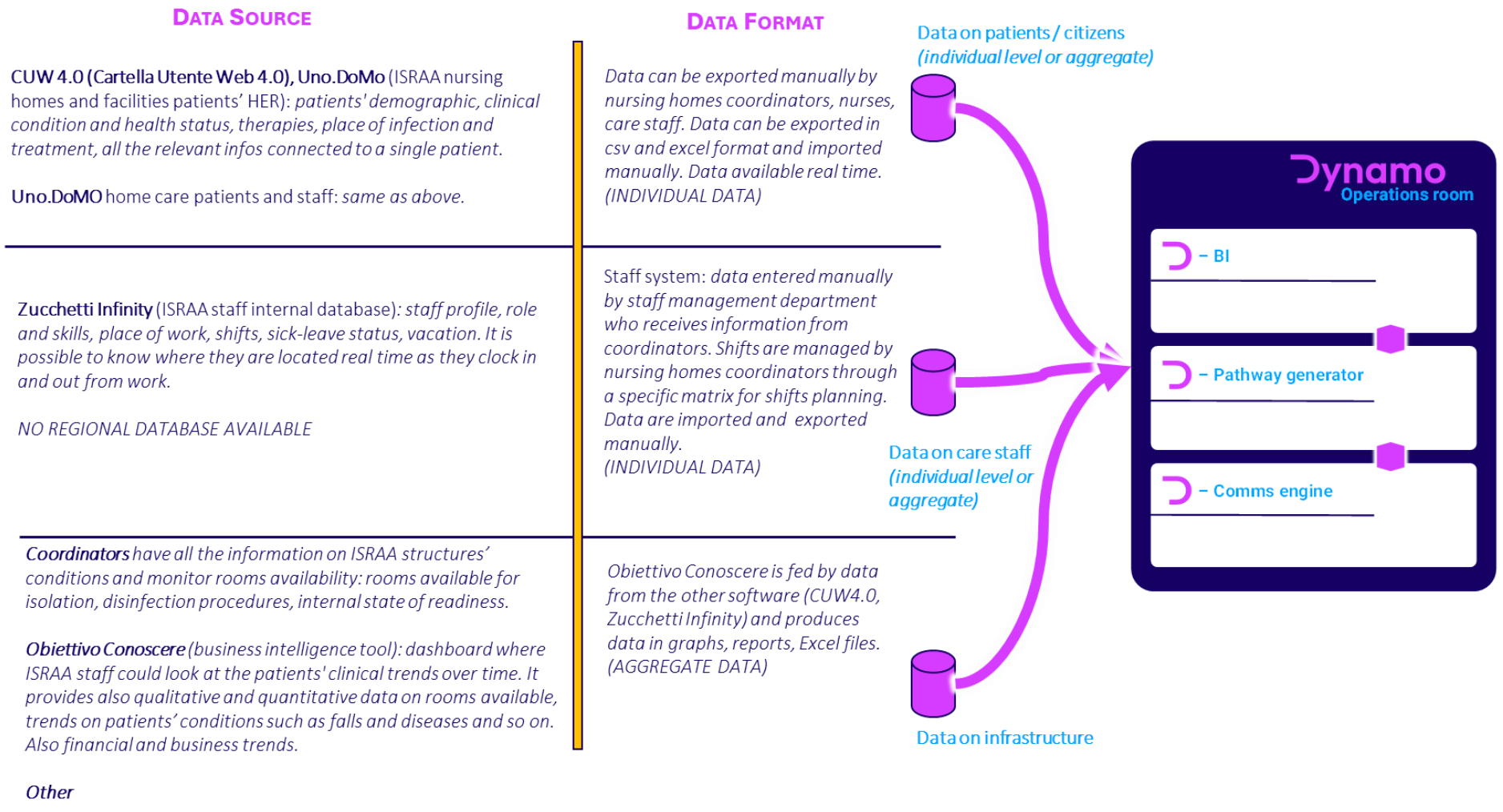

Figure 5 – Data sources and formats available in Treviso, IT

5.2 Use case - Heatwave

5.2.1 High-pressure scenario - Amadora

A heatwave can exert tremendous pressure on health and care systems, not just in Amadora, but globally. One of the most immediate impacts is the increase in hospital admissions, as hot weather often exacerbates existing health conditions like heart diseases, asthma, and respiratory issues. This uptick in demand stretches the capacity of healthcare facilities, requiring additional resources and manpower.

Vulnerable populations, such as the elderly, infants, and those with pre-existing health conditions, are particularly susceptible to heat-related illnesses like heat exhaustion and heatstroke. As a result, care services such as nursing homes and hospitals must take extra precautions to keep these patients safe, adding another layer of complexity and resource demand. In addition, dehydration and heat-related illnesses have become more common across the general populace, further amplifying the strain on medical services.

Emergency services also face added pressures as the incidence of heat-related health issues rise, leading to a higher volume of emergency calls. This surge in demand complicates the already challenging task of providing prompt and effective care.

The infrastructure of health and social care facilities is also put to the test. Hospitals and nursing homes can become uncomfortably hot, which not only compromises patient care but also creates challenging working conditions for care providers. Addressing this usually requires the implementation of additional cooling systems, which are both costly and energy intensive.

The energy demand for cooling also poses a broader challenge, as the widespread use of air conditioning can strain electrical grids and even lead to power outages, which can be particularly catastrophic for care facilities. On top of this, healthcare systems often have a role to play in communicating public health advice to help people stay safe during a heatwave. This involves a different set of resources and logistics, from producing public health messages to ensuring they reach the right audiences.

Moreover, the issue of mental health should not be ignored. Hot weather can exacerbate mental health conditions, adding yet another dimension to the healthcare challenge. Transportation issues, such as congested roads or less reliable public transit, could affect people's ability to reach care facilities in a timely manner.

If the heatwave coincides with another public health crisis, like the COVID-19 pandemic, the challenges multiply. Infection control measures have to be balanced with heatwave precautions, making the management of health and social care services even more complex.

Lastly, the situation often forces health and social care providers to make difficult decisions regarding resource allocation. The sudden increase in demand may necessitate tough choices about staffing, bed allocation, and the use of medical supplies, potentially leading to ethical dilemmas.

Given these multifaceted challenges, it's essential for cities like Amadora to develop and implement comprehensive heat action plans that coordinate with health and social care systems, local communities, government agencies, and other stakeholders. Such planning is crucial for mitigating the health impacts of extreme heat events.

5.2.2 Use case description - Amadora

Starting point

The scenario revolves around SCMA, a local NGO that provides services in 4 main areas: Health Care; Elderly; Education; and Social Support. All in all, SCMA operates throughout the

municipality two Day Care Centres, for Home Care Support Services, two Nursing Homes, and one Assisted Residential Unit, reaching in total about 600 older adults daily.

SCMA has a strong network of local partners with whom they collaborate actively such as the Municipality of Amadora, the Civil Protection and the Amadora Health Centres Cluster. Moreover, SCMA collaborates with several organisations providing services to older people such as nursing homes, day care centres and home care providers.

When it comes to organisational safety measures for heat waves mitigation, and although it is only mandatory for the Integrated Continued Care Unit (ICCU) as part of the national network, SCMA's Health Coordination produces and shares annually the Seasonal Health Contingency Plan - Summer Module. Every year, the plan is developed according to the national guidelines and activated in response to the alerts issued by the Regional Health Administration. In the remaining services, apart from the ICCU, the contingency measures are adapted to the needs and specificities of each service's specific context. As with the flu and now also Covid-19, the reduction in mortality and morbidity associated to heat waves is a concern of public health and, inherently, of SCMA.

The season of activation of the contingency plan has been reached (from the 1st of May to the 30th of September) and, for several days now, the meteorological forecast has been presenting increasingly hotter temperatures. Additionally, the national forecast and warning system (íCARO) has detected a level 2 alert, meaning "likely impact on mortality", which has been issued by the Regional Health Administration to SCMA's Health Coordination. An internal ad-hoc assessment revealed the need to activate the respective organisational contingency measures accordingly.

Set up of the Local Modelling Group (LMG)

SCMA convenes a meeting of the heat waves specific emergency planning group, the Local Modelling Group (LMG), which is chaired by the General Director in response to a notification received by SCMA's Health Coordination from the Regional Health Administration of a potential or imminent heat wave that will affect the region. Standing members include SCMA's social and clinical professionals from the nursing homes, day care centres and home care services, as well as operations representatives, namely:

- Health Coordinator
- Nursing Home/Assisted Residential Unit technical directors
- Homecare Support/Day Care Centres technical directors
- Research nurse
- Psychologist

As per existing planning, the LMG sets up a virtual operations room with help of the DYNAMO solution. Beyond the permanent members of the LMG, further stakeholders will be invited to join the temporary DYNAMO Operations Room and provide their expertise in two separate task forces (more detail below), in order to plan the implementation of the necessary heatwave mitigation measures, with a view to counteracting the heat-related impacts on health and to avoid casualties. They include representatives of the Municipality (Civil Protection included), of the local public Health Centres Cluster, and other health and social care providers with whom SCMA collaborates.

The healthcare coordinator triggers the process of decision making that involves from the social and clinical side, the nurses, the Directors of nursing homes, day care centres and home care support, as well as the family supporters working in the field; and from an environmental point of view, the Infrastructures and Maintenance Department for the physical conditions of the different facilities.

Different roles and responsibilities are agreed upon, including the nomination of a Pathway Modelling Task Force and a Pathway Impact Modelling Task Force. Both task forces are chaired by SCMA staff who had received specific training on care pathway modelling and impact modelling when the DYNAMO solution was procured.

DYNAMO Operations Room in operation

All permanent and temporary members of the LMG are granted 24/7 access to the DYNAMO solution via a secure internet connection after successful registration. Different roles and responsibilities are agreed upon, including the nomination of a *Pathway Modelling Task Force* and a *Pathway Impact Modelling Task Force*. Both task forces are chaired by SCMA staff who had received specific training on care pathway modelling and impact modelling when the DYNAMO solution was procured.

The Pathway Modelling Tasks Force uses the DYNAMO solution to develop an inter-organisational service pathway to minimise potential health risks to people in care from the heatwave that occurs.

Data on high-risk patients are identified from the internal service records available in the SINERGi and TSR (Clinical component) information systems. Socio-demographic data and ICF data (including social and clinical history; psychosocial condition; physical activity, etc) is also included in the DYNAMO system data set. All data is fed into the DYNAMO solution (e.g., SQL files, Excel files and CSV files). The data is then analysed to identify patients with specific risk profiles, such as individuals aged 65+ with obesity, kidney problems, psychiatric or chronic cardiovascular diseases; or receiving certain drugs such as antihypertensive drugs, antiarrhythmics, diuretics, or antidepressants. Individuals with a high-risk profile are identified from the data fed into the DYNAMO solution in the previous step.

Services and facilities principally available for mitigating their heat wave-related health risks are identified from the annual SCMA heatwaves mitigation Plan and National Heatwaves mitigation Plan. Data on resources available to these services/facilities are derived from the SINERGi and TSR (Administrative component) information system and fed into DYNAMO, including staffing, maintenance of infrastructures and cooling equipment (e.g., SQL, Excel, and CSV files) exported directly from the information systems. Staff-related information includes professional background, level of expertise, working history at SCMA, role and tasks, skills profile, place of work and historic sick-leave. In addition, data on occupancy rates of nursing homes and daycare centres, hydration resources, medicines, available air conditioning systems and other climatization equipment and food menu plans are derived from internal databases and the TSR information systems (stocks management) and fed into DYNAMO (e.g., SQL, Excel, and CSV files). The available heat wave mitigation services and related resources are then mapped against the high-risk client base identified earlier. This includes for instance a geographic mapping of services outreach to the residence or locality of place of living of high-risk patients. Moreover, the number of staff and professional profiles per service is mapped against the number of people requiring a particular service (e.g., health and social care). Where possible such data is imported from existing internal databases and repositories. Data that is not available from these sources is collated from paper-based records and manually entered into the DYNAMO solution via its user interface.

The identification of high-risk clients revealed that some of SCMA's high-risk home care clients have no air condition installed in their own homes. Air-conditioned room capacities within local care homes are identified with help of DYNAMO. A service pathway for temporarily admitting high-risk home care clients into suitable care homes is developed, and for their discharge once the heat wave ends. At the same time, a pathway is developed for the temporary delivery of a preventative counselling service to high-risk clients who can remain in their own air-conditioned homes during the heat wave, e. g. potential required adaptations to their medication and diet, possibilities to optimise room ventilation during the heat wave, organising

an adequate supply of drinking water, etc.. Both pathways are represented by a flow chart diagram which is shared with ISRAA's service units and with all collaborating parties concerned as well.

Based on the newly designed pathways concerning the temporary admission of home care clients to air-conditioned facilities and the delivery of a preventative counselling service for high-risk home care clients during the heat wave, the Impact Modelling Task Force starts working by identifying a set of key variables for monitoring the impacts of the new pathways after their implementation within the concerned stakeholders' day-to-day operations. The monitoring foresees regular mapping of the high-risk population against the availability of required resources. Key variables identified in this context include the number of high-risk users affected, their health and social care needs (e.g., medication needs and support needs in relation to activities of daily living), capacities available in terms of number of staff and skills possessed, and infrastructural living conditions (e.g., climatization).

Data on these variables is fed into the DYNAMO solution and regularly updated, either imported from the existing internal databases previously mentioned, and/or collated through paper-based records manually entered into the DYNAMO solution interface. Moreover, key meteorological indicators to be monitored on a daily basis are defined such as maximum temperature, air pressure and humidity forecasted for the next five days (e.g., temperature, air or atmospheric pressure, the level of humidity and the level of sun radiation). Indicator values are derived from available public weather platforms (e.g., the CLIMA.AML - Metropolitan Weather Monitoring and Alert Network, and IPMA - Portuguese Institute of the Sea and the Atmosphere websites).

Based on regular data updates, the pathway dashboard also provides several alerts, e.g., when detecting gaps in certain staff profiles or sets of skills; when the ratio of staff available versus the users in need is insufficient to ensure proper response capacity, or when the detection of a heat wave approaching raises the need to provide specific training. Such training concerns heat mitigation strategies and protocolar measures. Such training is then provided to all the professionals that are enrolled to provide care to older adults during heatwaves. Alerts are issued according to pre-defined ratios and parameters fed into the system by the MG (e.g., time elapsed since last training; level of responsibility on deployment of actions or professional background).

Through DYNAMO's communication engine the different stakeholders participating in the LMG (i.e., Health Coordinator, Nursing Home/Assisted Residential Unit technical directors, Homecare Support/Day Care Centres technical directors. Research nurse and Psychologist) involved in the interorganisational care pathway can coordinate its implementation, and be informed of situational updates (e.g., changes to the heat waves alert level, emergency measures and actions)

As the current heath wave further accelerates, the DYNAMO solution alerts the LMG members that the maximum temperature is forecast to rise above a pre-defined threshold within the coming days. In response to this development, it is decided to extend the preventative home counselling service provided during the heat wave's start-up phase to further client groups. The DYNAMO solution number of additionally identified high-risk clients proposed to receive temporary heat wave counselling service against the number of staff possessing the skills profile required for actual service delivery, thereby applying service staffing ratio pre-defined by the LMG turns out that the number of skilled staff currently available is not sufficient to provide the temporary counselling service to all newly identified at-risk clients. It is therefore decided to provide additional training to staff available from other services and prioritise the delivery of heath wave counselling to at-risk clients over certain other tasks as long as the heat wave continues.

As the heatwave is coming to its end and normal temperatures are being forecasted for the foreseeable future. All service provider organisations return back to regular service delivery. All relevant activity and impact assessment reports are delivered by the respective task forces,

and good practices and lessons learned are shared and fed into the DYNAMO solution for future use, following which the local DYNAMO Operations Room disbands.

5.2.3 Contextualised socio-technical process flow and data input - Amadora

Setup

- ✓ Heat Waves impacting older population in nursing homes, day care centres and home care (3 sectors of care)
- ✓ Setup and convening of heat waves specific emergency Planning Commission
- ✓ It includes representatives from
  - SCMA- including social and clinical professionals from the nursing homes, day care centres and home care services, and operations representatives
  - Civil Protection from the Amadora Municipality
  - Primary care
  - Community and social and healthcare providers
  - Regional statistics
  - All receive training by experts from the planning commission

Planning

- ✓ Older people in day care centres, nursing home residents and home care recipients
- ✓ Older people in primary care treatment are excluded,
- ✓ Pathway elements
  - Identification of high-risk people from service records
  - Identification of older adults, facilities and service needs at risk
  - Identification of service pressures and needs
  - Identification of governance requirements
  - Mapping of available services and associated resources including staffing, maintenance of infrastructures and cooling equipment
  - System pressure will be rapidly changing and so scenario must be informed by live data

Modelling

- ✓ Calculations include: understanding of baseline population, understanding of clinical, facilities and service needs, understanding of skills and resourcing and ratio of these to population, mapping changes in need and care provision over time, mapping course of heat waves, identifying external resources required for care delivery, understanding wider impact on physical and mental health, understanding of financial limitations and financial planning
- ✓ Utilising this data to plan services, prevent disruption and predict surges and impact of these during heat waves crisis

Testing / Operation

- ✓ For testing:
  - Planning Commission convenes testing board
  - Testing board defines test layout and parameters
  - Testing board runs test with the planning commission
  - Testing board rates test results in terms of system performance and approx. outcomes
- ✓ Real-life operation
  - Planning commission instantiates pathway
  - Heat waves specific emergency planning team convened
  - Confirm use of DYNAMO and initiate
  - Planning commission operates pathway for required time
  - Continual review of outputs and monitoring
  - Collection and sharing of good practices and lessons learned

Figure 6 – Contextualised DYNAMO process in Amadora, PT

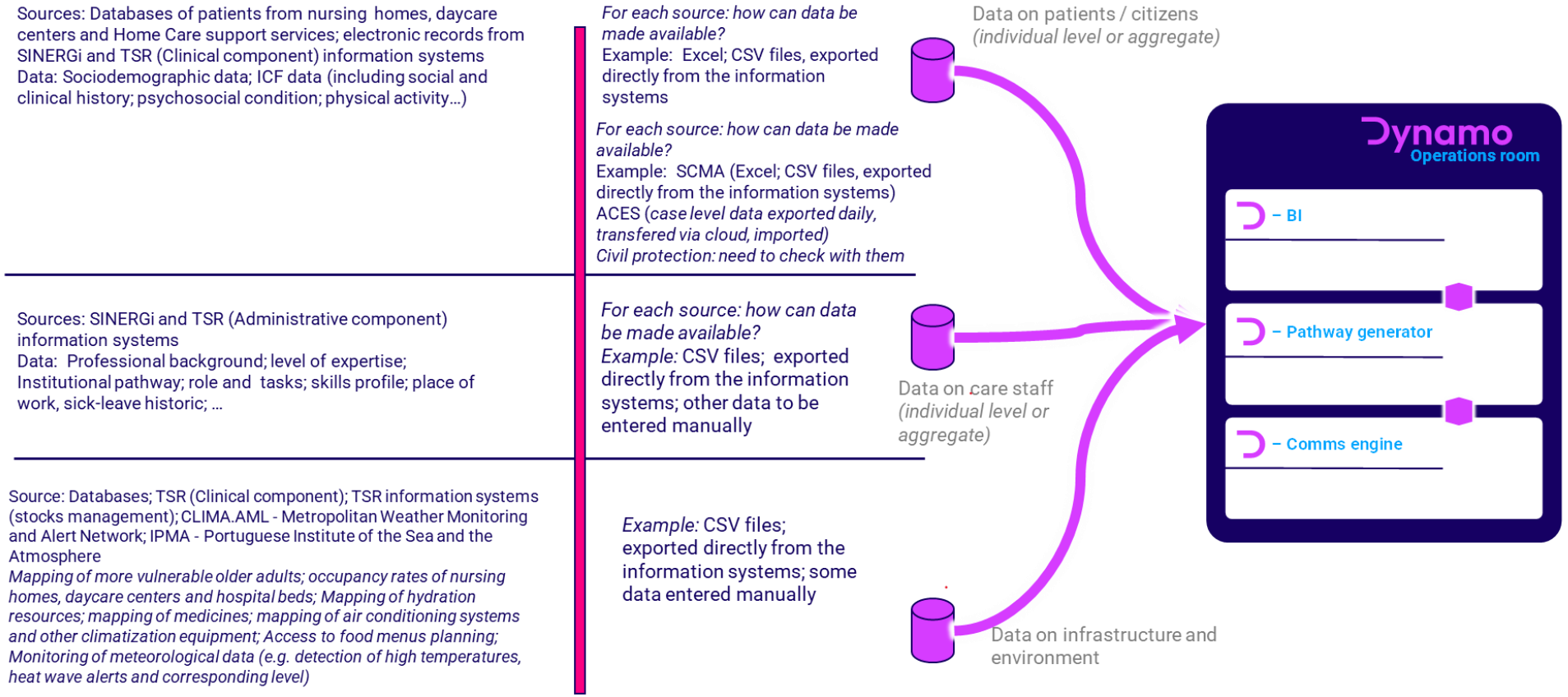

Figure 7 – Data sources and formats available in Amadora, PT

5.3 Use case - Cyberattack

5.3.1 High-pressure scenario - Catalonia

A cyberattack within health and care organisations creates a high-pressure scenario, which is extremely disruptive because health care operability is dramatically impacted. The extent to which services are affected will depend on the type of attack and the number of IT systems that are compromised. The worst scenario is that in which most services are highly and deeply affected, such as a distributed denial-of-service (DDoS) and the resolution of the problem takes time to be rectified resulting in a significant disruption in service levels for inpatients, surgical procedures, medication, laboratory and imaging reporting and results communication, outpatients, appointments etc. Even though health and care services in Catalonia are susceptible of a Cyberattack, this scenario could occur in any region as it is a global issue. As a result, the proposed scenario and DYNAMO solution, could be applied anywhere.

A cyberattack causes disruption not only at the affected targeted centre but other organisations that are connected to or have a relationship with the attacked centre are also likely to face challenges. Health and care delivery centres nearby or associated with the attacked centre might see an influx of patients that they are not fully equipped or resourced to care for. Furthermore, there is a risk that the cyberattack on one centre could be a precursor to or followed by attacks on other centres and thus causing additional problems.

Given these challenges, it is crucial for health and care centres to have a comprehensive plan in place which ensures a quick and adaptable allocation of patients and resources in the event of cyberattacks.

Shifting patient demand primarily involves the potential transfer of patients to other facilities. This process has several implications. First, some patients may be more vulnerable due to their health status or socio-economic challenges. So, when considering patient transfers, both their clinical severity and socio-economic conditions should be factored in. Second, emergency systems, like ambulance services, must be prepared to swiftly and efficiently relocate patients. Third, clear information must be provided to both the public and healthcare professionals to explain the reasons and logistics behind any changes, like relocations or schedule adjustments. Fourth, considering the potential impact on both patients and professionals, it's crucial to include ethical and legal experts in the decision-making process along with authorities, planners, and healthcare professionals.

The current model emphasises adaptability, even when reallocating resources. Centres receiving these transfers might struggle due to resource constraints, such as bed availability or staffing. Therefore, it is essential to determine how many professionals from the affected facility are unable to perform their duties. With accurate information on the capacity of receiving centres, it becomes possible to deploy human resources where they are most needed.

In conclusion, addressing the challenges posed by a cyberattack requires a well-coordinated effort across multiple facilities and disciplines. For this strategy to work, a diverse group of professionals must be familiar with the response plan, starting from the initial reaction. Additionally, having detailed pre-established information about staffing, facility health services, patient demand, and ambulance routes is crucial and must be continually updated during a cyberattack. This approach focuses on managing overall service capacity, leaving specific relocation decisions to planning and operational management teams.

5.3.2 Use case description - Catalonia

Background

The scenario revolves around one of several hospitals in Barcelona (hereinafter referred to as hospital A). Its hospital information systems have been attacked with ransomware. Digestive service is affected; it includes patients attended at hospital, digestive surgery, and consultations.

Set up of the Local Modelling Group (LMG)

In preparation for a possible cyberattack, all hospitals in Barcelona made some basic preparations to be able to react quickly with the help of DYNAMO in case of an actual attack.

A Planning commission (LMG) was formed. It includes permanent members (Health assistance director who convey PC, medical emergency and ambulance manager, health resource planner, bioethics professional, advocacy professional, IT, communication professional of Health Department) and temporary members (for each centre: geographical area health director, general director, clinical director, nursing director, responsible for communications, IT chief, human resource director, bioethics professional of centre, advocacy professional of centre).

All LMG members receive training on how to use DYNAMO prior to the actual occurrence of a cyber-attack. Their contact information (name, charge/responsibility, professional e-mail, and professional phone) is stored in DYNAMO. It is kept up to date on a regular basis. DYNAMO provides a confidential and fast 24/7 communication channel among all members of PC (virtual operations room).

Information on each centre's normal capacity was prepared and fed into DYNAMO, including the following information:

- Name, locality, population covered by the centre, geographical health area covered, surrounding centres, centres with which routine flux of patients or samples have already been established as part of routine operations.
- Capacity available
  - Surgery: number of operating room and operating teams (to include ambulatory surgery)
  - For each clinical services: maximum beds and consultation it can attend, service portfolio
  - ICU and emergency: maximum capacity
  - Day hospitals: number, type, maximum capacity
  - Pharmacy: maximum demand it could assume
  - Laboratory and image diagnosis: maximum number of diagnoses they can assure, service portfolio, ...
  - Number of ambulances and stretcher-bearers.
- Demand: weekly, median and percentage of maximum capacity of:
  - Beds and consultations in use by clinical service
  - Patients attended at emergency service.
  - Operation rooms in use
  - Lab and image diagnosis carried out.
  - Medication administrated.

- Number of ambulance services and median of ambulance journey

- DYNAMO should be able to access to socio-economical information of patients for prioritising among patients with same severity.

Moreover, for each centre, planning commission established priority categorization for each activity of the service portfolio and plan the following information: portfolio, service, priority categorisation, surrounding centres. This information is made available to DYNAMO and updated if there are any change related to service portfolio of centres, as shown by the table below.

Activity of service portfolio	Medical service that offers the activity	Priority categorization (Critical/High/Medium/Low/Very low)	Surrounding centres with same activity in their service portfolio (ordered by distance)
Cancer Colon surgery	Digestive	Critical	Hospital D (2km.), Hospital C (5km,)
Patients admitted digestive section	Digestive	High	Hospital B (2km.), Hospital D (2km.), Hospital C (5km.)
External consultations	Digestive	Medium	Hospital B (2km.) Hospital D (2km.), Hospital C (5km.)

Mapping medical emergency and ambulances (SEM): According to information showed in previous table and SEM maximum capacities, PC would design best routes among centres in case of cyberattack. SEM manager of each centre should be aware of this mapping. DYNAMO must be able to quickly show these routes to involved professionals in case of cyberattack. For instance, if LMG has decided that all patients of cancer colon surgery should go hospital D, DYNAMO should show a map with the best route from hospital A to D. This map is shown immediately to SEM service in order all professionals know that all there will be a certain number of patients for cancer colon surgery that need to be translate to hospital D using that route.

The LMG establishes which communication channels are to be used in the initial reaction, during monitoring of cyberattack and post-cyberattack to inform either professionals or general population/patients. Communication professionals of each centre should be aware of this planning. DYNAMO should facilitate these communication channels. It is the LGM's responsibility to decide if it is better to communicate that there is a cyberattack to patients who have some kind of appointment at hospital A and/or to professionals of hospital A/B/C/D. The LMG decides whether to use for instance mainstream channels such as SMS and/or the hospital web. All this should be planned prior to a cyberattack.

When the Cyberattack happens the LMG convenes. It is chaired by the general director of hospital A. He sends an alert to Health assistance director who convenes the LMG through DYNAMO. It includes permanent members and temporary members of hospital A and temporary members of centers surrounding hospital A (hospital B, hospital C and hospital D). The communication professional, being part of the LMG, informs professionals and patients of hospital A, B, C, D according to that previously established in pre-attack phase.

The DYNAMO Operations Room in operation

When the cyberattack occurs DYNAMO quickly shows following information related to hospital A to PC (activities are ordered by Priority categorization (1. –Critical, 2.- High, 3- Medium, 4- Low, 5-Very low). The Table below shows an illustrative example. Data for populating such a matrix is available from the electronic health register (% capacity in use), from hospital responsible staff who take part of LMG (Column 3 & 4, capacity of receiving centres). The prioritisation in column 2 (Categorization) was done by the LMG when DYNAMO was implemented in the territory (pre-attack phase)

Activity / service portfolio	Categorization previously stablished (Critical/High/Medium/Low/Very low)	% demand not attended because of cyberattack	% professionals who cannot carried out their job	Surrounding centres previously stablished and ordered with the following information visible: Actual % capacity in use, distance to hospital X. Ordered by less capacity in use and distance)
Cancer Colon surgery	Critical	100%	100%	Hospital D (70%, 2km) Hospital C (80%, 5km)
Patients admitted digestive section	High	100%	100%	Hospital C (20%, 5km) Hospital B (90%, 2km) Hospital D (90%, 2km.)
External consultations	Medium	100%	100%	Hospital D (10%, 2km.) Hospital C (85%, 5km,) Hospital B (100%, 2km.)

For those activities with critical priority, DYNAMO suggests best centres for relocation of patients (ordered as it is shown in table). For example, most patients pending of surgery are quickly distributed to hospital D, and those that cannot be attended at hospital D, are relocated to hospital C. When PC confirms receiving centres, 1). Required data are available from EHR and/or professionals of the hospitals who participate in the LMG. DYNAMO calculates number of patients that could be relocated to each hospital [For instance, 10 patients of hospital A need to be relocated and hospital C only have 3 beds available. DYNAMO thus knows that 7 patients need to be relocated to hospital C]. DYNAMO shows best routes previously stablished during *Mapping medical emergency and ambulances* and send an e-mail to those responsible of managing those transports.

For example, patients with socio-economic issues that need surgery are mainly located at hospital D and those that are attended to are mainly located at hospital B or D.

If the distribution of patients with critical and high priority cannot be treated due to capacity shortages, DYNAMO calculates:

1. What capacity hospitals B, C and D could still maintain, if professionals who cannot carried out their job at hospital A were translated to hospitals B, C and D.)
2. What capacity hospitals B, C and D could still maintain, if some activities of hospitals B, C and D with low or very low were postponed
3. What capacity hospitals B, C and D could have, if some activities of other services of any hospitals A-D with low or very low were postponed

Once patients of critical and high priority activities are distributed, the LMG assess if some patients of medium priority (for example, external consultations) activities could be transferred to receiving centres (in example, hospitals D and C).

The LMG meets daily to monitor evolution of centres' capacities and demand and resolve incidences. The purpose is that in hospital A there are patients (related to critical activities) who need to be attended because they are scheduled for the days of the cyberattack. To this end the LMG calculate each day with the help of the DYNAMO solution which patients would have a cancer colon surgery all days during cyberattack. Additionally, capacities of receiving centres can change every day. Thus, the LMG needs to dynamically adjust its recommendations daily. The final decision about which patient is relocated where remains exclusively with the LMG, i.e., by people. The member of LMG meet daily for joint decision making using the information and figures generated by the DYNAMO solution.

DYNAMO up-dates daily the information shown in previous assessment table. For each update, current demand as well as demand from waiting list (those patients scheduled for each day during cyberattack) must be considered. The latter information is obtained from hospital registers.

DYNAMO will continuously propose surrounding centres to re-distribute patients according to capacities and demands of either attacked centre or receiving centres. Once validated by PC, DYNAMO shows best routes previously stablished.

When a receiving centre gets 100% capacity (collapsed centre), DYNAMO send an alert to PC who could decide to convene an extraordinary meeting. For collapsed centre, a new process is initiated. For instance, hospital C cannot accept more patients for surgery. During the pre-attack planning assessment, a priority categorization and alternate services list was collated showing that digestive surgery of hospital C was linked to hospital E, hospital A, hospital F. Therefore, DYNAMO shows capacity and priority categorization according to table 2, and new transfers of patients were suggested from hospital C to E and F. If a new centre suffers a cyberattack, same process than that for collapsed centre is carried out.

When the cyberattack is solved, the LMG is informed through DYNAMO. Those activities that have been cancelled during cyberattack of any hospital are programmed.

DYNAMO records key parameters relating to the cyberattack (time to resolution, number of attacked centres, nº of involved centres, % Catalan population affected, % patients transferred to another centre, % patients who were not affected, increment of demand of receiving centres related to their median (absolute numbers and %), increment of ambulances journeys and km (absolute numbers and %), patients whose care services have been cancelled (absolute numbers and %), graphics on monitoring of involved centres capacities and demands, and incidences and alerts during cyberattack.

All information is reported to the LMG and authorities. A summary of the most relevant information (according to that stablished in pre-attack phase and review by PC) is reported to the professionals' involved centres.

5.3.3 Contextualised socio-technical process flow and data input - Catalonia

Setup

- ✓ Hospital Information Systems attacked with ramsomware. Contingency plans only can support the capacity to zero or a certain % depending on the service
- ✓ The planning commission is is conveyed by the Health Assistance Director and headed by the Geographical Area Health Director where the hospital belongs
- ✓ It include reps from
  - Main health facilities in the same and surrounding areas
  - Medical Emergency and ambulance services
  - IT
  - Health Resource Planning
- ✓ All receive access to DYNAMO
- ✓ All receive training by head of commission

Planning

- ✓ Inventory of services affected and capacity available
- ✓ Inventory of alternate services and procedures to derivate activity. Possibilities to increment capacity moving resources (technical and human) from affected to alternate facilities
- ✓ Pathway to access to alternate services and resources required
- ✓ Demographics of potential users (estimated consumption based on historical data) of affected services (ER, ambulatory, day care hospital, laboratory,...)
- ✓ Criticality categorization of services consumers
- ✓ Communication channels to citizens, professionals and facilities
- ✓ Specific procurement reqs for remaining services in the hospital

Modelling

- ✓ Calculations include:
- Services queue evolution based on alternate resources usage for different criticality levels
- Capacity usage
- Mapping of transportation resources
- Sensibility of queue and capacity calculations depending on demand variability
- Services consumption from internal patients and temporal evolution based on discharge expectation
- ✓ Definition of communication channels and tools selected to interact with professionals and citizens

Testing / Operation

- ✓ For testing
  - ✓ Mayor convenes testing board
  - ✓ Testing board defines test layout and parameters
  - ✓ Testing board runs test with the planning commission
  - ✓ Testing board rates test results in terms of system performance and approx. outcomes
  - ✓ Develop test scenarios based on historical data
- ✓ Real-life operation
  - ✓ Mayor convenes planning commission
  - ✓ Planning commission instantiates pathway
  - ✓ Planning commission operates pathway for required time
  - ✓ Retrospective analysis is performed

Figure 8 – Contextualised DYNAMO process in Catalonia, ES

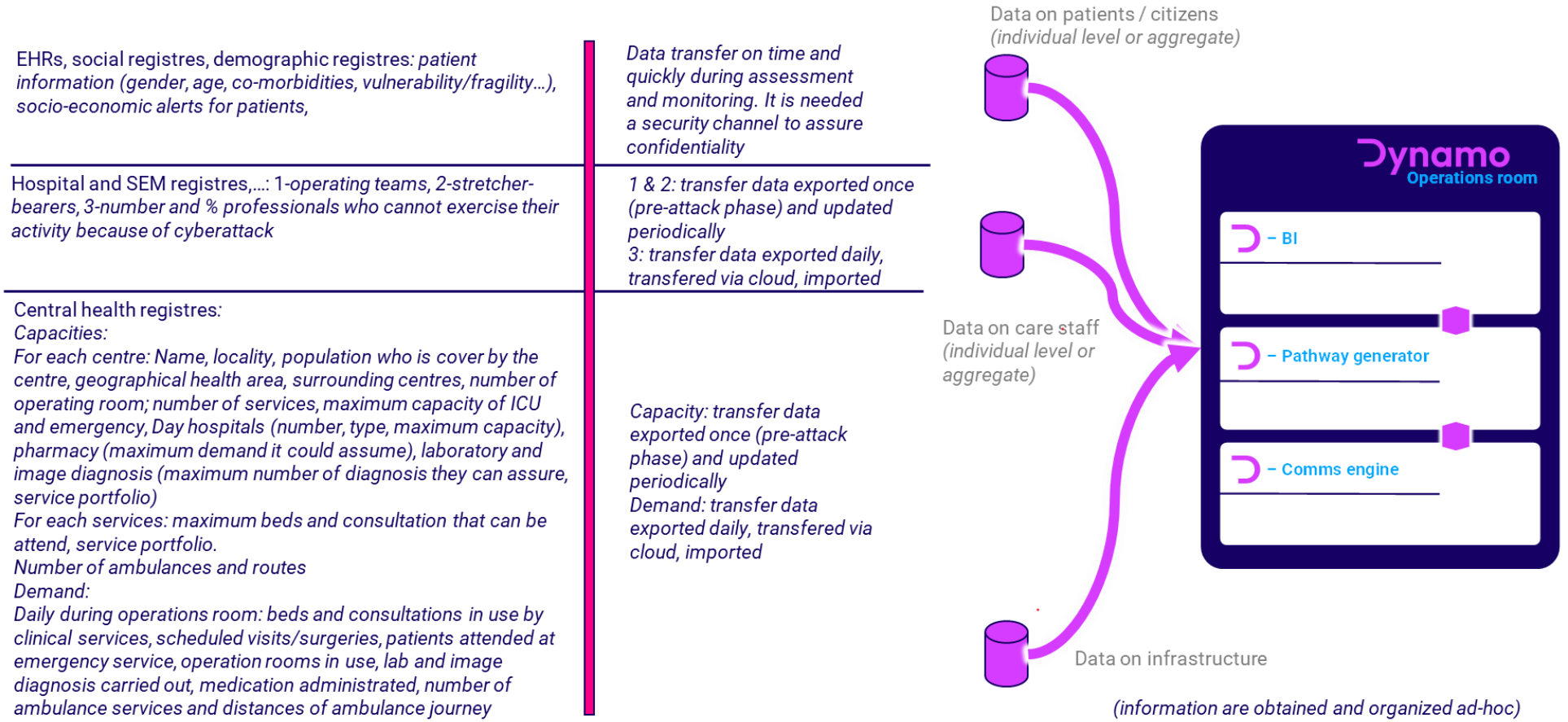

Figure 9 – Data sources and formats available in Catalonia, ES

5.3.4 High-pressure scenario – West Wales

We are now more digitally connected than ever before, the use of online services and digital technologies touch is widespread in society and across healthcare delivery. Wales' Digital Strategy focuses on delivering public services through collaboration and innovation, supported by effective cyber defence and resilience. Within this, the term 'cyber' means a public that feels safe and secure online, businesses that are resilient and public services that are effective and trusted.

Increasingly, digital services are accompanied by threats, with the global risk of cyber-attacks rising exponentially alongside developments in technology. Healthcare systems are especially vulnerable, due to limited investment in cyber security measures, large numbers of staff with minimal training in good cyber security practice, and the existence of multiple and varied legacy IT systems. In addition, there are inefficient incident response capabilities due to small numbers of staff working in specialist cyber security roles and complex operational structures which impede rapid and effective responses, when attacks occur. In recent years, multiple NHS systems were taken offline by a ransomware attack. These risks pose the threat of severe disruption to service delivery and since ever evolving cyber threats make it impossible for systems to be made totally secure and immune to attack, systems must be able to respond to incidents and recover as swiftly and effectively as possible.

In Wales and the UK, a number of complementary key documents address the needs in this area, including the Cyber Action Plan for Wales, the UK Government National Cyber Strategy 2022 and the Government Cyber Security Strategy 2022 to 2030. Within NHS Wales, Digital Health and Care Wales, a trusted partner organisation responsible for taking forward the next generation of digital and data services needed to transform health and care in Wales, is establishing a Cyber Resilience Unit to support health and care bodies prepare for and respond to cyber threats.

In West Wales, the healthcare system may face multiple challenges in the event of a cyber attack. Patient care would be impacted, through disruption caused by malware infection, lockout or disruption of health systems and devices. This might affect primary care, secondary care, and other NHS organisations in the form of disruption to organisations' abilities to provide emergency, unplanned and planned care and conduct test processing and communication of diagnostic results. Links and communication with social care services might also be impacted through delays in NHS care requiring business continuity arrangements needing to be put in place. Within NHS Wales, we need to be able to effectively model how such cyber incidents would impact systems across local, regional and national systems, understand how they could affect business continuity of individual organisations such as our own health board, and understand how this will lead to impacts for patients and other organisations involved in providing care services. The increasing complexity of health systems, and interdependencies and developing integration between system mean that attacks affecting one IT system can result in numerous, wider consequences.

In addition, it is recognised that the impact of the recent COVID-19 pandemic and the associated rapid, transformative changes in NHS working practices have left a security debt, resulting from cyber security concerns often taking a back seat in NHS organisations as they were faced with an exponential increase in patients needing care. This security debt leaves risks and vulnerabilities to the infrastructure that increase the need to plan and be able to respond to cyber threats, while cyber security measures are strengthened.

In summary, ever-present cyber threats present a significant and acute high-pressure scenario for healthcare systems, that might impact the delivery of healthcare in a myriad of ways. In a region like West Wales, with its geographic challenges, such an event would test the resilience and flexibility of the existing health and care systems in numerous ways.

5.3.5 Use case description – West Wales

Starting point

The scenario revolves around Hywel Dda University Health Board (HDdUHB), the NHS Health Board covering West Wales. HDdUHB plans and provides NHS healthcare services for Carmarthenshire, Ceredigion, Pembrokeshire, and bordering counties. More than 12,000 members of staff provide primary, community, in-hospital, mental health and learning disabilities services for an area that covers a quarter of the landmass of Wales. This is done in partnership with three local authorities and public, private and third sector colleagues, including volunteers through four main hospitals, five community hospitals, two integrated care centres, 48 general practices, 49 dental practices, 98 community pharmacies, 44 general ophthalmic practices, plus domiciliary only providers and health centres. There are numerous locations across the region providing mental health and learning disabilities services and highly specialised services, which are commissioned by Welsh Health Specialised Services Committee.

At 10am this morning the health board received an alert from the UK Department of Health and Social Care (DHSC) to a global ransomware attack affecting organisations globally. In the UK, this includes the NHS. By 12pm a major incident had been declared and emergency arrangements to maintain health and patient care were implemented.

Set up of the Local Modelling Group

HDdUHB establishes a Command Structure based on Gold/Strategic Level (Chaired by Chief Executive), Silver/Tactical Level (Chaired by Director of Operations), and multiple Bronze/Operational Level (chaired by operational lead for different functional or geographic areas of responsibility) groups. Gold and Bronze levels are not directly involved in the DYNAMO Operations Room, but the strategic plan and approval comes from Gold Group and multiple Bronze Groups implement required action.

The purpose of the Strategic/Gold Group is to take overall responsibility for managing and resolving an event or situation by establishing a framework of policy within which tactical managers will work by determining and reviewing a clear strategic aim and objectives. The Strategic/Gold Group has overall control of the resources of the Health Board and ensures sufficient resources are made available to achieve the strategic objectives set, also considering the longer-term resourcing implications and any specialist skills that may be required. The Strategic/Gold Group will delegate actions to the Tactical/Silver Group for them to implement a Tactical Plan to achieve the strategic aims.

The Silver/Tactical Group is responsible for developing and implementing a Tactical plan to achieve the Strategic direction set by the Strategic/Gold Group. They provide the pivotal link between Strategic/Gold and Operational/Bronze levels. The Local Modelling Group (LMG) is constituted by the Silver /Tactical Group.

The Operational/Bronze level responds to events at the operational level as they unfold. The term Bronze refers to Operational teams who will manage the physical response to achieve the tactical plan defined by Silver, controlling the management of resources within their given area of responsibility. There may be several Bronze groups based on either a functional or geographic area of responsibility. Representation within the Silver/Tactical Group which oversees the DYNAMO virtual operations room includes hospital staff with clinical and operational responsibilities:

- Local digital team
- Primary care
- Community care

The Local Modelling Group (constituted by the Silver /Tactical Group) oversees the DYNAMO virtual operations room. Representation includes hospital staff with clinical and operational responsibility. All receive access to DYNAMO and have received training by appointed training and data leads.

A virtual operations room is established utilising the DYNAMO system, identifying required data flows from hospital systems (patient demographic, diagnostic, clinical and testing data plus resource management data) and wider national (UK and/or Wales-specific) systems (e.g. prevalence/vaccination data if/when available).

Governance needs and reporting lines are linked to the Gold, Silver, Bronze Command Structure. Further stakeholders (representatives from social care, local authorities and Welsh Government plus attendees of NHS Wales including shared services, PHW, DHCW, WAST and NHS Executive) appropriate to the scenario are invited to join the case-specific DYNAMO Operations Room to address the growing concerns and oversee the delivery of short-, medium- and longer-term requirements and actions needed across a range of areas. This includes taking action to ensure the safety of patients, carers and staff, maintaining smooth continuation of critical services, maintaining the safety of the health board's estate, making provision for a 24-hour emergency response for appropriate services, assessing the ongoing issue and identify emerging issues, providing resources to support the local effort using mutual aid either locally or regionally and liaising directly with relevant external agencies as necessary.

DYNAMO Operations Room in operation

All members of the steering group are granted 24/7 access to the DYNAMO system via a secure internet connection after successful registration. Roles and responsibilities are established, based on the Command Structure in place and includes links to the Operational/Bronze level groups and additional Task Forces as required. Operational/Bronze level groups and Task forces are chaired by dedicated operational leads also trained in the DYNAMO solution and NHS crisis response management. Activity is undertaken aligning to four stages:

Stage 1 – Planning

Stage 2 – Modelling

Stage 3 – Operation

Stage 4 – Close

<u>Stage 1 – Planning - Determining cause and scale of problem and areas affected</u>

Following identification of the cyber-attack and the DYNAMO solution being activated, full planning commences to assess the problem and the implications of this on population and systems.

Based on established business continuity plans, safe communication channels need to be identified and established as a priority for use during the cyber-attack and guidance on this will need to be communicated to all staff via the DYNAMO communications engine to key communications points who will enable cascade messaging across the organisation. Communications to patients and public will also be considered in line with business continuity plans and communications policies to notify patients of any services disruptions or data breeches in line with data privacy guidelines.

Emergency and critical care activities will need to be prioritised for protection and support. The wider response will consider the healthcare needs of all those receiving or needing care. This will consider identification of service pressures caused by the cyber-attack and needs and mapping of services and associated resources including staffing.

System pressure and staffing, as normal, will be changing and so the cyber-attack response must be informed by data from local hospital-based systems providing data on current hospital admissions (WPAS). The planning task force will monitor this data to model a solution for implementation and testing.

Stage 2 – Modelling

The impact of the cyber-attack across local, regional and national systems will need to be modelled, to provide an understanding of how business continuity may be affected and in turn, affect staff, patients and other care providers. An understanding of how patient flow, hospital demand, and other knock-on effects to other services will be needed, dependent on systems affected by the cyber-attack.

Projections will need to be developed. Factors to be determined include understanding the baseline capacity of different sites, to cover routine service levels, current demand, physical capacities of hospital estates and data on ambulance services and length of travel to different sites as well as data on available skills and resourcing.

Utilising this data will aid planning of alternative care delivery for patients during the cyber-attack, in order to prevent disruption to their care delivery and allowing adaptation to deal with impacts of the cyber-attack across different systems. This will include planned appointment data from WPAS which will be used to allocate and secure sufficient resources to avoid disruption to care delivery.

The Tactical/Silver Command, informed by DYNAMO, will need information on alternative centres for emergency care delivery and distances/times for redirection of new patients and relocation of existing patients. Communications to notify of changes to care and service provision will be prepared, noting bilingual provision.

Stage 3- Operation

A testing panel is convened to pilot DYNAMO with available data feeds and evaluated outputs in terms of performance accuracy and usefulness. If deemed suitable in real-life operation the use of DYNAMO is confirmed and initiated. There is continual review and monitoring of DYNAMO outputs. In line with major incident response strategy, the initial response will need to focus on maintaining essential communications and securing emergency care services, followed by stabilising primary and planned secondary care delivery, and finally, remedial action required.

Communication with Strategic/Gold Level and Operational/Bronze Level groups is critical to inform stakeholders of ongoing activities and associated rationale. Daily communication summaries providing data on current inpatient numbers, planned outpatient appointments/surgeries and relocation of patients will inform daily meetings of Strategic/Gold Level, Tactical/Silver Level and Operational/Bronze Level groups.

DYNAMO presents alternative options for receiving emergency patients, relocation critically ill patients and redistributing resources (including staff) to support this. The Tactical/Silver Level group propose action to Strategic/Gold Level group for approval and then communicate with the Operational/Bronze Level groups to implement any required actions with specific data fed to appropriate teams/staff, e.g. to Hospital Bed Management teams who will manage transfers/receipt of patients.

The DYNAMO communications engine will be utilised to communicate changes to patients and notify public of the situation and any data breeches in line will all Wales policies and emergency planning.

Monitoring of current demand will be needed to indicate when capacity any centres is likely to be reached or exceeded. This will include details of any centres compromised by the cyber-attack and unavailable.

Remedial work to reschedule activities cancelled or postponed during the cyber-attack will need to be undertaken after the immediate impact of the cyber-attack is dealt with.

Stage 4- Close

When the cyber-attack has ended and all remedial work is complete, return to business as usual is required. The cyber-attack specific emergency planning team audit activity, and where applicable support national reviews. Lessons learnt are recorded and the cyber-attack specific team disbanded.

5.3.6 Contextualized socio-technical process flow and data input – West Wales

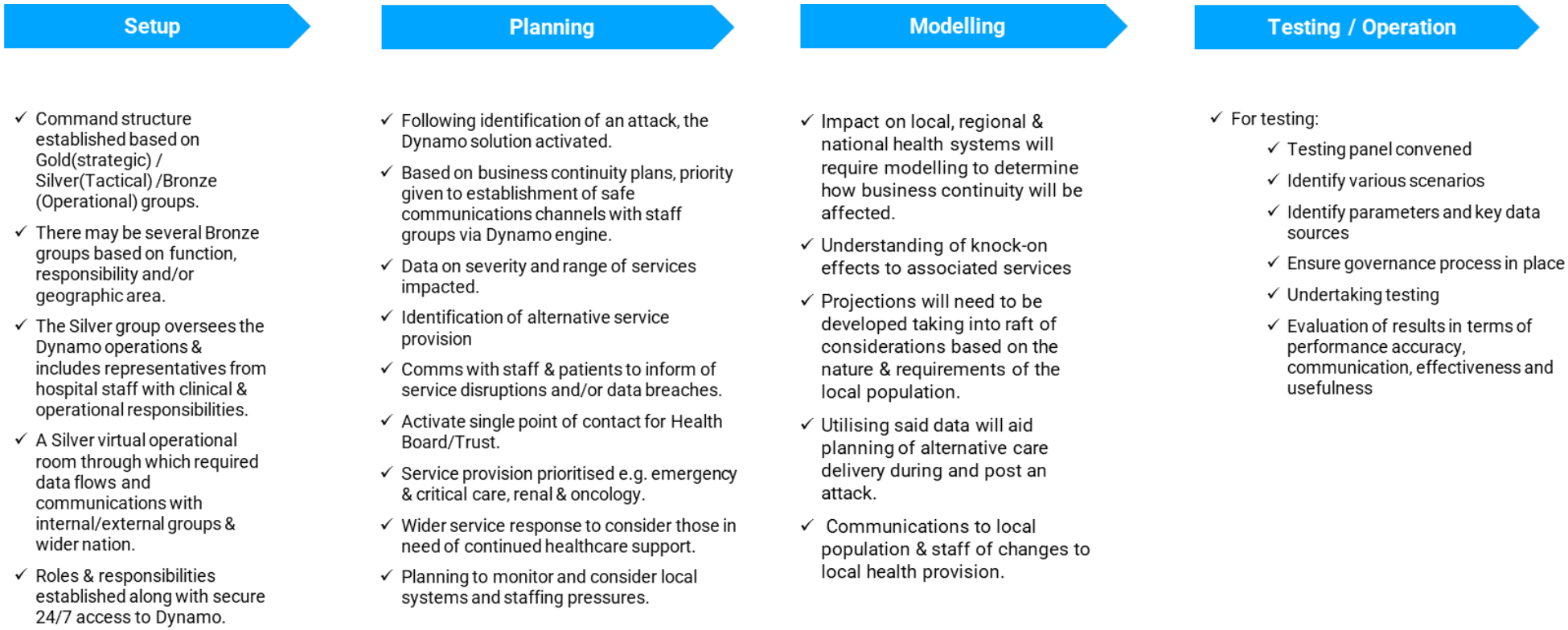

Figure 10 – Contextualised DYNAMO process in West Wales, UK

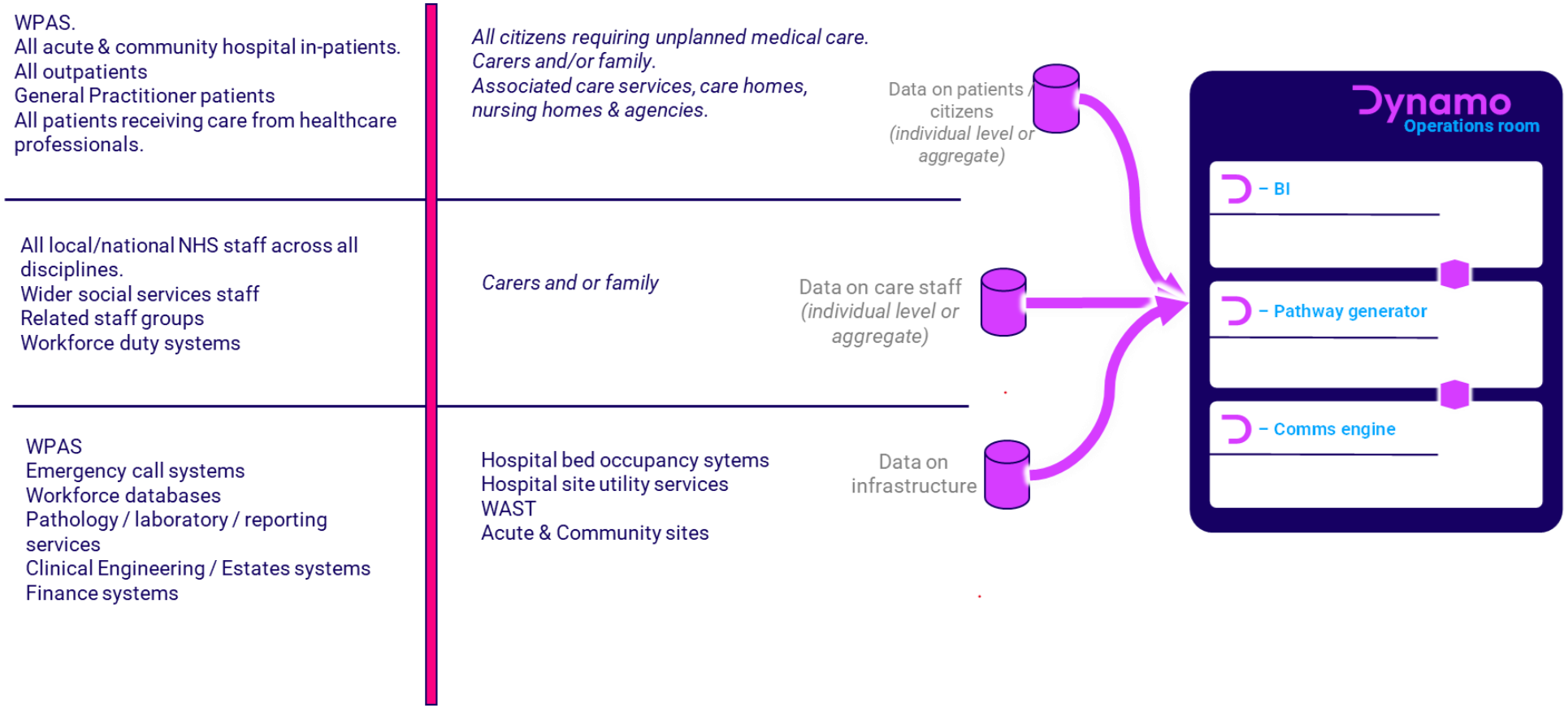

Figure 11 – Data sources and formats available in West Wales, UK

5.4 Use cases - Pandemic

5.4.1 High-pressure scenario – West Wales

A pandemic presents a significant and high-pressure scenario for health and care systems in any region, including West Wales. In West Wales, the healthcare system will face multiple challenges in the event of a propagated epidemic. The first obvious issue is the strain on clinical facilities. Hospitals, clinics, and care homes might experience an influx of patients, overwhelming their capabilities and leading to a shortage of beds, medical supplies, and personnel. This can make it difficult to maintain the standard of care expected for both those affected by the epidemic and patients with other health issues.

Secondly, the geography and demographics of West Wales could exacerbate the situation. The area is known for its rural communities, where access to healthcare services is varied geographically. The logistical challenges of delivering care to remote locations would be heightened during an epidemic. Older populations that might reside in these rural communities are particularly vulnerable to severe illness, thus amplifying the demand for healthcare services.

Another factor to consider is workforce availability. An epidemic could lead to healthcare staff falling ill, thereby further reducing the human resources available for patient care. This also places an emotional and physical toll on the remaining healthcare workers who must contend with increased workloads in high-stress conditions.

Communication and public trust also come into play. Health authorities would need to disseminate timely and accurate information to provide clear guidance to minimise panic and ensure that people take appropriate preventative measures. This is crucial in controlling the spread of the disease, especially in smaller communities where misinformation can spread quickly.

Financial constraints are another issue. Addressing an epidemic requires investment in medical supplies, emergency services, public health campaigns, and possibly even temporary medical facilities. These unexpected expenses could strain the budget, diverting funds from other essential services or initiatives.

Furthermore, pre-existing health conditions prevalent in the community could complicate the management of the epidemic. For instance, if there is a high incidence of chronic conditions like diabetes or heart disease, these could make the population more susceptible to severe forms of the illness, complicating treatment and potentially leading to higher mortality rates.

Lastly, a propagated epidemic could have a longer-term impact on mental health. The stress and anxiety associated with an outbreak can lead to a range of mental health issues, from acute stress disorders to longer-term problems like depression. This adds yet another layer of demand on healthcare services, both during the epidemic and in its aftermath.

In summary, while a propagated epidemic is generally more localised than a pandemic, it poses a significant high-pressure scenario for healthcare systems. In a region like West Wales, with its unique geographic and demographic challenges, such an event would test the resilience and flexibility of the existing health and care systems in numerous ways, from resource allocation to effective communication and long-term care.

5.4.2 Use case description – West Wales

Starting point

The scenario revolves around Hywel Dda University Health Board (HDdUHB), the NHS Health Board covering West Wales. HDdUHB plans and provides NHS healthcare services for Carmarthenshire, Ceredigion, Pembrokeshire, and bordering counties. More than 12,000

members of staff provide primary, community, in-hospital, mental health and learning disabilities services for an area that covers a quarter of the landmass of Wales. This is done in partnership with three local authorities and public, private and third sector colleagues, including volunteers through four main hospitals, five community hospitals, two integrated care centres, 48 general practices, 49 dental practices, 98 community pharmacies, 44 general ophthalmic practices, plus domiciliary only providers, and health centres. There are numerous locations across the region providing mental health and learning disabilities services and highly specialised services, which are commissioned by Welsh Health Specialised Services Committee.

Over the past month, multiple cases of a new, rapidly spreading virus have been reported. The first documented case was in the United States with further cases reported across Europe and Asia and most recently, the UK. The first cases of the virus have been reported within Carmarthenshire, the most easterly Health Board region, with several patients admitted to secondary care. New cases are appearing in other localities across Wales, and in line with the Civil Contingencies Act (2004), this has been flagged as a rising tide event to Local Resilience Forums, comprising membership from regional emergency services, local authorities, local health boards and other government agencies that have responsibilities in the region.

Set up of the Local Modelling Group

HDdUHB establishes a Command Structure based on Gold/Strategic Level (Chaired by Chief Executive), Silver/Tactical Level (Chaired by Director of Operations), and multiple Bronze/Operational Level (chaired by operational lead for different functional or geographic areas of responsibility) groups.

The purpose of the Strategic/Gold Group is to take overall responsibility for managing and resolving an event or situation by establishing a framework of policy within which tactical managers will work by determining and reviewing a clear strategic aim and objectives. The Strategic/Gold Group has overall control of the resources of the Health Board and ensures sufficient resources are made available to achieve the strategic objectives set, also considering the longer-term resourcing implications and any specialist skills that may be required. The Strategic/Gold Group will delegate actions to the Tactical/Silver Group for them to implement a Tactical Plan to achieve the strategic aims.

The Silver/Tactical Group is responsible for developing and implementing a tactical plan to achieve the strategic direction set by the Strategic/Gold Group. They provide the pivotal link between Strategic/Gold and Operational/Bronze levels.

The Operational/Bronze level responds to events at the operational level as they unfold. The term Bronze refers to Operational teams who will manage the physical response to achieve the tactical plan defined by Silver. Controlling the management of resources within their given area of responsibility. There may be several Bronze groups based on either a functional or geographic area of responsibility. Gold and Bronze groups are not directly involved in the DYNAMO Operations Room, but a strategic plan and approval comes from Gold Group and multiple Bronze Group implement required action.

The LMG is constituted by the Silver/Tactical Group. Representation within the Silver/Tactical Group which oversees the DYNAMO virtual operations room includes Hospital staff with clinical and operational responsibility.

- Local digital team
- Primary care
- Community care

All receive access to DYNAMO and have received training by appointed training and data leads. A virtual operations room is established utilising the DYNAMO solution, identifying required

data flows from hospital systems (patient demographic, diagnostic, clinical and testing data plus resource management data) and wider national (UK and/or Wales-specific) systems (e.g., prevalence/vaccination data if/when available). Governance needs and reporting lines are linked to the Gold, Silver, Bronze Command Structure. Further stakeholders (representatives from social care, local authorities and Welsh Government plus attendees of NHS Wales including shared services, PHW, DHCW, WAST and NHS Executive) appropriate to the scenario are invited to join the case-specific DYNAMO Operations Room to address the growing concerns and oversee the delivery of short-, medium- and longer-term requirements and actions needed across a range of areas, including managing ongoing and pandemic-related patient care in primary, community and acute care settings, ensuring adequate digital services support and ensuring workforce can respond to changing demand.

DYNAMO Operations Room in operation

All members of the steering group are granted 24/7 access to the DYNAMO solution via a secure internet connection after successful registration. Roles and responsibilities are established, based on the Command Structure in place and includes links to the Operational/Bronze level groups and additional Task Forces, such as Public Health and PPE. Operational/Bronze level groups and Task forces are chaired by dedicated operational leads also trained in the DYNAMO solution and NHS crisis response management.

Following identification of the pandemic and the DYNAMO solution being activated, full planning commences to assess the problem and the implications of this on population and systems. Whole population level data with specific prioritisation of clinically vulnerable populations, (such as those with auto-immune, respiratory conditions and cancer) is required. Particular considerations need to be given to patients in primary care, community care (including residential care) and those in hospital. The response will consider the healthcare needs of those affected by the pandemic alongside wider clinical needs.

The LMG defines which data at the whole population level exactly is required to be fed into DYNAMO solution to enable a mapping of the affected populations to the area, thereby prioritising:

a) vulnerable population groups such as autoimmune, respiratory and cancer

b) patients in primary care, community care and hospital care

Based on these data a “shielded patient list” is produced by Digital Health and Care Wales in line with advice from the Chief Medical Officer for Wales. Vulnerable patients (are mapped against the area. The list includes patients registered for healthcare in Wales and patients routinely identified as at high risk by their General Practice or hospital specialist.

A temporary counselling service pathway is designed with help of the DYNAMO tool to ensure that those identified as clinically vulnerable will be contacted by the GP and provided with guidance on shielding measures, priority vaccination and action required if infected. The counselling service also includes signposting to additional relevant advice on working arrangements, financial support available and other provision/support will also be provided. The temporary counselling service pathway is represented by a flow chart diagram, augmented with counselling guidelines developed by the Pathway Planning Task Force. Both are distributed to the GPs concerned via the local health boards in the area concerned. The shielded patients list is shared with local authorities and other relevant organisations to ensure any support required by this population can be provided/accessed.

The ‘shielded patients list’ is also shared with local authorities and other relevant organisations to ensure any support required by this population can be provided/accessed.

The response for clinically vulnerable members of the population will require the implementation and continued weekly monitoring of changes to the ‘shielded patients list’.

To this end, the LMG identifies key indicators required for monitoring of potentially required changes to the 'shielded patient list' and any implications for operating the temporary service response pathway on a weekly basis. Indicators to be monitored include:

- The identity and contact information of high-risk patients enrolled to temporary service pathway designed per service area.
- The health care needs of enrolled patients in terms of diagnosed risk factors per service area
- The overall number of high-risk patients enrolled to the temporary service pathway per service area.
- Identity and context information of GPs per service area.
- The overall number of GPs per service area.

These indicators are populated with data derived from health records maintained by General Practices or hospitals in the area. The data is uploaded onto a secure cloud environment once a week by the practices and hospitals in a commonly agreed format. Based on the monitoring data, the DYNAMO solution triggers an alert via its dashboard as soon as a predefined ratio of the number of identified at-risk patients and GPs per service area is exceeded.

System pressure and staffing must be expected to rapidly change over time and so the pandemic response is to be informed by data, from national systems recording daily case prevalence and local hospital-based systems providing data on current hospital admissions (WPAS). The task forces also look for trends in the data to identify clinically vulnerable sub-groups based on age, ethnicity, clinical diagnosis, geographical location.

Indicators developed to monitor overall system pressure, including:

- daily case prevalence per service area
- daily case prevalence on the national level
- number of Hospital admissions per service area according to age, ethnicity, clinical diagnosis, and geographical location

Data on daily case prevalence is imported from a national system recording daily case prevalence at the level of service areas. The data is made available for download from a public web site as an excel file. Data on hospital admissions of infected patients is downloaded from national systems recording daily case prevalence and local hospital-based systems providing data on current hospital admissions (WPAS).

DYNAMO a provides a regular trend analysis concerning of hospital admissions per age, ethnicity, clinical diagnosis, and geographical location. Outcomes are provided in graphical and numerical format.

These trends are mapped against available services and associated resources including staffing.

For validating the parameter defined by the LMG, a smaller data set is derived from the available sources and fed into DYNAMO in terms of test run. Outputs are evaluated in terms of performance accuracy and usefulness.

If deemed suitable in real-life operation the use of the temporary counselling service pathway designed with help of DYNAMO is confirmed and initiated. The pathway is represented by a flowchart diagram which is distributed to the relevant stakeholders in the service areas concerned.

Communication with Strategic/Gold Level and Operational/Bronze Level groups is critical to inform stakeholders of ongoing activities and associated rationale. Communication with Strategic/Gold Level and Operational/Bronze Level groups is critical to inform stakeholders of

ongoing activities and associated rationale. Written summary reports are generated by the LMG according to a common structure daily. These are channelled in electronic format through DYNAMO to the relevant stakeholders.

When the pandemic cases are falling and trends indicate no new surge, return to business as usual is required. The LMG audits activity, and where applicable supports national reviews. Lessons learnt are recorded and the pandemic specific team disbanded.

5.4.3 Contextualized socio-technical process flow and data input - West Wales

Setup

- ✓ Pandemic declared affecting primary, secondary and community care.
- ✓ Setup and convening of pandemic specific emergency planning team:
- ✓ It includes reps from
  - ✓ hospitals including clinical and operations representatives
  - ✓ Community and social care providers
  - ✓ Regional statistics/ONS and DHCW
  - ✓ Primary care
  - ✓ Welsh Ambulance
  - ✓ EMR
- ✓ All receive access to DYNAMO
- ✓ All receive training by appointed training and data leads

Planning

- ✓ Whole population level with specific prioritisation of clinically vulnerable populations, (such as those with auto-immune, respiratory conditions and cancer),
- ✓ Three main populations to consider:
- ✓ Patients in primary care
- ✓ Patients in community care, including residential care
- ✓ Hospitalised patients
- ✓ Response needs to consider the healthcare needs of those affected by the pandemic and wider clinical need
- ✓ Pathway elements
  - ✓ Identification of high-risk people from service records
  - ✓ Identification of patient and service needs
  - ✓ Identification of service pressures and needs
  - ✓ Identification of governance requirements
  - ✓ Mapping of available services and associated resources including staffing
  - ✓ System pressure and staffing will be rapidly changing and so scenario must be informed by live data

Modelling

- ✓ Calculations include: understanding of baseline population, understanding of clinical and service need, understanding of skills and resourcing and ratio of these to population and area, mapping changes in need and care provision over time, mapping course of pandemic, identifying external resources required for care delivery, understanding wider impact on physical and mental health, understanding of financial limitations and financial planning
- ✓ Utilising this data to plan services, prevent disruption and predict surges and impact of these during pandemic

Testing / Operation

- ✓ For testing:
  - ✓ Testing panel convened
  - ✓ Identify parameters and key data sources
  - ✓ Ensure governance process in place
  - ✓ Undertaking testing
  - ✓ Evaluation of results in terms of performance accuracy and usefulness
- ✓ Real-life operation
  - ✓ Pandemic specific emergency planning team convened
  - ✓ Confirm use of DYNAMO and initiate
  - ✓ Continual review of outputs and monitor

Figure 12 – Contextualised DYNAMO process in West Wales, UK

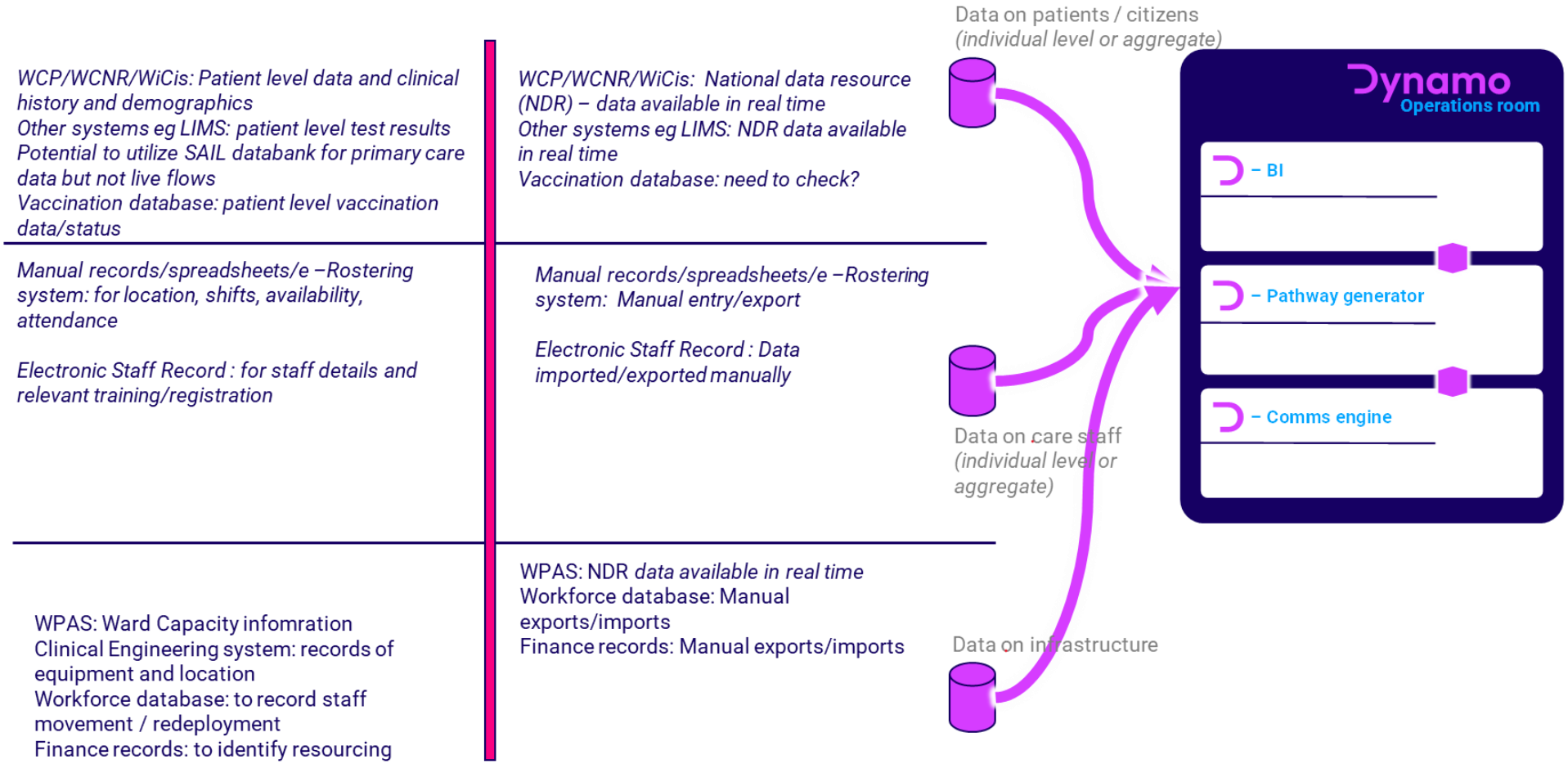

Figure 13 – Data sources and formats available in West Wales, UK

5.4.4 High pressure scenario - Olsztyn

This use case revolves around the Warmian-Masurian Lung Disease Centre (WMCCP) in Olsztyn. A pandemic is a scenario that is significant and puts a lot of pressure on health systems in any region, including the Olsztyn sub-region of the region Warmia and Mazury. In the event of a spreading epidemic, the health system will face several challenges. The first obvious issue is the burden on medical facilities. Hospitals, clinics, and nursing homes may experience an influx of patients that will exceed their capacity and lead to shortages of staff, beds and medical supplies. This may make it difficult to maintain the expected standard of care for both those affected by the epidemic and patients with other health problems.

Secondly, the situation is negatively affected by the geographical location and demography of the Olsztyn sub-region. The area is scattered with many rural areas, far from medical centres, where access to health care services varies and the system itself is characterised by low accessibility to advanced diagnostics, including pulmonology. The age structure of pulmonology physicians in the subregion exceeds the national average, while the number of physicians is one of the lowest in the country per 100,000 inhabitants. The logistical challenges of providing healthcare in areas far from the Centre during an epidemic would increase significantly. Older people living in rural areas are particularly vulnerable to serious respiratory diseases.

The higher demand for health services is also due to the average age of the subregion's population, as well as one of the highest per capita smoking rates in the country. A sensitive factor to consider is the direct exposure of medical staff to infections, which will result in sickness absences and insufficient resources for replacements. This fact can have an impact on patient safety. It can also result in additional emotional and physical strain on the other staff members of our hospital, who face an increased workload in the face of high stress.

Communication and public trust of dependent institutions is also important. This includes the Centre's cooperation with legally related health authorities such as:

- National Health Fund
- Sanitary and Epidemiological Station
- Provincial Office
- Marshal's Office

In addition, cooperation with the Provincial Crisis Management Centre and the local media will improve the flow of up-to-date and therefore valuable information. This will make it possible to act in an organised and less chaotic manner. This will minimize panic and ensure that decision-makers take appropriate preventive action. This is crucial in controlling the spread of a pandemic, especially in communities where misinformation can spread faster than the virus itself. Added to this will be other chronic diseases of civilisation - circulatory failure, diabetes, cancer. These people will require rapid intervention, further ensuring a comprehensive health approach during a pandemic.

5.4.5 Use case description – Olsztyn

Starting point

The starting point for activating the scenario behind the DYNAMO mechanism is the moment when the existing epidemic situation is confirmed and the procedure for responding to the first emerging emergency cases of sick or suspected infected persons needs to be initiated. The scenario assumes that the work of the Centre can be reorganised in the event of an epidemic in collaboration with local authorities.

The LMG will consist of the following individuals and institutional representatives:

- Director of the Centre

- Deputy directors (director of medical affairs, director of nursing and director of technical affairs)
- Director of the security and emergency management department
- Head of the organisation department
- Head of IT team
- Emergency room doctor
- Main specialist
- Epidemiological nurse
- Representative of the Provincial Office
- President of the Association of Hospitals of Warmia and Mazury - advisory vote

The Centre has procedures in place in case of a mass event and suspicion/confirmation of a particularly dangerous infectious disease and bioterrorist attack. The procedures are based on legal acts, including:

- Act of 05.12.2008 on prevention and control of infections and infectious diseases in humans
- Instruction to the Centre's crisis team in accordance with the procedure "Proceedings in the event of a mass casualty incident and cooperation with emergency services".

The provisions contained in these documents impose an obligation on the Centre to notify:

- Provincial Medical Rescue Coordinator
- Air Ambulance
- The District Sanitary and Epidemiological Station
- Nursing homes and other medical facilities
- Police and Fire Brigade
- Regional Security Centre
- Voivodeship Crisis Management Centre of the Warmińsko-Mazurskie Voivodeship

Set up of the Local Modelling Group

The Director of the Centre establishes and directs the LMG and assigns tasks to the individual members of the group, the composition of which is given above. The purpose of the LMG is to support the Team Leader in making the most effective decisions during emergencies and resolving them by establishing response patterns based on pathways accepted by all members. Accordingly, operational leaders will work with clear strategic goals and objectives to achieve these goals. In particular, the LMG:

- monitors the smooth implementation of pathways on an ongoing basis.
- liaises with overarching institutions authorised to manage crises at national and regional level.
- coordinates the flow of information outside and inside the Centre.
- exercises overall control over resources ensuring that they are sufficient to achieve the strategic objectives set.
- develops scenarios that consider long-term resource implications - personnel, infrastructure, equipment, and materials.

The members of the LMG implement the set tasks through their own actions and by delegating tasks to subordinate staff. As a condition for the implementation of the strategic plan developed by the LMG, the LMG communicates the plan and considers potential feedback where relevant to the implementation of the plan. The Chair of the LMG is responsible for organising the training of all LMG members. Based on ICT (Information and Communication Technology) solutions, a virtual operations room will be established using the DYNAMO support mechanism. DYNAMO will act as a support to the systems currently used by hospital staff, such as:

- CGM CliniNet
- SIMPLE.ERP
- Zoom or MS Teams communication tools

After observing an influx of more patients and obtaining information from the sanitary-epidemiological station, the emergency room doctor will inform the medical director of the situation by telephone and e-mail, and he or the centre director will activate DYNAMO, which will send a message (e-mail/sms) to the other members of the LMG. The extent of the data available to the DYNAMO system will be determined by the LMG.

DYNAMO Operations Room in operation

All LMG members gain 24/7 access to the DYNAMO mechanism via a secure internet connection. Once a pandemic is identified and the DYNAMO solution is activated, full planning begins to assess the problem and its implications for patients and residents in the region. The LMG will accurately determine the ranges of data relevant and necessary for further action. This is followed by segregation carried out by the medical staff (nurse and paramedic), who create a list of patients, where the appropriate colour code is assigned based on the vital signs selected by the Emergency Room Physician. Based on this division, visual signage is divided into four basic groups:

1. requiring immediate assistance - red colour
2. requiring urgent assistance - yellow
3. requiring deferred assistance - green
4. patients without prognosis - black

Based on the segregation data, DYNAMO notifies the LMG, which initiates a procedure to manage hospital beds, staffing and resources and determine alternative treatment regimens depending on the number of patients, e.g. in the case of an increased number of patients requiring urgent care (red), the DYNAMO system will send an alert to LMG members about the situation.

The LMG members will decide on the need to increase the number of staff. If additional staff is required, the DYNAMO system will send a notification to the medical staff group indicated by the LMG (data from the SIMPLE system – availability of staff with needed qualifications) about the need to support the staff of the Emergency Room and/or to notify the Crisis Management Centre. Also, DYNAMO system will send a message to other hospitals/medical facilities from the Olsztyn sub-region with a request for support.

Concerning the patients in the ward, the DYNAMO system generates a report upon request from the LMG members about the occupancy status and type of beds and when the occupancy of beds with oxygen access exceeds 85%, high medical supervision beds with ventilators and cardiac monitors exceeds 80% the DYNAMO system activates an alert and notifies the LMG

members about the situation. The LMG management then chooses the appropriate course of action, e.g. converting another ward into an infectious ward, thereby increasing the number of beds.

If the pandemic intensifies and thus the number of patients exceeds the capacity of the Centre, LMG will inform other institutions (Crisis Management Centre, hospitals, primary care facilities) of the situation, and DYNAMO will send a message to the other institutions via e-mail/sms requesting the necessary support.

At the same time, the DYNAMO system sends a bed occupancy report twice a day to the Emergency Management Centre Coordinator. If there are no beds available at the Centre, the Emergency Management Centre Coordinator will provide information on free beds in the Olsztyn sub-region where patients can be transported.

5.4.6 Contextualized socio-technical process flow and data input - Olsztyn

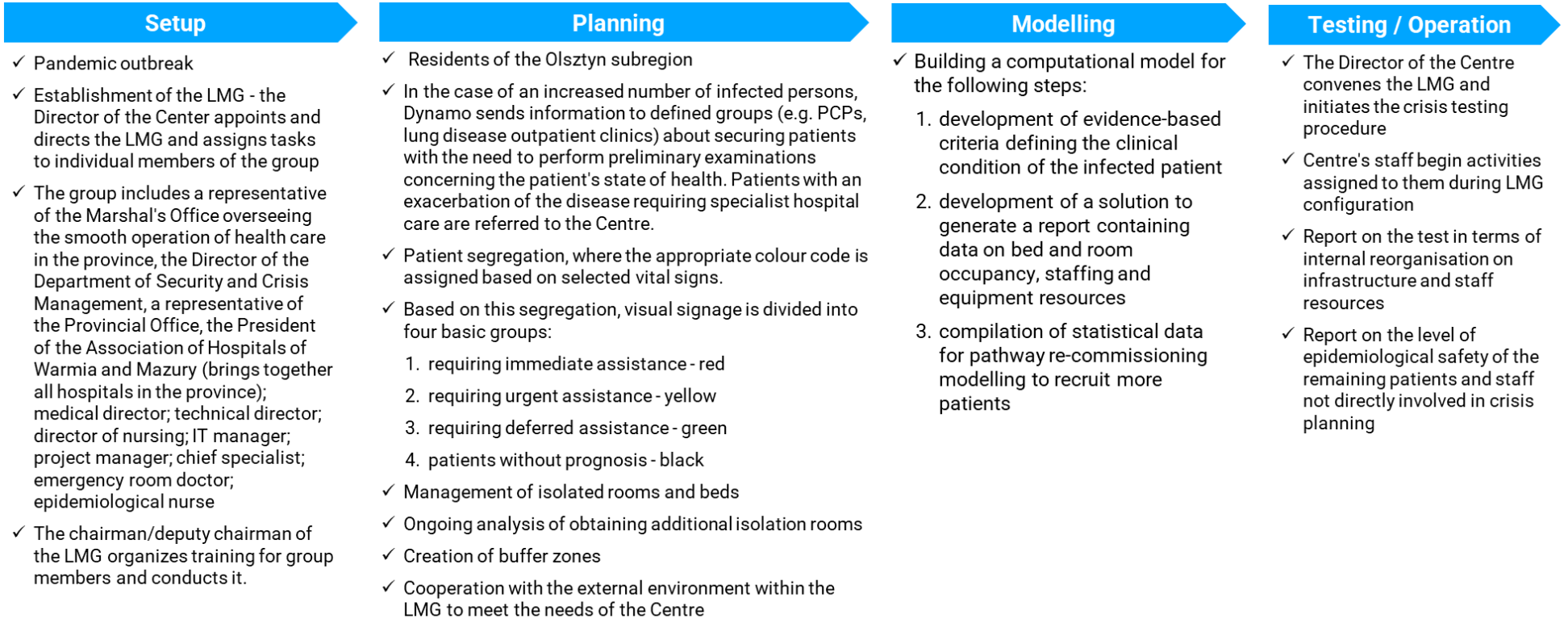

Figure 14 – Contextualised DYNAMO process in Olsztyn, PL

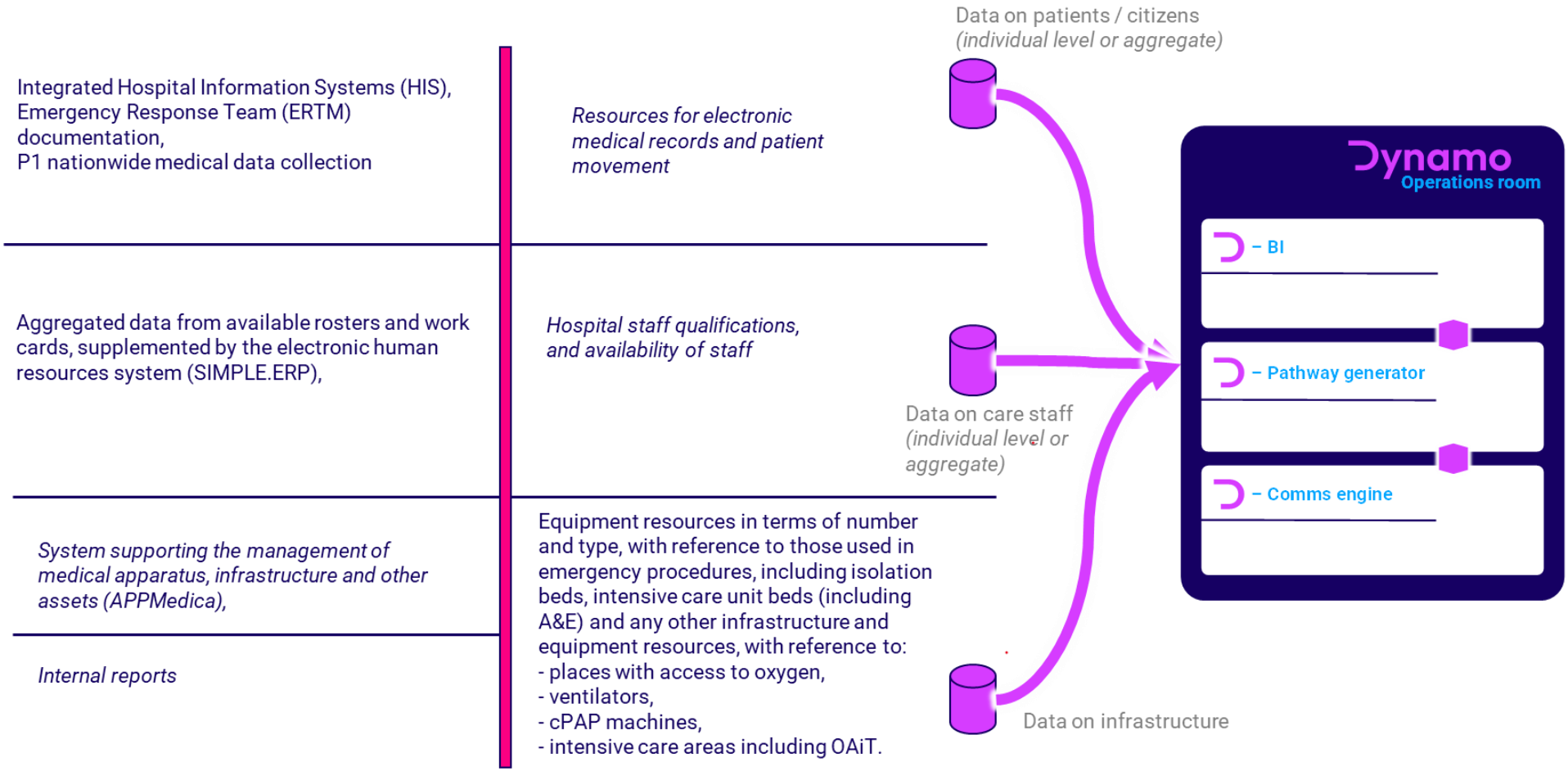

Figure 15 – Data sources and formats available in Olsztyn, PL

5.4.7 High-pressure scenario – Amadora

A pandemic can pose extreme danger for societies in general, since it presupposes the existence of an epidemic of a disease that is considered contagious, i.e., one that is transmitted through direct contact between people. In this way, a pandemic can escalate to a global level. As such, pandemics can have serious consequences at various levels, be it health, economic, social or the internal security of a country. In Amadora, a pandemic could present a significant challenge. Firstly, because it is the most densely populated region in Portugal. Secondly, because the region has worked hard and invested a lot on the mitigation of social exclusion and unequal access to services, which, with the arrival of a pandemic, would be negatively impacted. A phenomenon like this brings challenges to the civil society in its different sectors of activity and tests the resilience of a country and its structures to be able to maintain health and care services.

A significant change in the healthcare system is one of the obvious consequences in a pandemic situation. There is a frightening increase in the flow of patients in hospitals and clinics, causing an overload in these structures, which neither have the capacity nor are prepared to receive and care for such a large number of patients. Furthermore, such a situation could never rule out the existence of other patients with other health problems that are equally in need of attention and care. However, another likely scenario is also the decrease in appointments at hospitals and clinics, due to the fear caused by the pandemic, i.e., patients can be afraid to leave the house and go to the doctor due to the seriousness of the situation caused by the epidemic of a disease.

Another impacting aspect is the overload that falls on the health sector as far as health professionals are concerned. These professionals are already overburdened every day, but with this crisis scenario, they could possibly become ill and unavailable for work, leading to a crisis in the labour force available to care for patients.

As in any crisis, communication and financial issues are central to the debate. The health organisations responsible have to come forward and provide orientations and guidance on how to proceed onwards, what precautions and measures to take, and promote the dissemination of this information to all stakeholders. In this way, communication between organisations has to be proactive and assertive. With regard to financial issues, in a public health crisis, there will be further constraints on already overstretched services as it is necessary to invest in more medical equipment, more emergency/unplanned services and, perhaps, temporary physical infrastructures to cope with the large number of patients affected by the pandemic microorganism or because normal healthcare services are negatively impacted upon. These are all financial implications that, in a so-called "normal" situation, are not contemplated but are reallocated in crisis situations and can divert attention from other expenses and initiatives that are also needed.

When referring to the workload of health professionals, it is also worth considering the impact that a pandemic can have on the mental health of the general population. The fact that reality changes radically when a situation like this is faced, requires people to radically change their lives, forcing them to adapt their routines and habits, creating emotional distress that will later have repercussions. This can increase the number of cases of mental health problems related to anxiety and depression, which in the long term can become unsustainable.

With all these topics in consideration, it is crucial for a city like Amadora to have a guidance and a strategic plan that is capable of being implemented proactively in a pandemic crisis situation. The challenges that come with a pandemic must be tackled in coordination with health and social care systems, local communities, government agencies and other relevant stakeholders.

5.4.8 Use case description – Amadora

Starting point

Amadora's territory is located in the metropolitan area of Lisbon, and it is composed of 23.8 km^2 for a population of 175.558 inhabitants, being the region in Portugal with the highest demographic density. Amadora municipality is a living social laboratory, either in what concerns its physical characteristics as well in what regards the sociodemographic, sanitary and economic characteristics of the population. There is a high share of older adults living alone, 16000 people are unemployed, 30000 people have very low educational skills, and 35000 immigrants live in the municipality, corresponding to 20% of the total population.

This high-pressure scenario revolves around SCMA, a local Charity/NGO that provides services in 4 main areas: Health Care; Older Adults; Education; and Social Support. SCMA's services encompass 2 Day Care Centres, 4 Home Care Support Services, 2 Nursing Homes, an Assisted Residential Unit, an elementary school, 19 extra-curricular activities centres, a medical clinic, a long-term care unit for long dependant people and a social intervention team, reaching in average 6000 people daily. In what concerns the most critical groups, SCMA daily provides services to 1300 people with biopsychosocial vulnerabilities and 600 older adults.

SCMA has a strong network of local partners with whom the collaboration is very active such as the Municipality of Amadora, the Civil Protection, the Amadora public Healthcare Centres Cluster and several other end-user organisations providing health and social care services to the community.

Regarding safety measures or strategic plans in response to a pandemic SCMA launched, on March 5th, 2020, a first version of a Contingency Plan focussed on the COVID-19 pandemic. The Plan was updated several times over the following months, responding directly to the daily updated regulations published by the national Directorate General of Health and other entities that have a role in regulating the various activities of the communitarian Organisations.

SCMA plays a decisive role in meeting the critical needs of vulnerable populations, which is why its commitment and articulation with the guidelines and regulations of national, regional, and local health authorities are essential. All the managers/coordinators of SCMA's services play a fundamental role in supporting behaviour changes and the measures to be implemented, ensuring, on one hand, the interests and safety of the clients and, on the other, the safety of the employees, in a trusting and calm way.

In Portugal, the Directorate-General for Health (DGS) is the entity responsible for monitoring epidemiological situations and provides a set of guidelines and daily announcements in order to publicise the measures to be implemented in the containment stage, preventing social alarm, and actively informing the population. In its National Plan for Preparedness and Response to Disease, the DGS, as the national health authority, has defined three phases:

i. the preparation phase, when there are still no reported cases in Portugal, but there is a whole preparation for the eventuality.

ii. the response phase, where positive cases are already known in Portugal and different chains of transmission begin, which is a situation in which the Pandemic is already active in Portugal. With this in mind, the DGS decrees a State of Emergency and begins the containment and mitigation phase of the pandemic.

iii. and, lastly, the recovery phase whose purpose is to define what happens after the pandemic and how the recovery is envisaged to be.

Following the guidelines given by the General Directorate of Health, SCMA established a Crisis Office in order to provide an effective response to the various scenarios for COVID-19 pandemics. This Crisis Office was composed of seven members, chaired by the General Director, and comprehended the following professionals: the Health Coordinator, the Director of Infrastructures, the Responsible for Procurement, the Responsible for Office supplies, the

Director of Home care services and day care centres and the Director of the Nursing Homes for older adults. The Crisis Office met regularly during the whole duration of the pandemics as well as extraordinarily every time the necessity arose. This crisis office set off an enlarged and horizontal crisis management board, establishing an internal communication circuit, in terms of decision-making and coordination of human, financial and material resources to safeguard the wellbeing of the end-users, as well as an external communication circuit, whether with the media or with national, regional, and local authorities

Set up of the Local Modelling Group

The World Health Organisation has issued an alert about a possible variant of the virus that could escalate into a pandemic and enter Portugal, due to its severity and intensity. Following the WHO, the Portuguese Directorate-General for Health (DGS) reacted to this alert by establishing a set of guidelines and measures. SCMA's Health Coordinator receives this notification and immediately schedules an emergency meeting.

Building on the experience previously obtained during the COVID-19 pandemic and aligning with DYNAMO's scope, the former Crisis Office evolved to the creation and establishment of a Local Modelling Group (LMG), composed of SCMA's 7 internal members that were already part of the Crisis Office, as well as external members, representatives of the Amadora Municipality, Civil Protection, Public Healthcare Centres, and other organisations/NGOs from the local community. The involvement of these external representatives increases the support in the construction of measures to mitigate and contain the pandemic and allows for a more coordinated and sustainable response through the following critical dimensions:

- a regional perspective of the contextual dimension of the pandemic and the possibility to activate social contingency measures - Amadora Municipality
- a regional perspective of the impact and forecasting of the pandemic and emergency procedures to mitigate and contain the pandemic - Civil Protection
- a regional update on the number of cases, variety, and mitigation procedures - Public Health Care Centres
- benchmarking and mutual support between community Organisations that deal daily with the most vulnerable groups - Community Organisations/NGOs

The meeting seeks to gather more accurate data on the status of propagation of the virus, the resources available to mitigate and contain the spreading as well as establishing the role of each representative and respective organisations. The external representatives are expected to provide more specific information about the status and impact of the infection in Amadora, for example, where a higher incidence of cases is seen and what spaces have been created for the isolation of infected patients in hospitals and health centres, or even other spaces created for this purpose; on the mitigation and containment measures and procedures; as well as updating the status of the supplies chain for individual protective equipment (data to be provided by Civil Protection, Public Health Centres and Community Organisations). SCMA's internal representatives are then responsible for activating the necessary channels and implementing the necessary contingency measures/acquisitions according to the status reported.

This LMG meeting occurs in the Operations Room where the DYNAMO system and IT components are present. The external representatives who are part of this LMG and who join the DYNAMO system receive the necessary training to be able to work with this system.

DYNAMO Operations Room in operation

During the pandemic, the roles, and responsibilities of the different members of the LMG are defined, with the appointment of a Pathway Modelling Task Force and a Pathway Impact Modelling Task Force. Both teams were created according to the specificities and characteristics of the members of the LMG. The Pathway Modelling Task Force includes members such as the directors/technical coordinators of nursing homes, day care centres and homecare support services, the director of infrastructures, the responsible for office supplies, the responsible for the procurement, whose responsibility it is to model and adapt the current services to the new reality experienced, taking the necessary measures to mitigate against the impact of the pandemic, as well as the spread of the infection. The Pathway Impact Modelling Task Force includes members such as the Health Coordinator, with the support of the Public Health care Centres, Civil Protection and Amadora Municipality. This team will assess the impact of the measures already taken and whether redesigned care pathways are required to maintain business continuity as far as is possible.

All the members of these teams have access to the DYNAMO system 24/7, via a secure internet connection after registration, and communicate and interact online in order to quickly analyse the crisis situation, so that immediate decisions on maintaining as many existing care pathways can be made. Both the Pathway Modelling Task Force and the Pathway Impact Modelling Task Force have received the necessary training to be able to act and work with the DYNAMO system. It is through this system that these teams can access all the necessary data and information, which will lead to greater control of the crisis situation at hand.

The first cases of infection have been reported and the pandemic has reached SCMA, giving way to the activation of the DYNAMO system. The actions of the Pathway Modelling Task Force and the Pathway Impact Modelling Task Force begin, involving different levels of action.

a) End-users level:

- Number and variety of cases infected by the microorganism: It is necessary to understand the course of the pandemic in terms of the number of cases and their status, i.e., the number of infections in parallel with the number of deaths and hospitalisations. By identifying and understanding these figures, the response can be better targeted, pandemic monitored and managed, and this will facilitate activities designed to maintain delivery of as many routine health and care services as possible. Data and information to inform these activities can be provided through Public Health Centres' data systems (SClinico Platform) and through data shared by SCMA's databases and platforms as well as by the Civil protection and will be uploaded and/or entered into the DYNAMO system. The Pathway Impact Modelling Task Force will use this data and information to help in assessing which re-designed care pathways will be required.
- Identification of older adults groups that are clinically most vulnerable and those most at risk of contracting the infection: Identify which groups of older adults are most clinically vulnerable and at greatest risk of contracting the infection, using a set of defined criteria, such as age, clinical history of multiple chronic diseases, such as diabetes, cardiovascular diseases (hypertension and heart failure), chronic respiratory diseases (COPD), diseases of the immune system, oncological patients, and patients with co-morbidities. In addition, information about digital device ownership, e.g. mobile

phone or computer, will be identified to help inform decisions on redesigning the care pathways and maintaining business continuity as far as possible. The Pathway Modelling Task Force (in this case the technical directors of nursing homes, day care centres and home care support services) are responsible for gathering data on the most clinically vulnerable groups of older adults and those most at risk of infection through SCMA's internal systems like SINERGI and TSR – clinical component - and other sources of information such as databases. This information must be collated and uploaded into the DYNAMO system.

b) Organisational level

- Mapping of available staff and facilities and service needs at risk: Understand which services are most at risk, by analysing if their daily work is affected and if there is a possibility that they will not be able to carry out their daily activities due to the pandemic. For instance, these situations can occur due to a high number of infections in nursing homes, day care centres and homecare support services, with a low number of human resources available to respond, some of which may also be infected and no longer available to work. The complexity of treating infected patients may raise the need for new training for professionals to provide better and more appropriate care. Faced with this situation, appropriate measures are considered, such as the temporary hiring of new professionals, which can be done in partnership with the Public Health Centres (temporarily asking for the possibility to have the help of professionals from the Public Health Centres to respond to the high number of cases in nursing homes, day care centres and home care support services). In addition, adjusting the schedules of professionals who remain available and in good condition to work, in order to make the most of existing human resources, and not overburden professionals. Information on the availability of external professionals temporarily for hiring should be provided by the Public Health Centres, through internal human resources systems (Public Health Centres administrative system) and uploaded or entered into the DYNAMO system. With regard to adjusting the schedules of professionals, this data should be provided by the technical directors of nursing homes, day care centres and home support services and uploaded or entered into the DYNAMO system.
- Mapping of available resources and supplies: The materials and resources needed to mitigate the spread of the infection must be taken into account. To do this, it is necessary to survey the resources available to respond to infection situations, such as the number of beds available to isolate infected patients; the number of isolation rooms available in each service to isolate suspected or confirmed cases; the number of personal protective equipment available for professionals and patients; the number of medication available, if tele-monitoring and tele-consultation are possible to both supporting infected patients and maintaining business continuity services as far as is possible. In cases where the rooms and beds available are insufficient for the number of infected people, contacts are made with Civil Protection and the Public Health Centres, in order to find out if there are any isolation areas or zones created in Amadora, and if so, if they are available to receive SCMA patients. Information about the materials and resources needed and available should be collected by the technical directors of the nursing homes, day care centres and home support services (through internal systems SINERGi and TSR – administrative component - and other sources of information such as databases) and reported to the Responsible for Office Supplies

and to the Director of infrastructures, in order to provide the necessary material that is in short supply. Information about external isolation zones and areas should be collected from Civil Protection and Public Health Centres, through their internal data systems or other considered data systems. All this information must be uploaded or entered into the DYNAMO system.

c) Management Level

Based on the different levels of action and the course taken to mitigate the pandemic and the spread of the pandemic, the Pathway Impact Modelling Task Force (SCMA Health Coordinator, Public Health Centres and Civil protection) starts working by identifying a set of key variables for monitoring the impacts of the pandemics and to understand whether the redesigned care pathways need to be activated.

- Understanding of baseline population and their clinical needs (e.g. number of vulnerable users, evolution of users' general health status, level of digital connectedness, number of infections or hospitalisations due to the pandemic).
- Understanding of facilities and service needs (e.g., resources necessary to maintain the services and fulfil the tasks, in terms of the number of isolation rooms and beds available, alternative facilities).
- Understanding of skills and resourcing and ratio of these to the user population (minimum staff number per task, extra resources necessary or different skill sets due to users' needs).
- Mapping the changes in need and care provision over time and understanding the course of pandemic, as being aware of the status of the pandemic at all times helps to realise whether things are being done well, whether services are lacking something according to what is considered essential to have, whether there are measures that need to be reapplied or withdrawn.
- Identifying external resources required for care delivery and business continuity whenever necessary, due to complications that may arise as a result of the pandemic and to which the organisation's services are no longer able to respond on their own (e.g., lack of human resources or the increasing of sick leave can have a great impact on care delivery).
- Understanding wider impact on physical and mental health; understanding of financial limitations and financial planning.

Data on these variables is fed into the DYNAMO system and regularly updated, such as the number of high-risk users, the available human and material resources, the staff shortages due to infections and the available infrastructures (e.g., in case there are outbreaks which lead to services lockdown) either imported from the existing internal databases previously mentioned, and/or collated through paper-based records manually entered into the DYNAMO system via its user interface. Based on regular data updates, the pathway dashboard also provides several alerts, e.g., when detecting gaps in certain staff profiles or sets of skills; when the ratio of staff available versus the users in need is insufficient to ensure proper response capacity, or when problems resulting from illness require more specific treatment, raising the need for specific training, all of this according to pre-defined ratios and parameters fed into the system by the LMG. Through DYNAMO's communication engine the members of the LMG

involved in the care pathway can coordinate and continuously reassess its implementation and the resulting impact at both intra and interorganisational level.

When safety and hygiene measures are being correctly adopted and the number of cases is starting to decrease, it can be seen that the infectious disease is already stabilising, and life starts to get back to normal. All relevant activity and impact assessment reports are delivered by the respective task forces, and good practices and lessons learned are shared and fed into the DYNAMO system for future use, for ongoing improvement of the care pathway designed, following which the local DYNAMO Operations Room disbands.

5.4.9 Contextualized socio-technical process flow and data input – Amadora

Setup

- ✓ A Pandemic, resulting from an epidemic infectious disease, is declared by the World Health Organisation and the first cases entered the country
- ✓ The General Director convenes a meeting with the Crisis Office, that evolved into a Local Modelling Group.
- ✓ It includes representatives
  - Health Coordinator
  - Director of infrastructures
  - Responsible for Office Supplies
  - Responsible for the Procurement
  - Director of Home Care Services and Day Care Centres
  - Director of Nursing Homes
  - Amadora Municipality
  - Civil Protection
  - Public Healthcare Centres
  - Other Communitarian Organisations that provide care
- ✓ All receive access to DYNAMO
- ✓ All receive training by experts from Dynamo's project team

Planning

- ✓ The groups affected include the entire population, with specific priority given to clinically vulnerable populations.
- ✓ With representatives of the Local Modelling Group, a Pathway Modelling Task Forces and a Pathway Impact Modelling Task Force are created, having different levels of action:
  - **End-Users level**: Assessment of number and variety of cases; Identification of older adult groups that are clinically most vulnerable and those most at risk of contracting the infection.
  - **Organisational level**: Mapping of available staff and facilities and service needs at risk; Mapping of available resources and supplies;
  - **Management level:** Identification of key variables for monitoring the impacts of the pandemic and to understand whether the redesigned care pathways need to be activated
- ✓ Changes can happen rapidly, increasing the pressure over the systems, and so, regular and updated data must be provided to support in the (re)allocation of resources and measures.

Modelling

- ✓ The Pathway Impact Modelling Task Force identify a set of key variables for monitoring the impacts of the pandemics:
  - understanding of skills and resourcing and ratio of these to the user population;
  - understanding of clinical, facilities and service needs
  - mapping the changes in need and care provision over time and mapping the course of pandemic;
  - identifying external resources required for care delivery;
  - understanding wider impact on physical and mental health;
  - understanding of financial limitations and financial planning.
- ✓ Use this data to support services, avoid disruption, predict peaks in the number of infected people and the impact of the pandemic, and to understand whether the redesigned care pathways need to be activated.

Testing / Operation

- ✓ For testing:
  - The Pathway Impact Modelling Task Force convenes the Pathway Modelling Task Force for testing the model
  - Test layout and parameters are defined jointly by the Pathway Modelling Task Force and the Pathway Impact Modelling Task
  - The Pathway Modelling Task Force runs test with the Pathway Impact Modelling Task Force
  - The Pathway Impact Modelling Task Force rates test results in terms of system performance and approx. outcomes
- ✓ Real-life operation
  - The Pathway Impact Modelling Task Force instantiates pathway
  - Confirm use of DYNAMO and initiate
  - The Pathway Modelling Task Force operates pathway for required time
  - Continual review of outputs and monitoring by the Pathway Impact Modelling Task Force
  - Collection and sharing of good practices and lessons learned

Figure 16 – Contextualised DYNAMO process in Amadora, PT

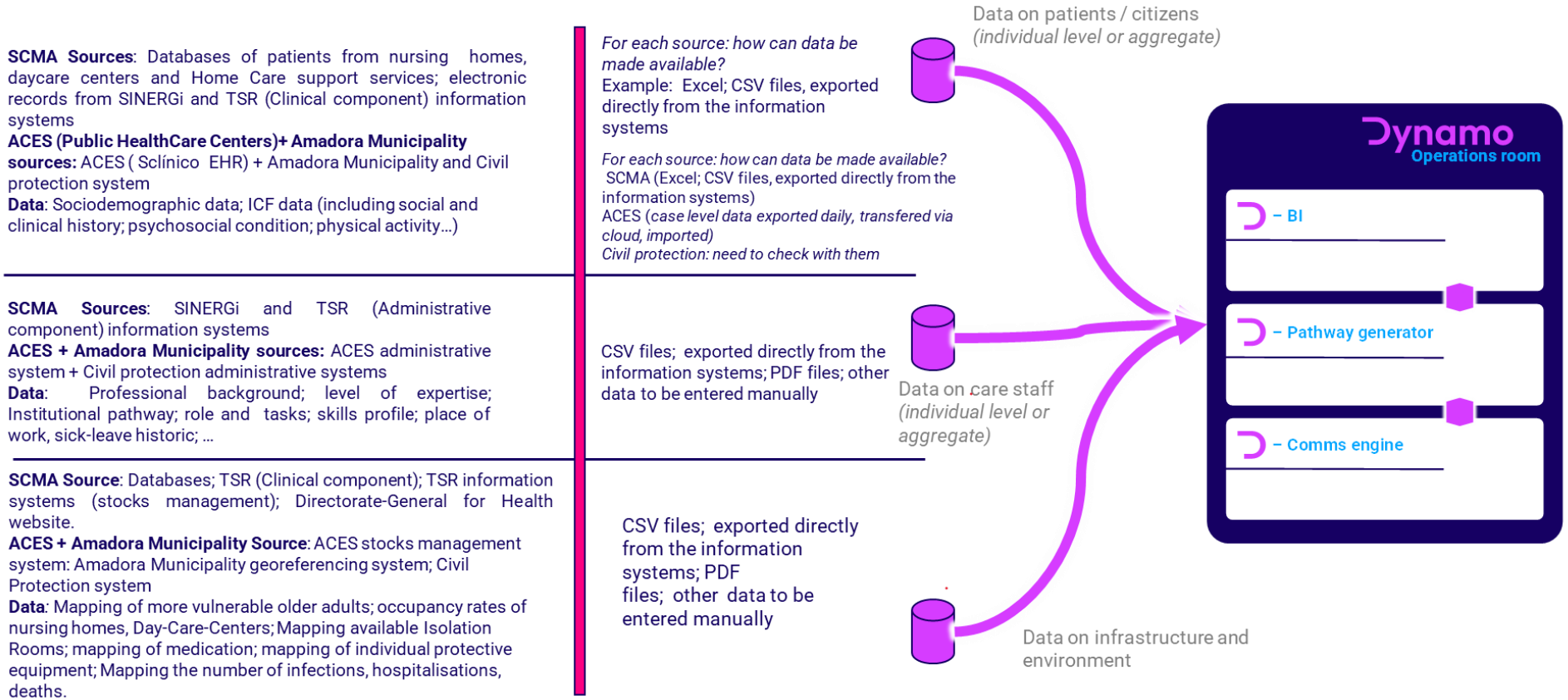

Figure 17 – Data sources and formats available in Amadora, PT

5.4.10 High-pressure scenario – Catalonia

Pandemic is a high-pressure scenario that cause one of the deeper and worst disruptions to the health systems operability. Firstly, the wide reach of a pandemic and the high number of people affected can result in the collapse of most health care providers. This fact has dramatic implications because patients infected by a new microorganism are added to those patients who also need care, treatment and support for other reasons and cannot manage without the healthcare services. Some examples of the latter could be oncologic patients, dialysis, those living with long term conditions as well as those with existing appointments for elective care such as diagnostics and surgery etc. In addition, we must be aware that other acute and emergency pathologies, e.g. stroke, cardiac arrest, accident trauma, will continue to appear during pandemics, and which require rapid attention because of their severity. The healthcare system needs to ensure an appropriate service for all of these kinds of patients. Therefore, it is essential to identify alternative pathways to re-allocate and follow-up all these patients either in the existing healthcare system, other facilities that can be converted to provide some healthcare services, e.g. hotels equipped with medical equipment and relevant clinical staff. or at home utilising digital health if necessary. Secondly, professionals dealing with patients can be susceptible to the new microorganism and get sick, reducing the number of professionals available. This situation will increase demand on resources and could compromise patient care irrespective of their pathology (e.g. infected patients, chronic patients, acute patients). Thirdly, pandemics are caused by new microorganisms or new strains of a microorganism that could have an unknown pathogeny, virulence, transmission, resistances to environment and treatments, mutation rates, population who is more vulnerable, etc. Therefore, in addition to the delivery of healthcare services it is crucial to update any relevant information that must be shared with professionals.

As it has been commented above, one of the main issues to deal with during a pandemic is the increasing demand on resources, both human and material assets. It is highly recommended to have re-designed pathways to facilitate the continuing delivery of healthcare services and support for as many patients as possible. These re-designed pathways and re-allocation of patients will need to take into account the following points: severity of patients, vulnerable status of patients, and re-designed pathways and distribution that avoid transmission chains. It is essential to plan for this eventuality in advance and to have a tool to facilitate the re-allocation of patients efficiently and quickly. In addition, telemedicine/teleconsultation technologies should be made available to provide remote consultations and monitoring for patients who have less severe pathologies and could remain at home. As these situations are not static, a tool is required for the continuously monitoring and adjustment of the re-location of patients according to their changeable health status (basically, severity and vulnerability).

Human resources are also compromised during a pandemic. On the one hand, the increasing demand above mentioned requires higher number of professionals. On the other hand, as professionals could get sick, the number of available professionals decrease. To address this, it is necessary to have information on all health professionals who work at the different care delivery settings that are able to manage patients or to be trained in their care and management. Additionally, information about clinical trainees, e.g. medicine, nursing, pharmacy, allied health professionals; biomedicine, etc. will be required as these people could add value to the workforce resources if necessary.

In the same way, health and care supplies could be a great issue during a pandemic. As many countries experience an increasing demand from patients, the supply chain could be internationally affected. Treatments, vaccines (if there were any), laboratory materials (since diagnosis test to tubes…), individual/personal protection equipment (IPE/PPE), etc. could be scarce and providers could run out of the supplies. Although this issue could mainly affect the materials required for patients infected by the new microorganisms, the management of the

whole patients can be compromised by a shortage. Therefore, it is necessary to identify new international markets and suppliers and carry out a coordinated acquisition of supplies by all medical centres of Catalonia. When providers' stocks are running out, the person in charge would introduce an alert into DYNAMO that should be sent to all centres and health managers. The latter would search for new suppliers. This information should be entered into DYNAMO and transmitted information to all centres.

In the course and management of a pandemic, identification of positive cases as well as identification of the most vulnerable populations at risk are key activities. Concerning the identification of cases, proper and fast identification of cases is crucial for the recovery and survival of patients. From a healthcare system point of view, quick case identification is directly related to break transmission chains and thus, decrease the number of new cases, which is strongly related with a reduction of the stress on health system, and this fact is one of the goals of this use case. For this reason, laboratories from the territory must be able to carry out diagnosis techniques without delay. However, clinical laboratory capacities are compromised during a pandemic because of lack of staff, consumables, and inventories. This fact also affects laboratory activity related to other diseases. Therefore, it is necessary to have alternative laboratory pathways, in order to assure laboratory capacities, whatever diseases and conditions the whole system will be required to respond to. In a geographical area, there are other laboratories, such as research labs, that could be included in the network of laboratories of support. For this, it will be necessary to certify their technical capabilities. The data and information relating to laboratory capacity inputted into the DYNAMO system will assist in determining where patients' samples can be re-allocated and at what time point will to other capacity, e.g. research laboratories, need to be activated. Redesigned laboratory service pathways will only relate to pandemic microorganism. If other laboratories, e.g. research laboratories, will support the pandemic microorganism diagnosis, pressure on clinical laboratory will decrease and they can continue with pandemic microorganism diagnosis without stopping any of other services offered.

Regarding vulnerable populations, (such as immunosuppressed individuals, elderly, new-borns, oncology, etc.) telemedicine could be an appropriate technology to monitor their health status without the need for them to be seen in a healthcare centre. Therefore, a tool that helps to identify the patients who could benefit from such technologies is detailed below. This fact has two direct benefits: it minimises the risk of the vulnerable population being infected and reduces stress on healthcare system. In addition, telemedicine would be the tool to provide them preventive measures as well as to detect if they are infected as soon as possible.

Because of the uncertainty generated by the lack of knowledge and experience, one of the fundamental activities during a pandemic is the communication. Effective communication is essential among authorities and different professionals. There are different sources of knowledge during a pandemic. 1) Public health professionals are continuously preparing and updating guidelines and guidance related to case identification, rules for the declaration of cases to professionals who are monitoring the pandemic, transmission, individual protection equipment, management of additional workload, management of deceased, etc. Related to this information, authorities make decisions that must be known quickly by all the staff involved. 2) Other source of knowledge is that generated by experts. During a pandemic, different groups of experts are established. For instance, experts on diagnosis, experts on patient management, or experts on the most frequent clinical manifestations, etc. These groups discuss new therapies, diagnosis methods and, if it is necessary, they perform or lead some studies before the decision-making. 3) Communication should also include all the knowledge and learning generated at the point-of-care by the professionals that deal daily with patients and their diagnoses. For example, during COVID professionals who took care of patients were trying different patients' stances to find those that allow patients to breathe better. All professionals must take advantage of this knowledge as quickly as possible. 4) Researchers work hard studying the new microorganisms and thus, every new data obtained, no matter how small, should be effectively shared. 5) Researchers, public health professionals

and health professionals are in contact with international knowledge through institutions as WHO (World Health Organization) or research publications, and, thus, this kind of knowledge should be also shared. Therefore, a tool that can facilitate quick, accurate, and effective communication of information to the members of the planning commission (named local modelling group (LMG) in this document) who can then cascade the message to relevant professionals in all care delivery settings would provide great value in such a situation.

To conclude, to ensure as many healthcare services are able to be continued in the event of a pandemic, a highly coordinated approach of multiple aspects and a multi-centre, multidisciplinary and multi-sectorial is required. From the healthcare system perspective, management at regional level is needed. The whole healthcare system is a net of care delivery nodes/centres that are likely to have different levels of pressure according to their scope of practice. This pressure concerns different issues such as patient demands/system capacity, lack of material resources, workforce availability, knowledge communication etc. The local modelling group (LMG), supported by different executive commissions, must deal with these pressures and plan different pathways. In the following section, it is detailed how DYNAMO could be helpful to deal with some of these issues.

Additionally, the ability of DYNAMO to receive information and learning relating to actions carried out in response to the pandemic could be useful for healthcare managers to evaluate the crisis response as a whole and determine what has worked well and not so well, for example. This analysis could be extremely useful for future crises. For that reason, information storage is considered in the following sections.

5.4.11 Use case description – Catalonia

Starting point

The scenario revolves around Catalonia. We had previously received an alert from WHO (World Health Organization) about a new pandemic. A few Catalan hospitals have declared having diagnosed the first cases.

Set up of the Local Modelling Group

In advance of a pandemic being announced, there are a number of actions required to set up the DYNAMO system ready for activation as follows:

Planning Commission (PC) established.

PCs representing two different organisational levels are constituted; high level managing PC (mPC) and lower-level executive Planning commissions (ePC). The mPC will interact directly with DYNAMO and become the Local Modelling Group (LMG) and be responsible for decision making. As the mPC will be responsible for a wide range of issues, it will be supported by different ePCs.

The mPC membership will include the Health assistance director, medical emergency and ambulance manager, health resource planners, bioethics professional, advocacy professional, IT, communications professional and procurement personnel of Health Department, public health professionals, geographical areas health directors, and 1-2 representatives of different professionals for geographical areas (e.g. medical professionals, nurses, researchers, pharmaceuticals, communications professional from hospitals, faculties deans), one member of the associations of medicine, nursing, laboratory, etc; and one member of each commission of experts that could be created during pandemic. Their contact information will need to be entered into the DYNAMO system and they will require user training. Contact information will include name, charge/responsibility, professional e-mail, and professional phone. This information should be updated if there are any changes related to group membership. DYNAMO must assure a confidential and fast 24/7 communication channel among members of PC (virtual operations room).

ePCs are different groups of professionals according to the task/challenge they are addressing. The leader of each ePC is also a member of the mPC and these leaders are responsible for communicating any information from the mPC to the ePCs members or vice versa. Some examples:

- Clinical ePC comprising at least one clinical professional of each healthcare delivery centre
- Nursing ePC constituted by at least one nurse of each healthcare delivery centre
- Research ePC constituted by at least one researcher of each research centre of Catalonia
- IT ePC constituted by at least one IT of each healthcare delivery centre
- Pharmaceutical ePC constituted by at least one pharmaceutical of each healthcare delivery centre
- Laboratory ePC constituted by at least one laboratory staff of each public and private clinical laboratory of Catalonia
- Procurement ePC constituted by at least one procurement staff of each healthcare delivery and research centre
- University deans, constituted by all faculty deans of Medicine, Biomedicine, Biology,…
- …

Capacity available: For each care delivery node/centre, the following information must be available into DYNAMO. This information could be obtained during DYNAMO set up both from centre registers/patient administration systems and from mPC members with the support of ePCs and periodically updated:

- Health centres (hospitals, mental centres, primary centres, specialized centres,…), clinical laboratories:
    - Maximum beds available and number of consultations/appointments it can provide
    - ICU beds and emergency room: maximum capacity, ventilators
    - Day hospitals: number, type, maximum capacity
    - Pharmacy: maximum demand it could assume
    - Laboratory and image diagnosis: maximum number of diagnoses they can assume
    - Number of ambulances and stretcher-bearers available.
    - Average number of vulnerable patients (immunosuppressed people, oncological patients, patients with co-morbidities,…) that they provide services to each month. This information is crucial to forecast how many telemedicine tools could be required in case of pandemic. The mPC will establish a minimum percentage of vulnerable populations per node/centre who should be provided with telemedicine tools. If a node/centre cannot get this minimum percentage, mPC, with the help of DYNAMO, will act as it is explained below.

  The mPC (LMG) will agree and populate the DYNAMO system with appropriate maximum capacity and capability thresholds (alert thresholds) for the above aspects of care delivery and its resource for the whole healthcare system. During a pandemic, actions will be initiated when one or more of these aspects of care delivery are close to reaching or have reached their respective threshold as it is explained in following sections.

- Research centres:

- Name, address, contact, and if they research into infectious diseases/microbiology
- Main inventory and materials
- Number of workers (staff, post-docs, pre-docs, technicians) and percentage of workers with skills in microbiological techniques.
- If they have biosafety 3 laboratories

- Other buildings/centres (Inventory of possible places where patients could be allocated if healthcare delivery centres are overloaded. For example, hotels, pavilions,…):
  - Name, address, personnel in charge, capacity, personnel, type of severity of patients who can be admitted.
- Universities
  - Name, address, dean, median number of students of last courses a year.

Material and Suppliers:

The mPC, supported by ePCs, should define a catalogue of materials and suppliers of centre/nodes, which should be entered into DYNAMO. (which types of materials the centre uses and the number of materials optimal for the capacity of the centre).

Initial reaction

Planning commission: As soon as WHO sends an alert the Health assistance director convenes mPC through DYNAMO to explain that the region should be aware of the occurrence of cases. mPC through ePCs expand this alert to all professionals. When cases are detected in Catalonia, Health assistance director convenes mPC through DYNAMO and pandemic management to activate the monitoring and re-designed care pathways is initiated. During the pandemic, mPC meet daily (once or twice, regularity will be according to mPC decision), and when any kind of alert enters to DYNAMO. The alerts are explained in the following sections.

DYNAMO Operations Room in operation

Patient management:

During the pandemic, with help of DYNAMO, the LMG will monitor the following information (capacities/demand for each care delivery node/centre): beds, primary care and community consultations, ICU and emergency. Capacity items related information will be obtained and uploaded into the DYNAMO tool periodically (regularity will be according to mPC decision). This information will be exported on a periodically (regularity will be according to mPC decision) basis from registers/patient administration systems of nodes/centres. Where such data is not available from an electronic data holding system, ePCs will generate the required information on a periodically (regularity will be according to mPC decision) in a commonly used format, e.g. as an Excel file.

As mentioned above, healthcare systems manage patients with a whole range of conditions and needs, who will require ongoing health care no matter their pathology and should ensure they receive appropriate and timely healthcare services. Therefore, the patient management of this section will comprise all kinds of patient.

mPC (LMG) had established a threshold of percentage of maximum capacity of the whole health system for each healthcare system capacity item (named “alert thresholds” in this document).

Two situations can be envisaged:

1. Capacity items of the whole health system were lower than the alert thresholds, and one centre became overwhelmed regarding one of the capacity items. The overwhelmed centre director should introduce an alert into DYNAMO, which LMG members will receive immediately. LMG will meet and have access to monitoring data of DYNAMO of the whole net of nodes. Then, the LMG will designs an alternative referral pathway for distributing the patients to other health care centres, thereby taking into account information available from the DYNAMO dashboard indicating available capacity. By means of an automatically generated message from DYNAMO, the LMG alternative care process pathway is communicated to all health care delivery centres concerned.
2. One or more capacity items of the whole health system exceeds the alert thresholds. DYNAMO will automatically send an alert to the mPC who meet immediately. The mPC will review data of the inventory of possible places where patients could be allocated (e.g. hotels, pavillions,…). The mPC will choose the best centres or environments to relocate patients in the region according to severity of patients (UCI > hospital beds > other centres $\geq$ home). Personnel in charge of new centres will join the mPC. If it is decided that patients with the lowest severity were to be looked after at home, telemedicine tools should be made available in the healthcare delivery centres where patients receive services. The data manager and health professionals of the healthcare centres of the areas of this "home-patients" will be responsible to make available these telemedicine tools. DYNAMO only will record which and how many tools have been provided to each healthcare node/centre. When any new node is added, it will be monitored and managed in relation to the issues of the following sections (material and procurement, staff, etc.) in the same way that any healthcare centre is.

DYNAMO should create an alert if one of the healthcare systems capacity items return to levels lower thresholds or a previous overwhelmed centre returns to normality. This alert will be received by the mPC who will determine next steps, which could be to maintain the current pathways or to return to "normal" practice (not applying the alternative care process pathway). The mPC always has the final decision. Any decision concerning this issue should be entered into DYNAMO.

DYNAMO should document the number of alerts generated during the pandemic, type of issue, and how they have been resolved: any pathway that the mPC has decided, date of decision, number of patients moved (the emitting and receiving centres), telemedicine tools available for each centre, evolution of the monitoring data during pandemic, etc.

Material and Procurement:

During the pandemic, with help of DYNAMO, the LMG will monitor any kind of materials for the management of patients, laboratory diagnosis and IPE as well as treatments. This information will be exported periodically (regularity will be according to mPC decision) and based on data from registers/patient administration systems of nodes/centres. Where such data is not available from an electronic data holding system, ePCs will generate the required information periodically (regularity will be according to mPC decision) in a commonly used format, e.g. as an Excel file.

Two situations can be envisaged:

1. One node/centre has a shortage of material/treatments. An alert should be entered into DYNAMO by the lead of the procurement ePC, and the mPC will access the materials monitoring data and decide what the best way to distribute materials from one node/centre to another is. By means of an automatically generated message, DYNAMO will communicate information to the LMG about the alternative pathway so that it can be communicated to all health care nodes/centres concerned.

2. Suppliers of materials/treatments run out. The lead of the procurement ePC will enter an alert into DYNAMO, which mPC members will receive immediately. The mPC and procurement ePC will search for new suppliers. DYNAMO will be updated with the new supplier information and, by means of an automatically generated message, will communicate to all health care nodes/centres concerned.

In Catalonia, each node/centre is usually responsible for procuring their own materials. However, in front of a crisis, procurement personnel of the Health Department can centralise the procurement activity for the whole healthcare system. If the mPC take this decision, DYNAMO should enter this decision and, by means of an automatically generated message, will communicate it to all health care nodes/centres concerned.

DYNAMO should create an alert if the above critical situation reverted. This alert will be received by mPC, who decide the next steps, and these will be entered into DYNAMO. Any decision concerning this issue should also be entered into DYNAMO.

DYNAMO should document the number of alerts generated during the pandemic, type of issue, any decision that the mPC has agreed to, date of decision, suppliers that run out of materials, new suppliers, centres/nodes that run out materials, new materials, evolution of the monitoring data during pandemic, etc.

Staff:

During the pandemic, with help from the DYNAMO system, the LMG will monitor staff (both clinical and laboratory). This will include staff capacity and staff demands of every node/ centre, laboratory, and patients' point of care. This information will be exported periodically (regularity will be according to mPC decision) basis from registers/patient administration systems of nodes/centres. Where such data is not available from electronic data holding systems, an assigned members of the ePCs concerned will generate the required information periodically (regularity will be according to mPC decision) in a commonly used format, e.g. as an Excel file.

Two situations can be envisaged:

1. The demand of one centre exceeded its staff capacities. The centre director should introduce an alert into DYNAMO, which mPC members will receive immediately. mPC will meet and have access to staff monitoring data of DYNAMO in order to re-distribute human resources.
2. Staff capacity of the whole health system is lower than demand. DYNAMO will enable and send a call for staff and students to associations and faculties of medicine, nursing, biology… The mPC will decide which association and/or faculty to send the communication call to dependent on staff required. An email request is distributed through the DYNAMO communication component to those relevant associations and faculties that the mPC had agreed to send to.

DYNAMO should create an alert if healthcare centre staff capacity return to levels lower than demand. This alert will be received by the mPC who will agree the next steps. The latter could be to maintain the current pathways or return to "normal" practice (not applying the alternative care process pathway). The mPC will always have the final decision. Any decision concerning this issue should be entered into DYNAMO.

DYNAMO should document the number of alerts generated during the pandemic, type of issue, and how they have been solved: any decision that the mPC has agreed to, date of decision, number of staff moved (the emitting and receiving centres), training of moved staff, type of staff (doctors, nurses,…) period in which new staff is working in a centre, evolution of the monitoring data during pandemic....

Laboratory:

During the pandemic, with help of DYNAMO, the LMG will monitor the laboratory activities (capacity and demand). This information will be exported periodically (regularity will be according to mPC decision) basis from registers/patient administration systems of nodes/centres. Where such data is not available from electronic data holding systems, members of the ePC concerned will generate the required information periodically (regularity will be according to mPC decision) in a commonly used format, e.g. as an Excel file.

Two situations can be envisaged:

1. The demand of one healthcare laboratory close to exceeding its capacity. The centre director will enter an alert into DYNAMO, which mPC members will receive immediately. The mPC will meet and have access to the laboratory monitoring data of DYNAMO in order to distribute patients' samples to other nodes/centres. The mPC, supported by laboratory ePC, will decide which available healthcare laboratory to send samples. By means of an automatically generated message of DYNAMO, the LMG communicates the redesigned sample distribution pathway to all health care nodes/centres and laboratories concerned.
2. The whole Catalan clinical laboratory capacity is overwhelmed. DYNAMO will enable a call communication to research centres to be sent and this will incorporate diagnosis of pandemic cases to their portfolio. The mPC will decide which centre will be incorporated considering its ability to perform a homologated technique. and subsequently communicate the adapted pathway to the health nodes/centres concerned by means of the DYNAMO communication component.

DYNAMO should create an alert if laboratory capacity return to levels lower than demand. This alert will be received by the mPC who will decide next steps. The latter could be to maintain the current pathways or to return to "normal" practice (not applying the alternative care process pathway). The mPC always has the final decision. Any decision concerning this issue should be entered into DYNAMO.

DYNAMO should document the number of alerts generated during the pandemic, type of issue, any decision that mPC has agreed, date of decision, number of samples moved, sending and receiver nodes/centres, research centres incorporated and date of incorporation, clinical staff who are validating data from research centres, number of centres that answer each call, percentage of them that are homologated, percentage of them that are finally incorporated in the net of laboratories, data of incorporation, period of incorporation, evolution of the monitoring data during pandemic, etc.

Vulnerable populations:

During the pandemic, with the help of DYNAMO, the LMG will monitor vulnerable populations and telemedicine resources deployed and available. In addition to classical vulnerable populations such as such immunosuppress individuals, elderly, new-borns, oncology, etc.; a new vulnerable population could be identified during the pandemic by clinical staff or researchers. If this occurs, the mPC could agree to incorporate this new group of susceptible people to the monitoring and management. Data from each node/centre that should be monitored will be: number of vulnerable people, number of vulnerable people followed periodically by telemedicine, number and data of preventable measures sent to them, number of pandemic cases with vulnerable populations, number of vulnerable people who get ill. This information will be exported periodically (regularity will be according to mPC decision) basis from registers/patient administration systems of nodes/centres. Where such data is not available from electronic data holding systems, an assigned member of the ePCs concerned will generate the required information in a commonly used format, e.g. as an Excel file.

As mentioned above, the mPC had established a minimum percentage of vulnerable populations per node/centre who should be provided with telemedicine tools. If a centre

cannot get this minimum percentage, DYNAMO will send an alert, which mPC members will receive immediately. The mPC will decide whether to provide more telemedicine tools to the centre either by procuring new telemedicines resources or re-distributing telemedicine resources among centres.

DYNAMO should document the number of alerts generated during the pandemic, type of issue, any decision that mPC has agreed, date of decision, number and type of new resources incorporated or distributed, and to which centres they are distributed, evolution of the monitoring data during pandemic,etc.

Knowledge:

As it is mentioned in detail in "Health care challenge: Pandemic" section, source of knowledge and learning could be public health reports, guidelines, research reports and articles, point-of-care observations, commission of experts' reports, and the like.

Knowledge should be updated to DYNAMO either as note, cite (with link) or as a completed publication.

Member of the ePCs, in contact with professionals who generate new knowledge should be aware of any new interesting data (public health reports, guidelines, research reports and articles, point-of-care observations, commission of experts' reports,…) generated and, then, report information to their leaders of their ePC. The later will introduce this information to DYNAMO, which will be like a repository. Every time that knowledge was updated into DYNAMO, DYNAMO should send an advice to all mPC members. Members of mPC will transmit information to ePCs members using DYNAMO, and ePC members will be in charge of the transmission to the professionals of the whole net of nodes.

As part of knowledge could be provided by the different commissions of experts established during the pandemic, whenever a new commission was created, one of their members should join to mPC in order to be able to communicate any new knowledge that this commission could generate.

5.4.12 Contextualized socio-technical process flow and data input – Catalonia

Setup

- ✓ World Health Organization alerted about a new pandemic. First cases have just been diagnosed in Catalonia.
- ✓ The planning commission: 1) managing PC-mPC (interact with DYNAMO [LMG]) 2) some executive PCs - ePC
- ✓ mPC include reps from
  - Main health facilities
  - Medical Emergency and ambulance services
  - Universities, research centres
  - Health Resource Planning
  - IT /Communication / advocacy / bioethics
  - Professional association
  - Experts commissions
  - ePC
- ✓ ePC includes groups of different kind of professionals who support mPC
- ✓ mPC members receive access to DYNAMO, and training

Planning

- ✓ Inventory of services either health centres, research centres, universities or other centres
- ✓ Inventory of material and suppliers for the whole of centres. Alternative suppliers
- ✓ alternate services and procedures to derivate activity or obtain staff from (research centres, universities...) Possibilities to increment capacity moving resources (technical and human) or patients from one centre to another centre
- ✓ Pathway to access to alternate services and resources required
- ✓ Aggregated data of vulnerable population for supply them with telemedicine tools for their follow-up
- ✓ Criticality categorization of patients affected by the microorganism according their severity in order to distribute them (UCI > hospital beds > other centres ≥ home)
- ✓ Communication channels for the whole of professionals and facilities

Modelling

- ✓ Calculations include:
- Centres demand and capacities evolution
- Sensibility of queue and capacity calculations depending on demand variability
- Mapping of affected patients according their severity and evolution of their location.
- Services evolution based on alternate resources usage for different criticality levels of patients
- Services and material consumption and temporal evolution based on discharge expectation
- Mapping of material suppliers and evolution.
- Telemedicine tools capacity and demand evolution for follow-up vulnerable population and for take care at home of patients with less severity
- ✓ Definition of communication channels and tools selected to interact among professionals

Testing / Operation

- ✓ For testing
  - ✓ Mayor convenes testing board
  - ✓ Testing board defines test layout and parameters
  - ✓ Testing board runs test with the planning commission
  - ✓ Testing board rates test results in terms of system performance and approx. outcomes
  - ✓ Develop test scenarios based on historical data
- ✓ Real-life operation
  - ✓ Mayor convenes planning commission
  - ✓ Planning commission instantiates pathway
  - ✓ Planning commission operates pathway for required time
  - ✓ Retrospective analysis is performed

Figure 18 – Contextualised DYNAMO process in Catalonia, ES

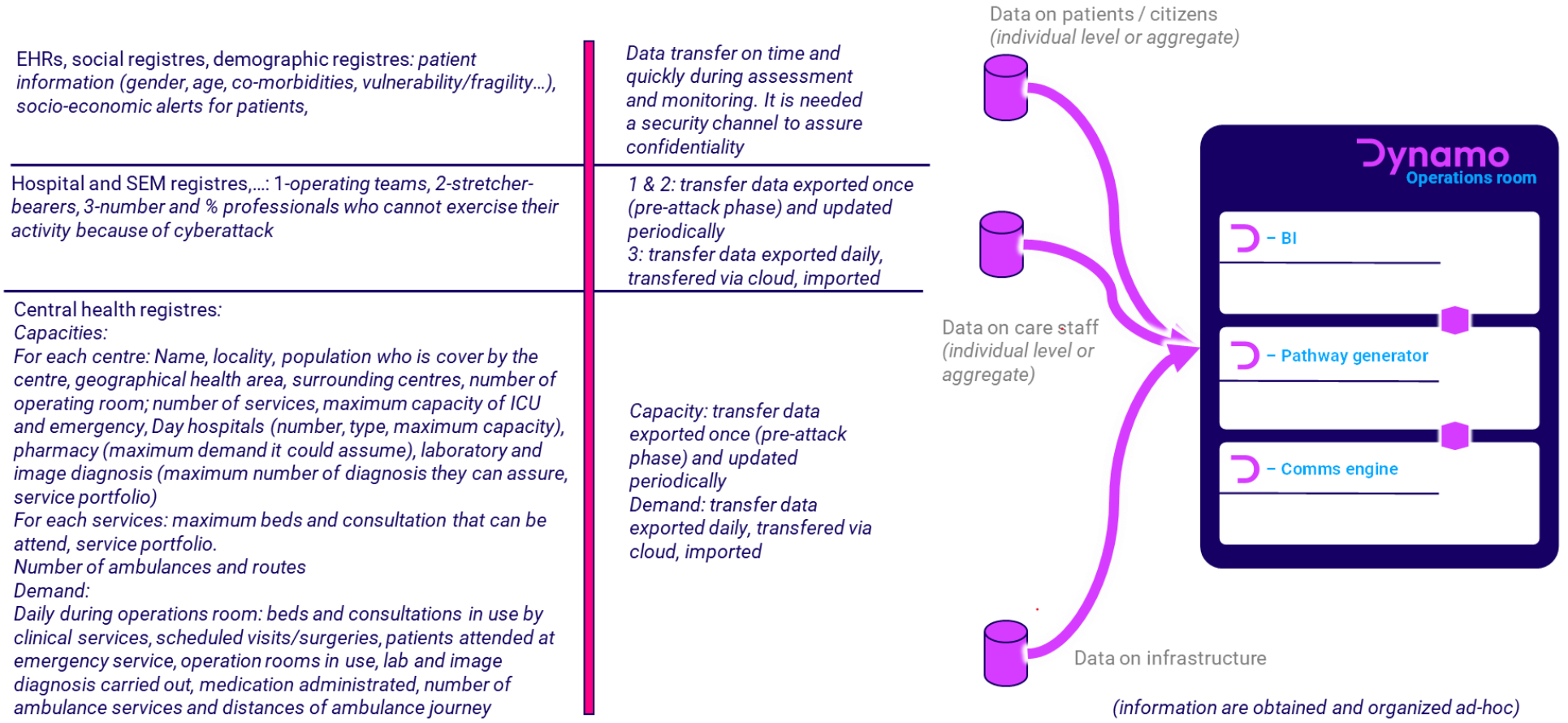

Figure 19 – Data sources and formats available in Catalonia, ES

5.5 Use cases - Power failure / black out

5.5.1 High-pressure scenario – Olsztyn

This use case revolves around the Warmian-Masurian Lung Disease Centre (WMCCP) in Olsztyn. The Olsztyn subregion's high-voltage electricity network operates in a closed system. This system affects the security of electricity supply to consumers. The technical condition of the above-mentioned substations and power lines is assessed by the operator as “medium”. Therefore, according to the Olsztyn subregion's development strategy and to ensure the reliability of electricity supply and its appropriate quality parameters, the existing networks are being successively modernised, including the installation of new power equipment and optimised network operation systems in accordance with an established schedule. In 2022, in the north-eastern part of the sub-region, power outages caused by sudden climatic phenomena (e.g. gales, intense snowfall, icing on transmission networks) resulted in a power outage of several days. The length of the outage was influenced, among other things, by the geographical conditions of the wooded areas, numerous lakes, but also by the average technical condition of the entire infrastructure, including a low-voltage ground installation supplying individual consumers.

The lack of electricity represents a significant and high-pressure scenario for health and care systems in every region, including the Olsztyn subregion. The healthcare system will face many challenges in the event of a prolonged power outage. Hospitals, outpatient clinics and care homes may experience an influx of patients who require electricity to power the oxygen therapy equipment that enables them to breathe. Also, a lack of electricity can lead to several events related to proper lung ventilation and can contribute to the exacerbation of many comorbidities or be life-threatening.

The geographical location and demography of the Olsztyn sub-region have a negative impact on the situation. The area is dispersed with many rural areas, far from medical centres, where access to health care services varies. Moreover, the system itself is characterised by low accessibility to advanced diagnostics, including pulmonology, and specialised treatment of respiratory diseases. The logistical challenges associated with providing oxygen therapy in a situation of limited or no power supply will result in an influx of patients in the first instance to specialised centres equipped with generators, providing pulmonology physicians, of which the Lung Centre is one. Emergencies associated with power outages will also affect the emotional state and high stress levels of patients receiving home treatment with oxygen therapy equipment through the insecurity of the therapy.

The efficiency of the response to this crisis will be positively influenced by the Centre's long-standing experience in cooperating with public institutions in the field of crisis management (the Crisis Management Centre at the Governor's Office) and the cooperation with the entity running the Centre, which is a Local Government Unit (Marshal's Office). The Centre's knowledge of the patients using the oxygen therapy equipment, based, among other things, on data from its own medical records, will also have an impact on efficiency.

Patients with chronic obstructive respiratory diseases will burden the system in such a crisis scenario, in particular breathing disorders in patients requiring oxygen therapy with oxygen concentrators or ventilators. These individuals will require, in addition to the provision of electricity and oxygen, rapid intervention additionally ensuring a comprehensive approach to their health problems.

Communication and trust among other public institutions is also important. This includes the Centre's cooperation with related health authorities viz:

- National Health Fund
- Provincial Office
- Marshal's Office

In addition, cooperation with the Provincial Crisis Management Centre and the local media will improve the flow of up-to-date and thus valuable information. This will make it possible to act in an organised and less chaotic manner, which will again minimise panic and ensure that decision-makers take appropriate preventive measures.

In summary, the occurrence of a potential problem of power supply curtailment or cessation over an extended period, although local in nature, will significantly affect the need to reorganise resources to mitigate this emergency within the Centre's structure. In the Olsztyn sub-region, characterised by low accessibility to specialised treatment including oxygen therapy and with the possibility of in-depth diagnostics and complex treatment, the Centre will assume the role of a focal point directly responding to the situation.

5.5.2 Use case description - Olsztyn

Starting point

The starting point for the activation of the DYNAMO use case scenario is the confirmation of an emergency (e.g. an alert from the Government Security Centre about anticipated power outages exceeding 48h or an increased influx of patients), and the need to initiate the procedure to respond to an influx of patients requiring respiratory support with oxygen therapy equipment. The scenario refers to the possibility of ensuring that enough oxygen therapy devices are connected to electricity and oxygen sockets, in the event of a power outage at the Centre and the activation of the generators. The generators will ensure the operation of DYNAMO.

The LMG will consist of the following persons and representatives of the institutions:

- Director
- Deputy directors (director of medical affairs, director of nursing, director of technical affairs)
- Director of the security and crisis management unit
- Head of organisation section
- head of IT team
- Emergency room doctor
- Main specialist
- Epidemiological nurse.
- Representative of the Health Department of the Marshal's Office - advisory vote
- President of the Association of Hospitals of Warmia and Mazury - advisory vote

The Centre has procedures in place in the event of a mass event and suspicion / confirmation of a particularly dangerous infectious disease and a bioterrorist attack. The procedures are based on legal acts:

- Act of 05.12.2008 on prevention and control of infections and infectious diseases in humans
- Instruction for the Centre's crisis team according to the procedure "Proceedings in case of a multiple, mass event and cooperation with emergency services."

The provisions contained in these documents oblige the Centre to notify:

- Provincial Emergency Medical Services Coordinator
- Air Ambulance

- The District Sanitary and Epidemiological Station
- Nursing homes and other medical facilities
- Police and Fire Brigade
- Regional Security Centre
- Warmińsko-Mazurskie Voivodeship Crisis Management Centre.

Set up of the Local Modelling Group

The Director of the Centre appoints and directs the LMG and assigns tasks to the individual members of the group. The purpose of the LMG is to support the Team Leader in making the most effective decisions during emergencies and to resolve them by establishing response patterns based on pathways accepted by all members. As such, operational leaders will work with clear strategic goals and objectives to achieve these goals. In particular, the LMG:

- monitors the smooth implementation of the pathways on an ongoing basis.
- liaises with overarching institutions authorised to manage a crisis at national and regional level.
- coordinates the flow of information outside and inside the Centre.
- exercises overall control over resources ensuring that they are sufficiently available to achieve the strategic objectives set.
- develops scenarios that consider long-term resource implications - human resources, infrastructure, equipment, and materials.

The members of the LMG carry out the designated tasks through their own actions and by delegating tasks to subordinate staff. The Chair of the LMG is responsible for organising the training of all LMG members. Based on ICT (Information and Communication Technology) solutions, a virtual operations room will be set up using the DYNAMO support mechanism. DYNAMO will have a supporting function to the systems currently used by hospital staff, such as:

- CGM CliniNet
- SIMPLE.ERP
- Zoom communication tools or MS Teams

When the Centre's Director or Medical Director receives information about a random event, e.g., an alert from the Government Security Centre about predicted power outages exceeding 48h or in the event of an influx of increased numbers of patients (an emergency situation, without prejudice from the power company or government services), he or she will trigger the DYNAMO mechanism, which will first notify (e-mail/sms) all LMG members. The extent of the data available to the DYNAMO system will be determined by the LMG.

DYNAMO Operations Room in operation

All LMG members gain 24/7 access to the DYNAMO mechanism via a secure internet connection. Once an emergency is identified (prolonged power outage) and the DYNAMO solution is activated, full planning begins to assess the problem and its consequences for patients and residents in the region. A switchover of the hospital to generator power takes place. The procedure considers the change in the need for medical services for which electrically powered medical equipment is required, such as CT scanner, x-ray, ultrasound and video bronchoscope. Redundant electrical equipment will be switched off and treatments will be rescheduled to take account of the current situation in the hospital. It will be necessary to

monitor and provide fuel to keep the genset running without interruption. Patients not requiring continuous care, e.g. those in rehabilitation, will be discharged to free up beds.

The LMG will carefully define the ranges of data relevant and necessary for the diagnosis and treatment of admitted patients. In a scenario involving a planned, prolonged power outage, the DYNAMO system will send out information to the Centre's patients receiving home oxygen treatment (the Centre's base) who live in the area affected by the incident about the power outage and about the possibility of reporting to the designated locations: the nearest hospital, WMCCP or going to the nearest location where power is available. The text message will instruct people to take their oxygen concentrators with them. In a life-threatening situation, haste causes chaotic behaviour.

In this emergency scenario, assuming an increased number of patients presenting to the Centre due to the need to secure oxygen therapy including those already under the care of the Centre and others who are not being treated at WMCCP, we expect the appearance of people who are experiencing shortness of breath under stress, and their presentation to the Emergency Room may be due to psychosomatic reasons. In this case, the Centre notifies cooperating institutions of an increased influx of patients.

Patients arriving at the Reception Room are subjected to segregation, carried out by the medical staff (nurse and paramedic). As part of this, vital parameters are assessed, with particular emphasis on saturation and the consequent urgency of connection to an oxygen and electricity source. Other parameters determined by the doctor of the Emergency Room, resulting from the general condition of the patients examined, are also taken into account. Based on this division, visual signage is divided into four basic groups:

1. requiring immediate assistance - red colour
2. requiring urgent assistance - yellow
3. requiring deferred assistance - green
4. patients without prognosis - black

Based on the segregation data, DYNAMO notifies the LMG, which initiates the procedure for managing hospital beds, staff and resources and determines alternative treatment regimens depending on the number of patients. The medical staff of the Emergency Room initiates the procedure related to the crisis event. Based on all this data in relation to all arriving patients, the staff of the Emergency Room segregates patients according to the internal procedure.

The members of the LMG will also decide on the need to increase the number of staff. If additional staff is required, the DYNAMO system will send a notification to the group of medical staff indicated by the LMG (data from the SIMPLE system - availability of staff with the necessary qualifications) about the need to support the staff of the Admission Chamber and/or to notify the Crisis Management Centre. Also, the DYNAMO system will send a message via e-mail/sms to other hospitals/medical facilities/primary care facilities from the Olsztyn subregion with a request for support.

In the case of a large number of patients with varying levels of hypoxia require medical interventions, the medical director heading the LMG in cooperation with the technical director will set aside rooms for those who require electricity, e.g. by converting a rehabilitation ward, the lecture room or an exercise room into a room with access to electricity for several people.

When the oxygen supply reaches a critical level (information based on the number of patients admitted and their oxygen consumption, e.g. 60% utilisation), the DYNAMO system will send an alert to LMG members about the situation. The LMG members then choose the appropriate course of action, e.g. notifying the Crisis Management Staff of low oxygen levels in the Centre. The Staff then activates the strategic reserves and transfers the necessary oxygen to the Centre.

At the same time, the fuel supply to the genset is monitored. When 50% of the fuel is depleted, the DYNAMO system will send an alert to LMG members about the situation. The LMG members then choose the appropriate course of action, e.g. ordering more fuel from the Crisis Staff's strategic reserves and/or requesting the transfer of an additional genset.

5.5.3 Contextualized socio-technical process flow and data input - Olsztyn

Setup

- ✓ Power supply failure for an extended period due to a sudden event
- ✓ Establishment of the LMG - the Director of the Center appoints and directs the LMG and assigns tasks to individual members of the group
- ✓ The group includes a representative of the Marshal's Office overseeing the smooth operation of health care in the province, the Director of the Department of Security and Crisis Management, a representative of the Provincial Office, the President of the Association of Hospitals of Warmia and Mazury (brings together all hospitals in the province); medical director; technical director; director of nursing; IT manager; project manager; chief specialist; emergency room doctor; epidemiological nurse
- ✓ The chairman/deputy chairman of the LMG organizes training for group members and conducts it

Planning

- ✓ Residents of the Olsztyn sub-region with diagnosed respiratory disorders who have had their power supply interrupted or whose power transmission system has failed- separation of a subgroup of people requiring home oxygen treatment, with whom the hospital has signed contracts for the lease of oxygen concentrators
- ✓ Dynamo sends a message to patients receiving oxygen therapy at the Centre about the possibility of reporting to the Centre or the nearest treatment facility. At the same time, Dynamo sends information to primary care physicians, specialist clinics about the possibilities of the Centre in securing home oxygen therapy patients who are not patients of the Centre daily.
- ✓ Admissions of patients presenting for dyspnoea and oxygen-related reasons: Patient triage and two options: admitting patients to released hospital wards or locating patients in dedicated special rooms e.g. lecture theatre.
- ✓ In the case of higher logistical capacity, also patients from the Olsztyn subregion not included in the Centre's medical registers- segregation, in which vital parameters are assessed, with particular emphasis on saturation and the resulting urgency of connection to an oxygen and electricity source. Other parameters resulting from the general condition of the patients examined are also considered. Based on this division, visual signs are divided into four basic groups:
  1. requiring immediate assistance - red colour
  2. requiring urgent assistance – yellow
  3. requiring deferred assistance – green
  4. patients without prognosis – black
- ✓ Input update; number of concentrator leases signed; number of oxygen therapy admissions from crisis intervention
- ✓ Possibilities to allocate the remaining needy in additional alternative rooms
- ✓ On-going estimation of number of patients according to allocation possibilities
- ✓ Management of vacant oxygen therapy positions
- ✓ Cooperation with the external environment within the LMG to meet needs outside the Dynamo area of influence

Modelling

- ✓ Construction of a calculation model for the following steps:
  1. development of evidence-based criteria characterising the clinical condition of the oxygen therapy patient (patient triage)
  2. development of a solution that generates a report containing data on bed and room occupancy, staff and equipment resources, and oxygen and generator fuel resources.
  3. compilation of statistical data for pathway restart modelling to recruit more patients

Testing / Operation

- ✓ The Director of the Centre convenes the LMG and initiates the crisis testing procedure
- ✓ Centre's staff begin activities assigned to them during LMG configuration
- ✓ Development of a test report for internal reorganisation on infrastructure and staff resources.

Figure 20 – Contextualised DYNAMO process in Olsztyn, PL

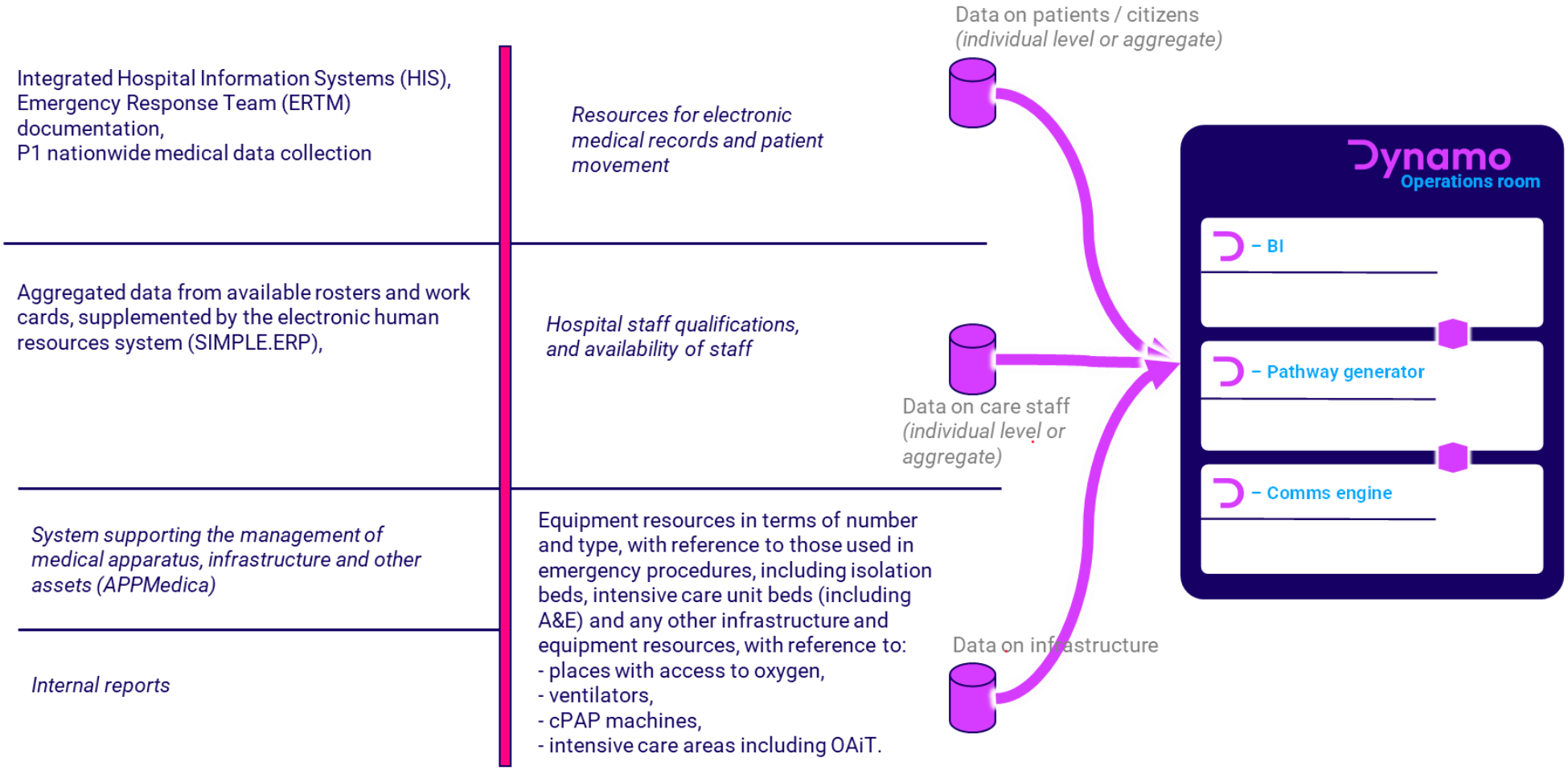

Figure 21 – Data sources and formats available in Olsztyn, PL

5.6 Use cases – Staff shortage

5.6.1 High-pressure scenario – Treviso

The scenario revolves around ISRAA, the largest provider of care services to older people in the wider area of Treviso. Overall, the public organization operates four residential care homes, 21 home care units throughout the region and one dementia care centre. In their daily work, ISRAA staff often interact with other health care providers, such as the regional health authority, several hospitals and a variety of general practitioners and specialist doctors.

One day (or for several days), the organisation experiences a critical shortage of staff, caused by a combination of factors predominately exogenous to the organisation, such as seasonal influences, strikes, roadblocks, earthquakes, effects of new pandemics, etc.

Under these conditions, one or more care units lack the minimum number of workers capable of going on duty and providing essential services to the patients. In particular, the most critical shifts are the afternoon and night shifts, in which there is already a small number of people usually rostered.

Moreover, home care services provided to other municipalities are affected as well. In particular, the most critical shifts in this case are afternoon and weekend shifts. Given that the service is provided by staff using cars for visiting patients in their home, road accidents are the main cause of delays or lack of staff.

5.6.2 Use case description – Treviso

Starting point

The scenario revolves around ISRAA, the largest provider of care services to older people in the wider area of Treviso. Overall, the public organization operates four residential care homes, 21 home care units throughout the region and one dementia care centre. In their daily work, ISRAA staff often interact with other health care providers, such as the regional health authority, several hospitals and a variety of general practitioners and specialist doctors.

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Moreover, home care services provided to other municipalities are affected as well. In particular, the most critical shifts in this case are afternoon and weekend shifts. Given that the service is provided by staff using cars for visiting patients in their home, road accidents are the main cause of delays or lack of staff.

Set up of the Local Modelling Group

ISRAA convenes a meeting of the DYNAMO Modelling Group (LMG) which is chaired by the general director. Permanent MG members include the HR manager, the chief of the security and safety service, four nursing home coordinators, 21 care unit coordinators, home care service coordinators. As per existing planning, the LMG sets up a virtual operations room with help of the DYNAMO system. Beyond the permanent members of the DYNAMO LMG, further stakeholders are invited to join the temporary DYNAMO Operations Room in order to cover the missing profiles and to ensure the provision of the essential services at least. They include representatives of social services of the municipalities where home care services are provided,

who are in charge of deciding whether a home service can be suspended or what the priorities should be.

DYNAMO Operations Room in operation

All permanent and temporary members of the LMG are granted 24/7 access to the DYNAMO system via a secure internet connection after successful registration and the group interacts online in order to rapidly analyse the situation and make decisions. Different roles and responsibilities are agreed upon, including the nomination of a Pathway Modelling Task Force and a Pathway Impact Modelling Task Force. Both task forces are chaired by ISRAA staff who had received specific training on care pathway modelling and impact modelling when the DYNAMO solution was procured.

Immediately, the Pathway Modelling Task Force contacts the Care Units' Coordinators or Home Care Coordinators in order to understand how many people are not able to take up service and their location, what kind of profiles are missing, what services are affected and how many people are needed to cover the absent staff. Specific protocols are activated according to the service affected: procedures for residential care are different from home care procedures and coordinators are different as well.

First of all, priority of presence according to staff type and specific services' needs are identified: the priority is given to those providing essential and primary care such as healthcare staff, followed by speech therapists, physiotherapists and educators. Each group has specific duties and skills and cannot act in other roles according to regulations for specific tasks.

Lack of external staff such as nurses is also identified and taken into account. However, according to specific regulation, the external company assigned with the task of providing nursing staff is solely responsible for the substitution of absent staff.

Duties to be performed are prioritised based on patients' conditions. DYNAMO identifies what units are the most affected and in need to be covered according to type of patients, based on patients' care unit's internal health records. Following already existing protocols for mitigation of staff shortages, specific "Work Plans" are applied, in order to understand what services are essential and what can be reduced or suspended, based on levels of severity of staff shortage, type of patients and patients' conditions and care unites affected.

The first thing to do in order to cover absent staff as quickly as possible is to contact staff off duty and to start recalling them to work. First, staff who has already been at home for more than one day is convened to work. Second, those with at least one day of rest and lastly those who just went off duty. In doing so, a number of elements are taken into consideration: days off already done, at least 11 hours of rest between one service and the other, any kind of limitation in performing the duty (such as physical limitations), specific skills required, number of previous recalls to work.

DYNAMO connects care units' coordinators' inputs and Zucchetti Infinity software, an HR management tool for programming, managing and reporting the HR working in each ISRAA units and office departments. Its functionalities are mainly to report, from each line manager, the number of employees' working hours, the day off, the extra working hours and other elements related to the contract, that automatically feed the employer's electronic records needed to calculate the payment criteria according to the national contract in force. Moreover, it connects to the home care services management system (UnoDo.MO software).

From this, DYNAMO selects from a list of possible names to recall back to work and suggests the Pathway Modelling Task Force who can be contacted according to identified needs and place of work. The system also provides information on the required actions to be performed to the covering staff and training (tutorials, protocols, other) in real time and extremely customized on the existing knowledge gap between the person and the new task required (Example: healthcare staff normally used in units for elderly people who are not self-sufficient lucid with functional limitations reallocated in a unit for people with dementia). The matching tracks also of any limitations and prescriptions, by the occupational physician, that might limit that human resource's operational scenarios.

Based on variables defined by the LMG, DYNAMO provides a system of warning and alert of absent human resources and staff to allocate to specific services, including a list of people on leave to contact that must return to work and a calculation of order of call, taking into consideration days of leave, hours previously work, skills and tasks. When it comes to the onboarding in the target care unit and preparation of colleagues and host team, DYNAMO identifies a possible a tutor who explain logistics, supplies and anything related and modalities of "end of emergency" and re-entry of resources in the care units/workplaces of origin, as defined by the LMG.

Data on these variables is fed into the DYNAMO system and regularly updated. Some data, such as staff profiles, roles and skills, place of work, shifts, sick-leave status, vacation are imported regularly from care unit's internal staff record system and database. Other data are staff shortage emergency procedures, services to be reduced (no. of showers and other non-essential actions for patients, etc) that are imported manually by nursing homes coordinators, nurses, care staff and people are contacted via telephone calls and related information are subsequently exported manually via user interface. It is possible to know where they are located in real time as they clock in and out from work.

Using the DYNAMO comms engine, messages to different care units' coordinators, home care coordinators and previously mentioned external stakeholders are generated and sent-off, appraising them of situation updates and informing them what staff need to be deployed and where profiles with specific skills need to be sent.

After monitoring updated dashboard figures and specific dashboard alerts for a certain time, the Pathway Modelling Task Force notices that all the essential and primary services are covered but still it is not possible to ensure the provision of all the services as usual despite measures taken so far. They decide to revise the initially defined pathway by adding the names of people working in other care facilities within ISRAA. The comms engine contacts the care unit coordinator of the new care facility involved asking for a list of workers available for covering the needed services. The number and qualifications of the new staff members is entered into the system. The pathway is updated accordingly, and care unit's coordinator receives a generated message instructing him/her to reallocate the selected staff as established from the defined time.

With this last round of calls, the staff shortage emergency seems to be subsiding and the provision of services starts to operate in full. As soon as all the services are covered thanks to the reallocation of resources, the DYNAMO Operations Room produces a report of all its activities over the last couple of days and then disbands.

5.6.3 Contextualized socio-technical process flow and data input – Treviso

Setup

- ✓ Peaks of staff shortages resulting from causes that are predominantly exogenous to the organization: seasonal influences, road blocks, earthquakes, effects of new pandemics, etc. Under these conditions, one or more care units would be without the minimum number of health workers capable of taking service. In particular, the most critical shifts are the afternoon and night shifts, in which there is already a small number of people scheduled.
- ✓ The planning commission is convened and it includes:
- ✓ General director
- ✓ HR manager
- ✓ Chief of the security and safety service
- ✓ Nursing home coordinators (4)
- ✓ Care units' coordinators (21)
- ✓ Home care service coordinators
- ✓ The group interacts online in order to rapidly analyse the situation and make a decision.
- ✓ Access to DYNAMO should be possible 24 hours a day, also via mobile devices (smartphones).

Planning

- ✓ Different type of services: home care vs residential care.
- ✓ Staff type and priority of presence: healthcare staff, educators, physiotherapists, etc. Each group has specific duties and skills and can not act in other roles according to regulations.
- ✓ External personnel (like nurses)'s shifts are managed externally and the company must always provide substitution on its own when needed.
- ✓ Prioritise duties according to patients' conditions. Application of specific "Work Plans" based on levels of staff shortage: some services might be suspended.
- ✓ Options on who to reallocate and where taking into account the required operating environment. The system could also provide information/ training (tutorials, protocols, other) in real time and extremely customized on the existing knowledge gap between the person and the new task required (Example: healthcare staff normally used in units for elderly people who are not self-sufficient lucid with functional limitations reallocated in a unit for people with dementia). The matching should also automate the tracking of any limitations and prescriptions, that can limit operational scenarios.
- ✓ For home care: involvement of representatives of social services of municipalities responsible for deciding what services need to be prioritized.

Modelling

- ✓ Decision on the reallocation of human resources or suspension of services, according to actual availability of staff as established by the existing Work Plans.
- ✓ System of warning and alerts for people involved about staff unable to go on duty, services to be prioritized, services to be suspended, etc.
- ✓ List of names of those on leave to contact that must return to work. Calculation of order of call, taking into consideration days of leave, hours previously work, skills and tasks.
- ✓ Onboarding in the target care unit and preparation of colleagues and host team: possible identification of a tutor, who explains logistics, supplies, anything else related.
- ✓ Definition of the modalities of "end of emergency" and re-entry of resources in the care units/workplaces of origin.

Testing / Operation

- ✓ For testing: interface for model datasets for test scenarios.
- ✓ General director and planning commission convene testing board for testing the model.
- ✓ Model testing run with planning commission.
- ✓ Results and outcomes are evaluated according to specific parameters and target achievements.
- ✓ Real-life operation:
- ✓ Planning commission is convened
- ✓ Confirm use of DYNAMO and initate.

Figure 22 – Contextualised DYNAMO process in Treviso, IT

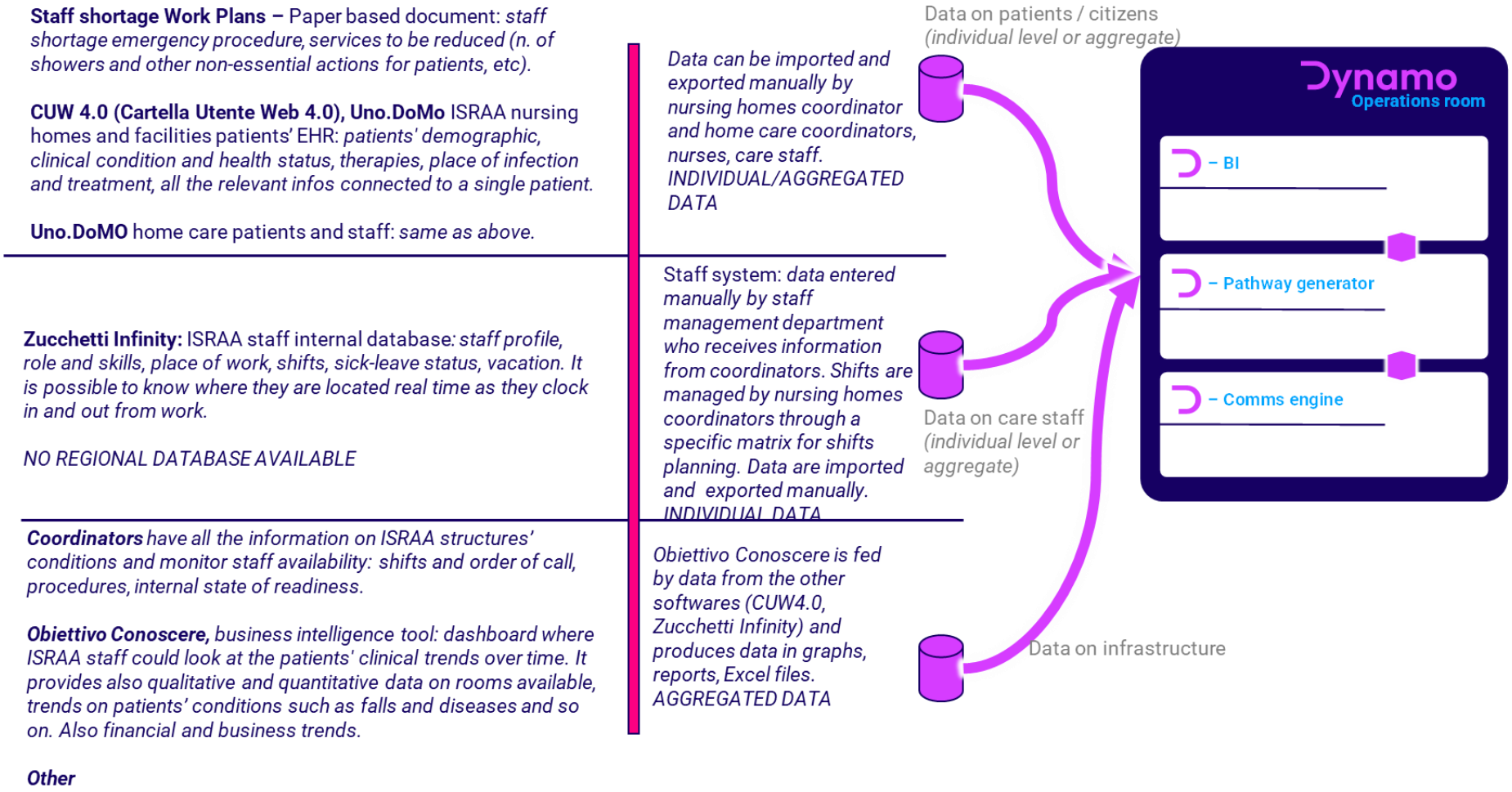

Figure 23 – Data sources and formats available in Treviso, IT

6 The DYNAMO Change Management Framework

The DYNAMO solution is expected to empower the participating Procurers and Associated Partner to better respond to emerging crisis situations with the goal to flexibly adapt the way health and other services are usually provided within their area of responsibility. The DYNAMO solution will be innovative by providing a lean and powerful solution that enables quick, data-driven, and platform-independent planning of care pathways for situations where health system functions are threatened by pandemics, natural disasters, and other crises. As a strategic planning tool, the system to be newly developed should be capable of effectively guiding the evidence-based modelling of crisis pathways across different health sectors and adjacent public service domains.

As an innovative key feature, the DYNAMO solution will support care pathway planning and assessment across prevailing Organisational and sectoral service boundaries. Under day-to-day conditions, the technology to be procured will, however, not be utilised within an Organisational vacuum. Rather, it will be applied within local multi-stakeholder ecosystems, which, in turn, may vary in composition from site to site. The inherent properties of the new technology by themselves will thus not lead to better multi-stakeholder response to a crisis. In fact, the desired outputs and related impacts summarised in the figure below can usually not be delivered by the new technology solution alone but by socio-technical systems relying upon innovative technology.

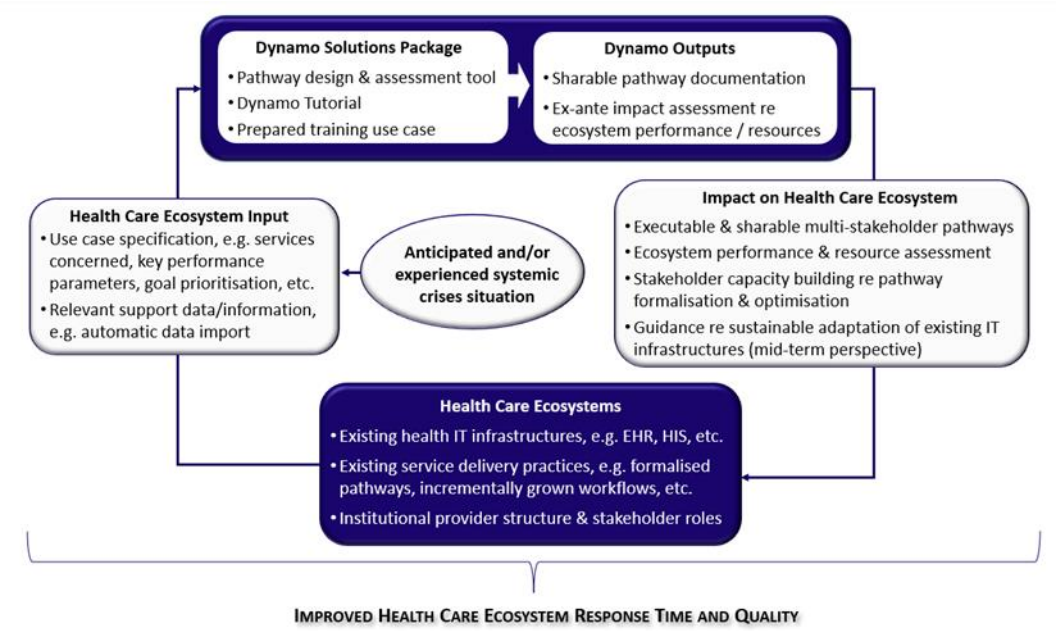

Figure 24 - Outputs and related impacts of DYNAMO solution

In a socio-technical system, output generation incorporates a number of elements in addition to technology, in particular specific roles played by a range of staff with appropriate qualifications that apply technology for the purposes of generating desired outputs. This does not exclude that in some cases, the generation of desired outputs can occur almost entirely automatically. Here overall outputs and automatically generated outputs are close to identical. Even for fully automated output generation, the wider socio-technical system is however never completely absent. Where there is an Organisation with responsibility for the automated output generation, Organisational processes are always necessary, if not for acquiring data, then for maintaining and updating software.

Applying the new DYNAMO digital solution in a real-world setting will therefore require the Organisations involved to adapt current working practices and to change the way they have collaborated with each other in the past, if they did at all. The DYNAMO co-creation approach described in the previous chapters will therefore be augmented by a change management approach that enables the local stakeholder ecosystems at the individual sites to make purposeful use of the new technology solution to be procured. Specifically, change management in DYNAMO will concern two core elements:

- A multi-stakeholder service pathway design and assessment, which represents a new activity at all sites, especially when it comes to cross-organisational and cross-sectoral pathway modelling.
- A multi-stakeholder modelling group will be established at each site.

The members of each modelling group will receive training and advice on how to apply the new DYNAMO technology solution for the purposes of dynamic service pathway design and assessment in relation to specific high-pressure scenarios to be simulated at each procurement site.

6.1 Basic principles

Overall, the training measures to be developed will be inspired by a set of generic change management axioms:

Axiom 1 – Creating a clear vision

A vision should be ambitious, concrete, action-orientated and inspiring. A clear vision will increase not only collaboration level, but it will invite meaning and sense-making into the Organisation. The DYNAMO consortium has been working from scratch on the definition of a clear vision that encompasses the design and development of a strategic planning tool suitable to guide relevant stakeholders in concept development, data modelling, process design and implementation planning. More specifically, the vision is to ultimately put in place at each site a cross-organisational, socio-technical system enabling each site to:

- Efficiently adapt service delivery processes to shocks and structural changes;
- Share and integrate cross-sectoral data to accurately forecast outcomes and impacts of alternative pathway configurations;
- Facilitate task planning and skills matching in times of crises.

During the first months of the project, this generic vision will be further developed by means of a set of high-pressure scenarios, with a view to enabling the DYNAMO Procurers and Associated Partner to effectively respond to possible crisis situations. The change management framework will ensure that a common DYNAMO vision is equally understood by the individual stakeholders involved at a given site, and across different national/regional stakeholder ecosystems represented through the DYNAMO business group.

Axiom 2 – Trust in leadership

Establishing trust among stakeholders from varied professional backgrounds and different organisations and sectors is pivotal for change management as teams venture into unfamiliar terrain under their organisation's guidance. Employees invest their trust in leaders whom they believe possess the competence, goodwill, and honesty to achieve a favourable result. In an organisation, an environment characterised by trust and fairness not only enhances adaptability and performance but also fosters a psychologically secure space for employees to express themselves and innovate. This is particularly important when integrating a new technical system in existing organisational infrastructures. The DYNAMO change management strategy will focus not only on cultivating trust through transparent and equitable

leadership within individual procurement entities but also among the various stakeholder organisations anticipated to work together in applying the DYNAMO solution during potential crisis scenarios.

Axiom 3 – Supervisory support

Experiences from successfully managed transformation processes suggest that the monitoring of performance against a goal rather than setting the goal itself is the key to motivation and transformation. Supervisors who demonstrate they value an employee's contribution, and they care about their well-being can create a psychologically safe environment for feedback. Supervisory support is the tipping point between the success and failure of a change initiative. Employees are more positive towards change when they can see how their small, isolated change fits within the context of an overall strategic narrative of their Organisation. When it comes to cross-organisational collaboration practices, the establishment of inter-organisational feedback loops has a similar effect when it comes to the different Organisations involved. The DYNAMO approach to change management therefore aims to provide supervisory support and appropriate feedback loops at the level of individual Organisations involved in project activities, as well as across multiple Organisations participating in DYNAMO activities at each site.

Axiom 4 – Setting clear goals

In an environment where change is constant, Organisations should focus on setting challenging and specific development goals rather than performance goals or ability demonstration. Employees with learning goals have a higher need for achievement. They will seize opportunities to change because they are more likely to be intrinsically motivated, task interested, agreeable and conscientious. Here again, the DYNAMO change management approach will be directed towards setting clear development goals, both at the level of individual Organisations and at the level of relevant multi-stakeholder ecosystems collaborating at each site.

6.2 Operational Planning and Implementation

A dedicated work task (T1.6) starting in project month seven will focus on the transposition of the basic principles outlined above into an operational change management framework and related implementation measures, and their subsequent implementation at all sites. Within the project duration, the co-development and piloting of the DYNAMO prototype system relate to a set of high-pressure scenarios anticipated by the Procurers and Associated Partner. For practical and ethical reasons, the DYNAMO prototype system cannot be co-developed and piloted in the framework of real-world crises events. Therefore, simulation techniques will be applied in the framework of the DYNAMO project. In line with the Handbook on simulation exercises in the EU published by the European Centre for Disaster Prevention and Control (ECDC), a set of core elements to be addressed by operational change management activities can be identified at this stage already. At the current stage of the project, these are briefly summarised in the following paragraphs.

Foundation

As part of the project's change management work strand, Procurers and Associated Partner will be supported in carrying out the tasks that must be completed to provide the foundation for an effective and successful simulation exercise concerning the utilisation of the DYNAMO solution. At this early stage, primarily administrative steps for the envisaged simulation exercise are addressed. Issues deserving attention at an early stage should focus on selected key elements such as preliminary resources planning and priority setting in terms of identifying those capabilities most critical for accomplishing those aims and objectives that relate to the specific high-pressure scenario to be simulated.

Design and development

Building on a solid foundation of the simulation exercise as outlined above, a further step deserving attention from a change management angle concerns the more detailed conceptual and processual design of the envisaged simulation exercise. This starts with the agreement of clear and unambiguous operational objectives such a cross-organisational exercise should have among the different stakeholders involved. Such operational objectives may vary from site to site, depending on the specific high-pressure scenario to be simulated in each case. Having a few, well defined objectives for each high-pressure scenario will ensure commitment from the different stakeholders to be involved in the modelling group at each site. Achieving consensus on scenario-based operational objectives may require setting up a joint reflection process addressing diverse issues from a multi-stakeholder perspective, for example, anticipatable capacity building requirements and desired improvements of current practices.

Logistics and documentation

Care must be taken to ensure that the logistics required for the simulation exercise are put in place in a timely manner. This relates in the first instance to the availability of the DYNAMO prototype system for practical simulation activities at each site. The DYNAMO solutions package is envisaged to comprise of a pathway modelling and assessment tool, a user tutorial and several prepared training cases. A data manager to be appointed by each modelling group will identify all data required to be fed into the modelling process. These may either be available from electronic data holding systems (EHR, HIS, etc) or in other formats, e.g., on paper from publications or other sources. Where the required input data is not available, it can also be generated by means of surveys, expert interviews, workshops, or other data gathering techniques. The data manager will be responsible for staging and ingesting the required data into the DYNAMO solution during the logistics preparation stage. Beyond this, any other materials and facilities required for successfully conducting the scenario-based simulation exercise will be determined. An appropriate documentation format will be agreed upon as well. Evaluation planning (T 7.3) should go hand-in-hand with agreeing initial aims and objectives of each scenario-based simulation exercise as discussed earlier.

Supervision

Each scenario-based simulation exercise will need to be centrally managed, with an exercise manager monitoring and coordinating all activities of the multi-stakeholder exercise team. During the ‘planning phase’ already, functions needed, and the general setup of the simulation exercise team will have to be specified. From a change management perspective, care will also be taken to ensure that the simulation exercise team at each site will be organised in accordance with the type and scope of the high-pressure scenario to be simulated. Prior to the execution of the actual simulation exercise, a technical review will ensure that the DYNAMO prototype system functions properly and that logistical arrangements have been made according to the plan. The technical review may encompass diverse activities, for instance, functional testing of required system components and/or features, checking the availability of any materials required during the simulation exercise and checking the accessibility of the DYNAMO solution such as potentially required personal login details. Beyond this, participants should be given a preparatory briefing before the simulation exercise starts, supported by suitable briefing materials if considered helpful. The appointed simulation exercise manager should oversee the whole exercise according to a documented exercise plan designed during the initial planning stage. It will also be important that the Procurers and the Associated Partner understand why this simulation exercise has produced a certain result. To this end, a dedicated work strand will focus on the specification of a dedicated evaluation plan (T 7.3). From a change management perspective, it will be ensured that all evaluation activities are smoothly aligned with the overall simulation exercise and that outcomes are fed back to the stakeholders concerned in an appropriate manner.