Original Article
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Medical Journal of the Islamic Republic of Iran (MJIRI)

Med J Islam Repub Iran. 2022 (14 Apr);36.35. https://doi.org/10.47176/mjiri.36.35

Proposed Model of Management for Patients with Multi-Morbidity in Iranian Hospitals

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Received: 25 Sep 2021 Published: 14 Apr 2022

Abstract

Background: Today, multi-morbidity (MM), the presence of more than one disease in the same person at the same time, has been prevalent. This is while the healthcare delivery systems are formed based on a single-disease-oriented approach. Hence, this study intended to address presenting a model for the management of patients with multi-morbidity in Iranian hospitals.

Methods: This was a mixed-method study. The data was gathered from 54 semi-structured interviews with the participation of experts in inpatient care management who were purposefully selected. The qualitative data were analyzed using content analysis. The Interpretive Structural Modeling (ISM) via STATA and Excel software was exploited in the quantitative phase.

Results: The factors affecting the management of patients with multi-morbidity were identified in 26 main themes and 142 sub-themes, and ultimately, a model for improving the management of patients with multi-morbidity in Iranian hospitals at six different levels was offered. The "Comprehensive Health Care Information System (CHIS) and Electronic Health Record (EHR)" had the greatest influence and the lowest dependency. "Efforts to remove patients' confusion" had the highest dependency and the lowest influence. The results of employing the Cross Impact Matrix Multiplication Applied to Classification (MICMAC) analysis demonstrated that most of the variables are placed in the third group of linkage variables that have high driving power and dependence power.

Conclusion: Concerning the sophisticated needs of patients with multi-morbidity for the management of their clinical conditions, the presented model could be provided to policymakers and health care managers as a beneficial performance guideline for improving the quality of care.

Keywords: Multi-Morbidity, Inpatients, Hospital, Health Care Management, Interpretive-Structural Modeling (ISM)

Conflicts of Interest: None declared
Funding: This study was conducted as a part of a doctoral thesis in healthcare management and no financial support was received.

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Cite this article as: Toofan F, Hosseini SM, Alimohammadzadeh Kh, Jafari M, Bahadori M. Proposed Model of Management for Patients with Multi-Morbidity in Iranian Hospitals. *Med J Islam Repub Iran.* 2022 (14 Apr);36:35. https://doi.org/10.47176/mjiri.36.35

Introduction

Chronic diseases are currently the leading cause of disability and mortality that account for the highest costs of health care systems (1). Based upon studies of the World Health Organization (WHO) in 2013, of the 57 million

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↑What is "already known" in this topic:
Multimorbidity, the co-existence of at least two long-term conditions in the same patient, is increasingly the norm in healthcare systems. Co-occurrence of chronic conditions is associated with reduced quality of life, increased disability, increased healthcare utilization and expenditure, and increased risk of adverse drug events and mortality. Optimizing healthcare services for patients with multimorbidity is a challenging task. These circumstances make it essential for healthcare policymakers to design and implement effective interventions to improve the quality of healthcare services in this patient group.

→What this article adds:
Factors regarding the management of inpatient care for multimorbid patients in Iran are multifaceted. Reforming the inpatient healthcare system or working out complementary strategies is critical for improving the quality of inpatient care for patients with multiple clinical conditions.

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[DOI: 10.47176/mjiri.36.35]

deaths that happened in the world, a total of 36 million deaths (more than 60 percent) were related to chronic diseases. This figure is much more prominent in developing countries, in which 80% of all deaths are caused by chronic diseases (2).

A dilemma that increasingly complicated the management of chronic diseases is the co-occurrence of multiple chronic conditions within one person, which is recognized as "Multi-Morbidity (MM)" (3). Multi-Morbidity results in loss of functional abilities (5), poor quality of life (6), mental disorders (7), and increased mortality (8). Moreover, multi-morbidity leads to greater exploitation of outpatient and inpatient healthcare services not only in comparison with patients without chronic diseases but also relative to patients with only one chronic disease (9). In order to satisfy their various needs, these individuals get different medical interventions from various health care providers, which could lead to duplicated, non-effective, and in some cases, harmful interventions (10).

In spite of these explanations, the healthcare systems of various countries, particularly developing countries, are based on a single-specialty approach and separate management of each illness (11). These systems would not be effective and efficient to satisfy the extensive needs of patients with multi-morbidity, and the safety and health of these patients may be even jeopardized as a result of various fragmented care (non-integrated) interventions (12). Iran's health system is no exception (13, 14).

As one of the developing countries, management of chronic conditions is one of the most important challenges of the Iranian health system (15). This problem, i.e., the high prevalence of chronic diseases and the extravagant costs imposed on the body of the economic and health systems of the country, becomes ever-rising serious (16). Furthermore, it is expected that the prevalence of multi-morbidity conforms to the pattern in the same way that observed in the age distribution of the population, taking into account that the multi-morbidity prevalence has a positive and significant correlation with increasing age (10, 17, 18) and considering the figures of the rapid increase in the elderly population in the country (19). This is while this issue has received less consideration by researchers and decision-makers in health systems, not merely in Iran but all developing countries. The majority of investigations carried out worldwide in regarding the management of multi-morbidity are conducted in developed countries. Besides, these studies have mainly dealt with the management of these patients in non-inpatient settings such as outpatient care. This is while the inpatient sectors allocate the highest costs of the health system.

To the best of our knowledge, there is not any published study, not only in Iran but also in most developing countries, which comprehensively explores the management of patients with multi-morbidity within inpatient care. With regard to the stunning figures in relation to the prevalence of chronic diseases and prediction of the ever-rising increase of patients with multi-morbidity, as well as with respect to the single specialized structure of the health care system, the significance of assessing the management of patients with multi-morbidity in the country's hospitals appears to be essential. In this respect, this study aims to address offering a management framework for multi-morbidity in hospitals of the country by extracting the challenges and strategies for the management of patients with multi-morbidity from the opinion of experts and stakeholders.

Methods

This was a mixed-method study. The results achieved from the first phase of this survey (qualitative study with a Grounded Theory approach: identification of the factors influencing the management of multi-morbidity in Iranian hospitals) contributed to the results and analysis of the second phase of the study (presenting a model with multi-morbidity management using interpretive structural modeling). The study was conducted between 2019 and 2021 in several medical sciences universities of Iran.

Identifying the Factors Influencing the Multi-morbidity Management in Iranian Hospitals

This phase of the study was conducted in the vice-chancellors in treatment affairs and health, as well as various faculties and hospitals of medical universities in the country. Participants in this survey consisted of experts in the field of the study, including officials, senior executives, and experts of the Ministry of Health and Medical Education, as well as educational and medical centers of medical universities, expert professors in the subject studied in the country's university of medical sciences, and experienced researchers in the target field, who were selected by purposive sampling method so that the people who have the highest and richest information in the scope under study were chosen (20).

Inclusion criteria for participants were as follows:

* Having education (at least bachelor's degree) and enough information in the field of providing health services to chronic patients or patients with multi-morbidity
* Having activities in health services management centers, scientific and educational centers of health management, and research centers of health services management, and other relevant centers
* Enjoying at least five years of work in providing inpatient health care to chronic patients
* Publishing books, research projects, and articles in connection with the management of providing healthcare services for chronic diseases
* Having managerial experience in the health service delivery system at various levels of the health care systems
* Willingness and capability to participate in the study

Individual interviews were used as a qualitative data collection method in this survey. The interview sessions were led by a member of the research team who was experienced and skilled in conducting interviews, and another person acted as a facilitator (for recording conversations and taking notes). At the beginning of each session, the goal of the study was explained to the invitees by the session leader. Then they were asked to express their opinions concerning the interview questions. The instrument applied in this phase of the research was a semi-structured

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interview guide. With the participants' permission, the discussions raised in the sessions were recorded, and notes were taken. The time and place of the meetings were arranged in coordination with invitees' convenience. Each of the sessions lasted in the interval between 40 and 70 minutes. Data saturation in any of the meetings was the end of the session.

Content analysis was used to analyze qualitative data (21, 22). Thus, after the interviews, the sentences expressed were implemented in the format of text as they were stated in the discussions. Next, two research team members separately study the implemented texts several times, and the so-called data immersion step happens. After that, the initial coding is performed. This means that the meaning units associated with the questions are identified and extracted from the texts as the initial code. The identification process of the initial codes continues to the saturation point. In the next step, the extracted codes are placed in identical categories and form the main themes concerning the meaning similarities, and the resultant themes are named. Subsequently, the results of these two processes, which were conducted by two separate people, are compared together, and the existing differences are eliminated with the agreement of the research team. To make assurance of the consistency and accuracy of the results, four criteria of credibility, confirmability, dependability, and transferability were employed (22).

Quantitative Part: Presentation of a Model for Multi-morbidity Management in Iranian Hospitals

In this investigation, Interpretive Structural Modelling (ISM) was exploited, which was raised by Warfield in 1974 for the first time and introduced by Sage in 1977. Interpretive structural modeling (ISM) is a well-established methodology for identifying the relationships between the underlying variables of a multifaceted and complex phenomenon and is suitable for management and social science studies (23-25).

The steps of interpretive-structural modeling (ISM) are illustrated in Figure 1.

Similar to the qualitative study, the population employed in this part consists of experts, managers, and knowledgeable professors in the domain of inpatient care management. In this section, the purposive sampling approach was exploited. This method is the conscious choice of certain participants by the researcher (26).

Steps of interpretive-structural modeling (ISM)

Determining the Relationships between Variables

Formation of Structural Self-Interaction Matrix (SSIM):

After identifying and extracting as well as finalizing the most important elements and influential variables for the multi-morbidity management in the country's hospitals, determining the relationships between the variables is the next step. In this part of the study, the most critical instrument for data collection is the questionnaires related to the various matrices referred to in interpretative structural modeling. Typically, these questionnaires are designed based on matrix operations and processes using special scenarios and symbols. The validity and reliability of the questionnaire were not reported as these kinds of questionnaires are related to only a certain research question, and generalizability is not the case.

In this phase, the relationships between indicators were analyzed as pairwise comparisons by applying interpretive structural modeling and using the conceptual relationship

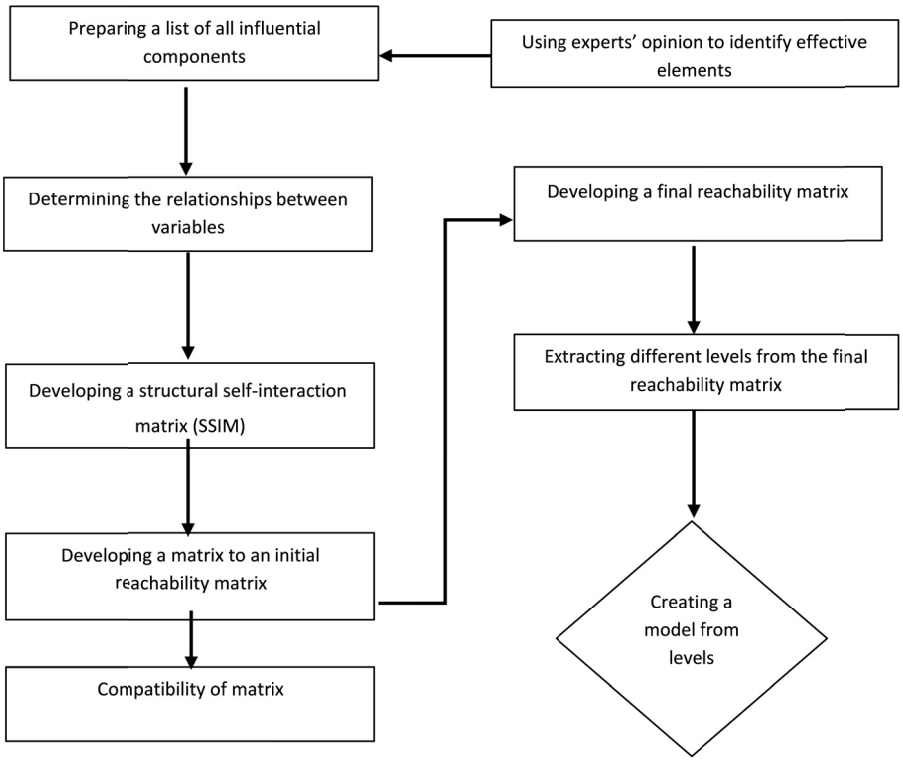

Fig. 1. Flowchart of interpretive-structural modeling (ISM) for presenting a multi-morbidity management model in Iranian hospitals

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Table 1. Symbols employed to identify the relationships of the multi-morbidity management model in Iranian hospitals

Parametes	1	-1	2	0
	The variable i influences j	The variable j influences i	There is a two-way relationship between i and j	There is no relationship between i and j
(i, j)	1	-1	2	0
(j, i)	-1	1	2	0
Instructions for use of these symbols	1: i influences j -1: j influences i 2: i and j have a mutual influence on each other 0: No relationship between i and j			

"lead to". Also, the experts dealt with determining the relationships between the variables using particular symbols and guidelines given in Table 1.

To assess the impact of variables on each other, all variables in a separate row and column were compared with each other, and coding operations were begun. The form utilized in this phase of the study is given in Appendix 1. In this survey, expert judgment technique was exploited for identifying the relationship between variables. In this respect, a questionnaire was distributed among the members of the experts aimed at evaluating the interaction of factors affecting the management of patients with multimorbidity in Iranian hospitals in terms of influence and dependency relative to each other.

Formation of Reachability Matrix

After the completion of the structural self-interaction matrix (SSIM), the next step is the formation of the initial reachability matrix. At this stage, the lower side of the structural self-interaction matrix is completed. This matrix is transformed into a matrix with complete cells, the initial reachability matrix. This issue is to gain the inverse relationships between the components, which could be collected using the information offered in the triangle on top of the original diameter.

Formation of Initial Reachability Matrix

The initial reachability matrix is achieved by the conversion of the initial reachability matrix to a binary matrix (0 and 1). The following rules were intended to substitute zero and one with the symbols introduced in the initial reachability matrix:

- If the input (i, j) (the confluence of row i and column j) in the structural self-interaction matrix is 1, the initial reachability matrix of 1 at the input (i, j) and 0 at the input (j, i) will be placed, respectively.
- If the input (i, j) (the confluence of row i and column j) in the structural self-interaction matrix is 2, the initial reachability matrix of 1 at the input (i, j) and 1 at the input (j, i) will be placed, respectively.
- If the input (i, j) (the confluence of row i and column j) in the structural self-interaction matrix is 0, the initial reachability matrix of 0 at the input (i, j) and 0 at the input (j, i) will be placed, respectively.

To put it simply:

Now, we should construct the initial reachability matrix. To extract the initial reachability matrix, we must replace 1 and 2 in each row of the structural self-interaction matrix (i.e., the upper matrix) and zero instead of the numbers -1 and 0. After converting all the rows, the obtained result is referred to as the initial reachability matrix.

Final Reachability Matrix

The matrix should be compatible in the next step of interpretive structural modeling (ISM). The final reachability matrix is gained by applying the transitive relations (transitivity) between the components. The transitive relation is so that if component i leads to component j and component j leads to component k, so one can argue that component i also leads to component k. Typically this symbol in the final reachability matrix is specified with 1*. Moreover, the dependence and driving power of each component are specified:

- Driving power: It is the amount of influence on other components, which is achieved from the sum of the numbers of each row in the final reachability matrix for each component.
- Dependence power: It represents the dependency from other components, which is obtained from the sum of the numbers of each column in the final reachability matrix for each component.

The levels of the components are determined with respect to the final reachability matrix. Components with high dependence power are placed at the top levels, and components with high driving power are placed at the bottom level.

Specifying relationships and levels of components

After carrying out the previous stages in the interpretive structural modeling (ISM) technique, determining the levels of each component needs to be done. At this point, a list of influential and dependent components for each component should be separately obtained. To this end, three sets are defined:

- *Reachability set:* The reachability set for a specific variable is the variable name, along with other variables that are involved in its creation. To put it simply, the reachability set is all the components that get 1 in the row related to the intended component.
- *Antecedent set:* The antecedent set for each variable includes the variable name, along with other variables that are involved in its formation. To put it simply, the antecedent set is all the components that get 1 in the column related to the desired component.
- *Intersection set:* As is evident from its name, it is obtained from common variables in the above two sets

The variables that their gained intersection is identical with the reachability set are regarded as top-level variables in the ISM hierarchy. This means that these variables

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have a low influence on other variables. After identifying the top-level variable, that variable is excluded from the list of variables. These iterations continue until the level of all variables is determined. The identified levels are exploited to fabricate the final ISM model.

MICMAC Analysis

Cross Impact Matrix Multiplication Applied to Classification is abbreviated as MICMAC. The purpose of MICMAC analysis is to analyze the drive power and dependence power of enablers. In this part of the study, the variables and factors affecting the defined problem were classified into four categories in terms of drive power and dependence power. Using the scores related to the driving power and dependence power, which were calculated in the previous steps for each item, eventually, the driving power and dependence were provided in the form of a reachability matrix.

In this study, the most important software employed in the quantitative and modeling sections included STATA software version 16 and MS Excel software version 2020. All equations, run of data management codes, codes conversion, identification of intersection points, reachability matrix, and final reachability matrix were carried out using the STATA software.

In this study, the following items were taken into account for observing the ethical considerations.

* Lack of disseminating any information related to the participants in the study

* Obtaining informed consent from participants at each phase of the research via using informed consent forms in an oral or written manner

* The research team members are required to observe a lack of bias in dealing with data and results of the research

* Obtaining permission from the ethics committee of Islamic Azad University (code of ethics No. IR.IAU.TNB.REC.1398.003)

Results

In this study, a total of 54 stakeholders from 16 provinces were interviewed. Most of them were male (72%) and had a median experience of 18 years. Included participants held differing professions in providing care for and/or research in managing patients with multimorbidity; 12 inpatient care providers, 26 inpatient care providers and healthcare managers, and 16 healthcare researchers. The interviews lasted an average of 42 min (range 29-58 min).

After data analysis, 814 initial codes without taking into account overlap were extracted. After merging, 142 sub-themes remained by considering overlap. Summarization and finalization of the main themes from the sub-themes were conducted using an in-person session with experts from various disciplines, which ultimately, 26 main themes in relation to the management of patients with multi-morbidity were achieved (Table 2: main themes and their codes).

After the preparation of the structural self-interaction matrix (SSIM), the initial reachability matrix (Appendix 1), and the final reachability matrix (Appendix 2), the final reachability matrix was prepared.

The results of assessing the driving power and the dependence power of the 26 factors investigated suggest that seven factors (codes 5, 6, 7, 10, 20, 23, and 26) with the driving power of 26 have the strongest influence, i.e., affects all other factors considered in this study , and a factor (code 16) with the driving power of 1 have the lowest influence (Table 3) which is influenced by all other factors

Table 2. The main themes and their codes (guideline to items included in the interpretive-structural modeling) for multi-morbidity management in Iranian hospitals

Main themes	Codes
Scientific and immune development of hospital wards, beds, and units on the basis of needs assessment	C01
Single specialty hospital /general hospital	C02
Utilization of scientific and evidence-based management in centers for decision-making and distribution of resources	C03
Lack of human resources or inappropriate employment	C04
Respect for the principles of professional conduct and clinical ethics	C05
Teamwork in providing care and treatment	C06
Scientific knowledge and skills of providers	C07
Field supervision and evaluation of the clinical performance of providers	C08
Effective human resource management	C09
Commitment to patient-centeredness	C10
Integrated services	C11
Quality and safety of care, treatment, and diagnostic services	C12
Clinically oriented protocols and guidelines	C13
Suitable and systematic response to needs	C14
Participation and empowerment of patients (education and self-care)	C15
Efforts to remove patients' confusion	C16
Appropriate supply and management of financial resources	C17
Effective scientific and proportionate health-oriented tariffs	C18
The effective payment method with respect to financial support and coverage	C19
Comprehensive health care information system and electronic health record	C20
Application of scientific and safety principles for drug administration	C21
Access to medication and medical supplies and equipment	C22
Integration and obligation for the deployment of accreditation standards	C23
Supervision of education and efficacy of training	C24
Inter-sectoral and interdisciplinary coordination of services	C25
Implementation of high-level issued communication priorities associated with appropriate management of these patients	C26

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Table 3. The driving power and the dependence power of factors influencing the multi-morbidity management in Iranian hospitals

Dependence power	Driving power	Code
25	18	C01
24	22	C02
23	23	C03
20	22	C04
24	26	C05
25	26	C06
22	26	C07
17	24	C08
23	23	C09
25	26	C10
25	22	C11
25	16	C12
14	25	C13
25	24	C14
25	17	C15
26	1	C16
20	16	C17
12	24	C18
19	23	C19
8	26	C20
25	20	C21
25	16	C22
24	26	C23
19	21	C24
25	25	C25
19	26	C26

considered in this research.

After specifying the antecedent set, reachability set, and intersection set, eventually, the model of improving the multi-morbidity management in Iranian hospitals based upon Interpretive Structural Modeling (ISM) was proposed according to Figure 2 in order to calculate determining the levels (Table 4) and determining the variables of different levels (six levels) in a hierarchy of ISM levels (Appendix 3). The outcomes of this model indicate that the "Comprehensive Health Care Information System (CHIS) and Electronic Health Record (EHR)" had the highest influence and the lowest dependency. In contrast, "Efforts to remove patients' confusion" had the highest dependency and the lowest influence.

The factors affecting the management of patients with multi-morbidity in Iranian hospitals were classified into one of the four clusters (including autonomous enablers, dependent enablers, linkage enablers, independent enablers) of the influence of variables matrix method using the MICMAC analysis. The results demonstrated that most of the variables are placed in the third group of linkage variables, which have high driving power and dependence power. Actually, any action on this index of variables will cause a variation in other indicators (Fig. 3).

Discussion

In this survey, initially, the factors influencing the management of patients with multi-morbidity in Iranian hospitals were identified in 26 main themes and 142 sub-themes using the opinions of 54 experts in various domains. Eventually, the model of improving the management of patients with multi-morbidity in Iranian hospitals was

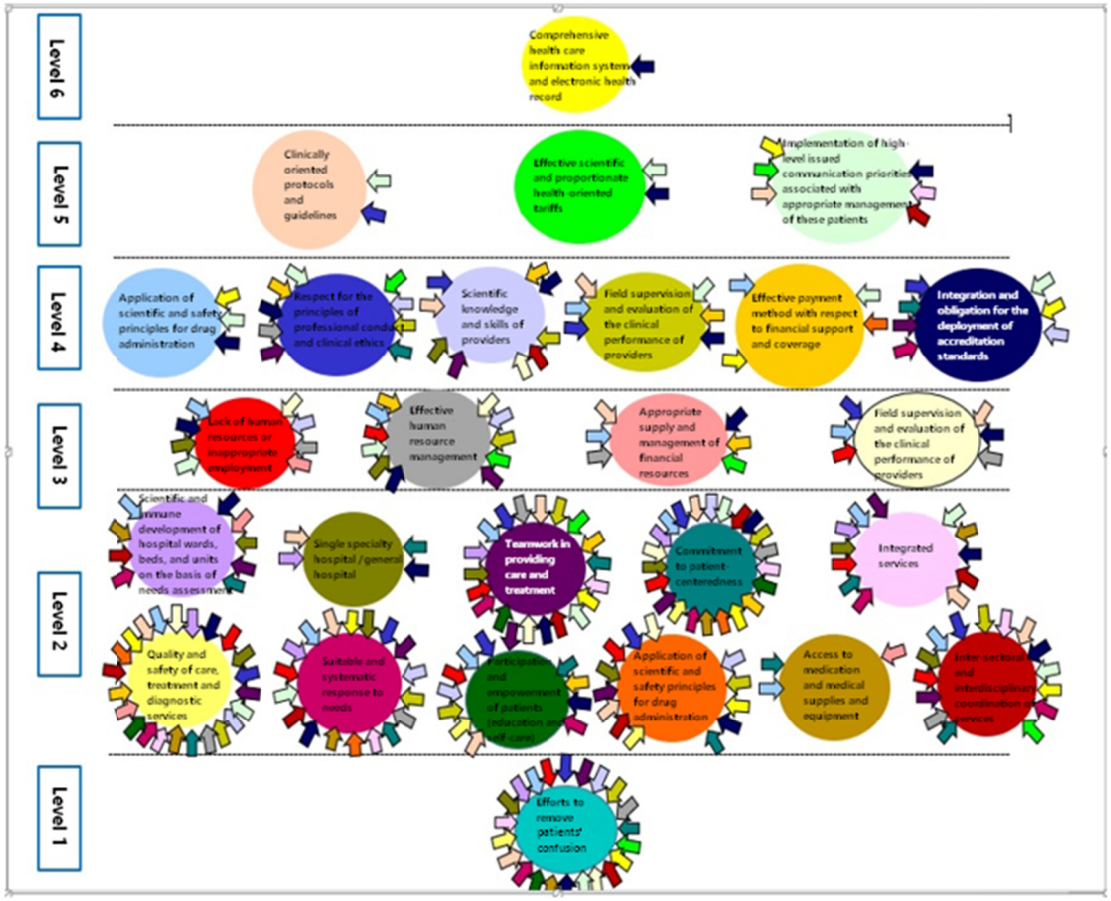

Fig. 2. The ultimate model of multi-morbidity management in Iranian hospitals

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Table 4. Antecedent set, reachability set, and intersection set to calculate determining the levels of multi-morbidity management model in Iranian hospitals

Cods	Reachability Set	Antecedent Set	Intersection Set
C01	1,2,,4,5,6,7,,9,10,11,12,,14,15,16,,,,,,21,22,23,,25,26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,,17,,18,19,20,21,22,23,24,25,26	1,2,,4,5,6,7,,9,10,11,12,,14,15,,,,,,,21,22,23,,25,26
C02	1,2,3,4,5,6,7,,9,10,11,12,,14,15,16,17,,,19,,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,,17,,,19,20,21,22,23,24,25,26	1,2,3,4,5,6,7,,9,10,11,12,,14,15,,17,,,19,,21,22,23,24,25,26
C03	1,2,3,4,5,6,7,8,9,10,11,12,,14,15,16,17,,,19,,21,22,23,24,25,26	,2,3,4,5,6,7,8,9,10,11,12,13,14,15,,,,18,19,20,21,22,23,24,25,26	,2,3,4,5,6,7,8,9,10,11,12,,14,15,,,,,19,,21,22,23,24,25,26
C04	1,2,3,4,5,6,7,,9,10,11,12,,14,15,16,17,,,19,,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,,,13,14,,,17,,18,19,20,,,23,24,25,26	1,2,3,4,5,6,7,,9,10,,,,14,,,17,,,19,,,,23,24,25,26
C05	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,,18,19,20,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,,,,18,19,20,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,,,,18,19,20,21,22,23,24,25,26
C06	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,,18,19,20,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,,17,,18,19,20,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,,17,,18,19,20,21,22,23,24,25,26
C07	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,,18,19,20,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,,13,14,15,,,,18,19,20,21,,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,,13,14,15,,,,18,19,20,21,,23,24,25,26
C08	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,,,19,,21,22,23,24,25,26	,,3,,5,6,7,8,9,10,11,,13,14,,,,,18,19,20,21,,23,,25,26	,,3,,5,6,7,8,9,10,11,,13,14,,,,,,19,,21,,23,,25,26
C09	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,,,,,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,,13,14,15,,17,,18,19,20,21,,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,,13,14,15,,17,,,,,21,,23,24,25,26
C10	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,,18,19,20,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,,17,,18,19,20,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,,17,,18,19,20,21,22,23,24,25,26
C11	1,2,3,,5,6,7,8,9,10,11,12,13,14,15,16,,,18,19,,21,22,23,,25,26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,,17,,18,19,20,21,22,23,24,25,26	1,2,3,,5,6,7,8,9,10,11,12,13,14,15,,,,,18,19,,21,22,23,,25,26
C12	1,2,3,,5,6,,,,10,11,12,,14,15,16,,,,19,,21,22,23,,25,	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,,17,,18,19,20,21,22,23,24,25,26	1,2,3,,5,6,,,,10,11,12,,14,15,,,,,19,,21,22,23,,25,
C13	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,,18,19,,21,22,23,24,25,26	,,,,5,6,7,8,9,10,11,,13,,,,,,18,19,20,,,23,,25,26	,,,,5,6,7,8,9,10,11,,13,,,,,,18,19,,,,23,,25,26
C14	1,2,3,4,5,6,7,8,9,10,11,12,,14,15,16,17,,18,,20,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,,17,,18,19,20,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,12,,14,15,,17,,18,,20,21,22,23,24,25,26
C15	1,2,3,,5,6,7,,9,10,11,12,,14,15,16,,,,,,21,22,23,,25,	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,,17,,18,19,20,21,22,23,24,25,26	1,2,3,,5,6,7,,9,10,11,12,,14,15,,,,,,,21,22,23,,25,
C16	,,,,,,,,,,,,,,,16,,,,,,,,,,,	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,,18,19,20,21,22,23,24,25,26	,,,,,,,,,,,,,,,16,,,,,,,,,,,
C17	1,2,,4,,6,,,9,10,11,12,,14,15,16,17,,,,,21,22,,24,25,	,2,3,4,5,6,7,8,9,10,,,13,14,,,17,,18,19,20,21,,,23,24,25,26	,2,,4,,6,,,9,10,,,,14,,,17,,,,,21,,,24,25,
C18	1,,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,,18,19,,21,22,23,24,25,26	,,,,5,6,7,,,,10,11,,13,14,,,,,18,,20,,,23,,25,26	,,,,5,6,7,,,,10,11,,13,14,,,,,18,,,,,23,,25,26
C19	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,,,19,,21,22,23,24,25,	,2,3,4,5,6,7,8,,10,11,12,13,,,,,,18,19,20,21,,23,24,25,26	,2,3,4,5,6,7,8,,10,11,12,13,,,,,,,19,,21,,23,24,25,
C20	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,,18,19,20,21,22,23,24,25,26	,,,,5,6,7,,,,10,,,,,14,,,,,,,20,,,23,,,26	,,,,5,6,7,,,,10,,,,,14,,,,,,,20,,,23,,,26
C21	1,2,3,,5,6,7,8,9,10,11,12,,14,15,16,17,,,19,,21,22,23,,25,	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,,17,,18,19,20,21,22,23,24,25,26	1,2,3,,5,6,7,8,9,10,11,12,,14,15,,17,,,19,,21,22,23,,25,
C22	1,2,3,,5,6,,,,10,11,12,,14,15,16,,,,,,21,22,23,,25,26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,,17,,18,19,20,21,22,23,24,25,26	1,2,3,,5,6,,,,10,11,12,,14,15,,,,,,,21,22,23,,25,26
C23	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,,18,19,20,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,,,,18,19,20,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,,,,18,19,20,21,22,23,24,25,26
C24	1,2,3,4,5,6,7,,9,10,11,12,,14,15,16,17,,,19,,21,22,23,24,25,	,2,3,4,5,6,7,8,9,10,,,13,14,,,17,,18,19,20,,,23,24,25,26	,2,3,4,5,6,7,,9,10,,,,,14,,,17,,,19,,,,23,24,25,
C25	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,,18,19,,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,,17,,18,19,20,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,,17,,18,,19,,21,22,23,24,25,26
C26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,,18,19,20,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,,13,14,,,,,18,,20,,22,23,,25,26	1,2,3,4,5,6,7,8,9,10,11,,13,14,,,,,18,,20,,,22,23,,25,26

offered on the basis of Interpretive Structural Modeling (ISM). The results of this model reveal that the "Comprehensive Health Care Information System (CHIS) and Electronic Health Record (EHR)" had the strongest influence and the lowest dependency. On the contrary, "Efforts to remove patients' confusion" had the highest dependency and the lowest influence. The results of utilizing the MICMAC analysis demonstrated that most of the variables are placed in the third group of linkage variables with high driving power and dependence power.

The outcomes of the model proposed in this investigation represent that the "comprehensive health information system and electronic health record" has the highest influence and the lowest dependency. In other words, it could be regarded as one of the most key and essential factors affecting the management of patients with multi-morbidity in Iranian hospitals. The current study suggested that, from the opinion of experts responsible for the management of patients with multi-morbidity in inpatient departments and hospitals, the existence of a comprehensive health information system at the national level, along with an efficient and effective electronic health record, can upgrade the management of patients with multi-morbidity in several aspects, both in terms of the economy and in terms of access as well as in terms of patient safety, etc. Sheikh Eslami et al. (2020) studied the Identification of

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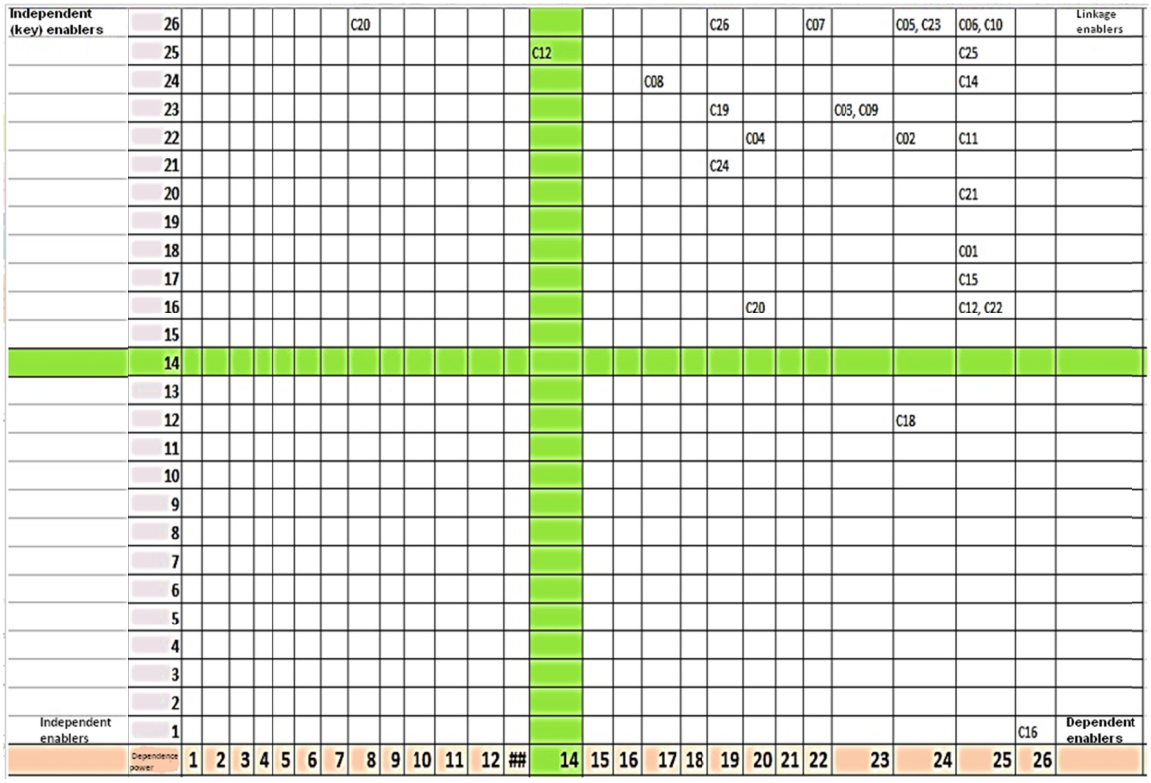

Fig. 3. The results of MICMAC analysis for the factors affecting the management of patients with multi-morbidity in Iranian hospitals

Effective Factors related to Implementation of Electronic Health Records in Imam Khomeini Hospital, Tehran. The result of this study demonstrated that the implementation of an electronic health record needs to take into educational, cultivation, comprehensiveness, safety & privacy, constructive communication, collaboration, technology / economic, social/cultural, management / structural, and legal factors (27). In recent years, the application of integrated information systems and electronic health records has been exploited in most countries of the world, even in many Low and Middle-Income Countries (LMICs), in the effective management and providing high-quality services to patients, which led to remarkable achievements (28-30). Ebrahimoghli et al., using data recorded in the Iranian Health Insurance (Bime Salamat Iranian) Information System in East Azarbaijan Province, could carry out many analyses and achieve a lot of information in connection with the management of multi-morbidity outpatients in various dimensions, which is a salient example of the positive and influential effects of the existence of health information system (HIS) and their beneficial applications (31, 32). Although employing a health information system (HIS) has been much welcomed in Iranian hospitals over the past several years, nevertheless, the results of several studies reflect the presence of numerous challenges and problems in this sphere (33-35). Hence, concerning the results of this survey and previous studies, which approve the significance and place of efficient and effective health information systems in hospitals and overall health system, particularly in the management of patients with multi-morbidity, managers and custodianship (responsible charge) of the field need to take action a variety of serious and effective planning to promote this circumstance. Due to some causes, such as lowering the cost of the health system, increasing satisfaction, and promoting the quality and safety of the patient and other rational and necessary reasons, including appropriate management of patients with multi-morbidity, it is therefore essential that a proper structure for the comprehensive health information system and electronic and national records of individuals in the community to be deployed scientifically and safely through the responsible charge of the health system, while protecting the rights of service recipients at all levels of health.

The findings of this study revealed that "efforts to remove patients' confusion" had the highest dependency and the lowest influence on the management of patients with multi-morbidity in Iranian hospitals. This may be due to the weaknesses of management in handling hospitals during recent years and the multiple challenges and problems in this sphere. Thus, most experts and specialists argued that there is insufficient effort to remove patients' confusion in Iranian hospitals. Moreover, the diversification of decision-making decision centers and long and bureaucratic structures available in hospitals and generally in the country's health system could be another critical cause in this matter. Another thing that can be pointed out is that patients with multi-morbidity receive their health care from various providers because of their multiple needs. The results of this investigation illustrated that the complicated situations of these patients could be regarded as a reason for inadequate attention and the so-called "patient

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neglect" by different providers. The findings of this study have been emphasized in other international studies. For example, Ester et al., in a comprehensive project comprehensive for assessing coordinated and integrated care, came to the conclusion that the likelihood of physicians neglecting patient care increases considering that a variety of providers are involved in the care of patients with multi-morbidity, and this could result in patients' confusion in receiving care, especially inpatient care (36).

Overall, in addition to the abovementioned contents, some suggestions could be offered to upgrade the quantity and quality of services provided to patients with multi-morbidity on the basis of experts' opinions and the model proposed in this study. For example, payments to service providers for patients with multi-morbidity considering the significant role healthcare provider (37), consideration of effective performance-based payment, and financial and coverage support based on effective performance regarding quality and safety indicators to physicians and other service providers are among the most important measures that can be done. Besides, it is recommended that the scientific knowledge and skills of service providers to patients with multi-morbidity be assessed scientifically and periodically in several respects, including adherence to professional principles and clinical ethics, scientific and safe principles of drug administration, theoretical knowledge and practical skills, participation in teamwork, providing safe services to patients with multi-morbidity, and even how the safety and quality of service provided has the necessary compliance with the relevant protocols and guidelines. In this regard, innovative approaches such as analytical hierarchical process colud be beneficial in terms of quality improvement within inpatient settings (38). It is proposed that the potential of hospitals in terms of providing proper health care services to patients with multi-morbidity from multiple dimensions, containing effective human resource management, respect to protocols and guidelines, applying scientific and safe principles in diagnostic, treatment, care, etc. services, commitment to patient-centeredness, teamwork, empowerment of patients, and other items, including suitable and systematic response to the needs of patients with multi-morbidity, be addressed by hospitals in the form of internal assessment and by the Ministry of Health in the form of external assessment. Appropriate performance indicators in connection with the management of patients with multi-morbidity should be specified by the responsible charge of the health department for the centers and evaluated based on the level of access to the objectives set in the indices, both in terms of the commitment of the centers to create facilities and resources and in terms of quality and safety of services provided to these patients and in terms of outcome indicators that are considered by the health care system so that the necessary support to be done from the centers tailored to the achievement of the defined goals.

Among the most critical limitations of this study was access to managers, experts, and clinical professors, mainly because of COVID-19 conditions. Nevertheless, virtual communication channels were exploited as much as possible for smoothing the challenge. Job bias of clinical professors in their disciplines in terms of the completion of the questionnaires, their summarization, especially in the quantitative phase of the research, and ISM was one of the other practical limitations of this survey.

Policy implications

This study provides several implications for healthcare decision makers to improve inpatient care for patients with multiple clinical conditions. From the position of the core drivers in the hierarchical structural model and their characteristics that were identified in this study, we could understand how they affect inpatient care for multimorbid patientsand assist authorities in making effective interventions.

Strenghs and limitations of the study

The important aspects of the inpatient care for multimorbid patieents have been identified in this study and ISM has been used to convert the identified domains into a clear structured map which deciphers the contextual relationship among these factors. In addition, , this qualitative study applied purposive sampling method to enable variation of our sample within the healthcare provision, management, and research. Howereve, one important limitation is that the developed model is derived from a limited number of experts' view. As in any qualitative studies, subjectivity in interpretation of qualitative data is impossible to avoid and can be affect the generalisability of our findings.

Conclusion

In the present study, the factors affecting the management of patients with multi-morbidity in Iranian hospitals were initially detected using experts' opinions in various domains. Ultimately, a model for improving the management of patients with multi-morbidity in Iran's hospitals was presented. It is suggested that policy-makers and senior managers of hospitals and universities be acquainted with these items and components and pay attention to their impact factor on other components and paving the way for the deployment of a comprehensive health information system and electronic health records to be on the agenda by them. Moreover, they should establish the necessary grounds for promoting the status of providing services to patients with multi-morbidity by the follow-up and attention to other factors identified in this study.

Acknowledgments

he authors would like to acknowledge all the participants contributed in any way for the completion of this study. We also thank the members involved in quality improvement office of Imam Reza hospital, Tabriz for their guidance and support.

Ethcial approval

This study was approved by Research Ethics Committee of Islamic Azad University-North Tehran Branch (IR.IAU.TNB.REC.1398.003).

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[DOI: 10.47176/mjiri.36.35]

Conflict of Interests

The authors declare that they have no competing interests.

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[DOI: 10.47176/mjiri.36.35]

Appendix 1. Initial reachability matrix

	C01	C02	C03	C04	C05	C06	C07	C08	C09	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	C22	C23	C24	C25	C26
C01	1	2	-1	0	0	2	0	0	0	2	1	1	0	2	0	1	-1	0	0	0	0	-1	-1	0	-1	0
C02	2	1	0	1	0	1	1	0	1	2	1	1	-1	1	0	1	0	0	0	0	1	0	-1	0	1	0
C03	1	0	1	1	0	1	0	1	1	1	1	1	0	1	1	1	1	0	1	-1	0	1	-1	1	1	-1
C04	0	-1	-1	1	0	1	-1	0	2	1	1	1	0	1	1	1	-1	0	0	0	1	0	-1	2	1	-1
C05	0	0	0	0	1	2	2	2	-1	2	0	1	1	1	1	1	0	-1	-1	0	1	0	2	1	1	-1
C06	2	-1	-1	-1	2	1	1	-1	2	2	2	1	-1	2	2	1	0	-1	-1	-1	1	0	2	-1	2	-1
C07	0	-1	0	1	2	-1	1	-1	1	1	0	1	-1	1	1	1	0	0	-1	0	1	0	2	-1	-1	0
C08	0	0	-1	0	2	1	1	1	1	1	0	1	-1	1	1	1	0	0	-1	0	1	0	-1	0	1	-1
C09	0	-1	-1	2	1	2	-1	-1	1	1	0	1	0	1	0	1	1	-1	-1	0	0	0	-1	2	1	-1
C10	2	2	1	-1	2	2	-1	-1	-1	1	2	2	-1	2	2	1	0	0	-1	-1	2	2	2	-1	2	-1
C11	-1	1	-1	-1	0	2	0	0	0	2	1	1	-1	2	0	1	0	0	0	0	0	-1	-1	0	2	2
C12	1	-1	-1	-1	-1	-1	-1	-1	-1	2	-1	1	-1	-1	2	1	-1	0	-1	-1	2	-1	-1	-1	-1	-1
C13	0	1	0	0	-1	1	1	1	0	1	1	1	1	1	1	1	1	0	0	0	1	0	0	1	1	2
C14	2	-1	-1	-1	-1	2	-1	-1	-1	2	2	1	-1	1	1	1	0	0	0	-1	-1	-1	2	0	2	-1
C15	0	0	-1	-1	-1	2	-1	-1	0	2	0	2	-1	-1	1	1	0	0	-1	0	0	0	-1	0	0	0
C16	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	1	0	-1	0	-1	0	-1	-1	-1	-1	-1
C17	1	0	-1	1	0	0	0	0	-1	0	0	1	-1	0	0	0	1	-1	-1	0	0	1	-1	0	0	0
C18	0	0	0	0	1	1	0	0	1	0	0	0	0	0	0	1	1	1	0	0	0	0	-1	0	1	2
C19	0	0	-1	0	1	1	1	1	1	1	0	1	0	0	1	0	1	0	1	-1	-1	0	0	0	0	-1
C20	0	0	1	0	0	1	0	0	0	1	0	1	0	1	0	1	0	0	1	1	1	0	2	0	1	1
C21	0	-1	0	-1	-1	-1	-1	-1	0	2	0	2	-1	1	0	0	0	0	1	-1	1	0	-1	-1	-1	0
C22	1	0	-1	0	0	0	0	0	0	2	1	1	0	1	0	1	-1	0	0	0	0	1	0	0	0	0
C23	1	1	1	1	2	2	2	1	1	2	1	1	0	2	1	1	1	1	0	2	1	0	1	1	1	2
C24	0	0	-1	2	-1	1	1	0	2	1	0	1	-1	0	0	1	0	0	0	0	1	0	-1	1	0	0
C25	1	-1	-1	-1	1	2	1	-1	-1	2	2	1	-1	2	0	1	0	-1	0	-1	1	0	-1	0	1	2
C26	0	0	1	-1	1	1	0	1	1	1	2	1	2	1	0	1	0	2	1	-1	0	0	2	0	2	1

Appendix 2. Final reachability matrix

A	C01	C02	C03	C04	C05	C06	C07	C08	C09	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	C22	C23	C24	C25	C26
C01	1	1	0	0	0	1	0	0	0	1	1	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0
C02	1	1	0	1	0	1	1	0	1	1	1	1	0	1	0	1	0	0	0	0	1	0	0	0	1	0
C03	1	0	1	1	0	1	0	1	1	1	1	1	0	1	1	1	1	0	1	0	0	1	0	1	1	0
C04	0	0	0	1	0	1	0	0	1	1	1	1	0	1	1	1	0	0	0	0	1	0	0	1	1	0
C05	0	0	0	0	1	1	1	1	0	1	0	1	1	1	1	1	0	0	0	0	1	0	1	1	1	0
C06	1	0	0	0	1	1	1	0	1	1	1	1	0	1	1	1	0	0	0	0	1	0	1	0	1	0
C07	0	0	0	1	1	0	1	0	1	1	0	1	0	1	1	1	0	0	0	0	1	0	1	0	0	0
C08	0	0	0	0	1	1	1	1	1	1	0	1	0	1	1	1	0	0	0	0	1	0	0	0	1	0
C09	0	0	0	1	1	1	0	0	1	1	0	1	0	1	0	1	1	0	0	0	0	0	0	1	1	0
C10	1	1	1	0	1	1	0	0	0	1	1	1	0	1	1	1	0	0	0	0	1	1	1	0	1	0
C11	0	1	0	0	0	1	0	0	0	1	1	1	0	1	0	1	0	0	0	0	0	0	0	0	1	1
C12	1	0	0	0	0	0	0	0	0	1	0	1	0	0	1	1	0	0	0	0	1	0	0	0	0	0
C13	0	1	0	0	0	1	1	1	0	1	1	1	1	1	1	1	1	0	0	0	1	0	0	1	1	1
C14	1	0	0	0	0	1	0	0	0	1	1	1	0	1	1	1	0	0	0	0	0	0	1	0	1	0
C15	0	0	0	0	0	1	0	0	0	1	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0
C16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
C17	1	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0
C18	0	0	0	0	1	1	0	0	1	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	1	1
C19	0	0	0	0	1	1	1	1	1	1	0	1	0	0	1	0	1	0	1	0	0	0	0	0	0	0
C20	0	0	1	0	0	1	0	0	0	1	0	1	0	1	0	1	0	0	1	1	1	0	1	0	1	1
C21	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	0	0	0	1	0	1	0	0	0	0	0
C22	1	0	0	0	0	0	0	0	0	1	1	1	0	1	0	1	0	0	0	0	0	1	0	0	0	0
C23	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	0	1	1	0	1	1	1	1
C24	0	0	0	1	0	1	1	0	1	1	0	1	0	0	0	1	0	0	0	0	1	0	0	1	0	0
C25	1	0	0	0	1	1	1	0	0	1	1	1	0	1	0	1	0	0	0	0	1	0	0	0	1	1
C26	0	0	1	0	1	1	0	1	1	1	1	1	1	1	0	1	0	1	1	0	0	0	1	0	1	1

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Appendix 3. Determining the six levels of variables in the ISM hierarchy

The first levels of variables in the ISM hierarchy				
Level	Codes	Reachability Set	Antecedent Set	Intersection Set
	C01	1,2,,4,5,6,7,,9,10,11,12,,14,15,16,,,,,21,22,23,,25,26	1,2,3,**4**,5,6,7,8,9,10,11,12,13,14,15,,17,,18,19,20,21,22,23,24,25,26	1,2,,4,5,6,7,,9,10,11,12,,14,15,,,,,,21,22,23,,25,26
	C02	1,2,3,4,5,6,7,,9,10,11,12,,14,15,16,17,,,19,,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,,17,,19,20,21,22,23,24,25,26	1,2,3,4,5,6,7,,9,10,11,12,,14,15,,17,,,19,,21,22,23,24,25,26
	C03	1,2,3,4,5,6,7,8,9,10,11,12,,14,15,16,17,,,19,,21,22,23,24,25,26	,2,3,4,5,6,7,8,9,10,11,12,13,14,15,,,,18,19,20,21,22,23,24,25,26	,2,3,4,5,6,7,8,9,10,11,12,,14,15,,,,,19,,21,22,23,24,25,26
	C04	1,2,3,4,5,6,7,,9,10,11,12,,14,15,16,17,,,19,,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,,,13,14,,,17,,18,19,20,,,23,24,25,26	1,2,3,4,5,6,,7,,9,10,,,,14,,,17,,,19,,,,23,24,25,26
	C05	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,,18,19,20,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,,,,18,19,20,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,,,,18,19,20,21,22,23,24,25,26
	C06	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,,18,19,20,21,22,23,24,25,26	1,2,3,**4**,5,6,7,8,9,10,11,12,13,14,15,,17,,18,19,20,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,,,17,,18,19,20,21,22,23,24,25,26
	C07	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,,18,19,20,21,22,23,24,25,26	1,2,3,**4**,5,6,7,8,9,10,11,,13,14,15,,,,18,19,20,21,,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,,13,14,15,,,,18,19,20,21,,23,24,25,26
	C08	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,,,19,,21,22,23,24,25,26	,,3,,5,6,7,8,9,10,11,,13,14,,,,,18,19,20,21,,23,,25,26	,,3,,5,6,7,8,9,10,11,,13,14,,,,,,19,,21,,23,,25,26
	C09	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,,,,,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,,13,14,15,,17,,18,19,20,21,,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,,13,14,15,,17,,,,,21,,23,24,25,26
	C10	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,,18,19,20,21,22,23,24,25,26	1,2,3,**4**,5,6,7,8,9,10,11,12,13,14,15,,17,,18,19,20,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,,17,,18,19,20,21,22,23,24,25,26
	C11	1,2,3,,5,6,7,8,9,10,11,12,13,14,15,16,,,18,19,,21,22,23,,25,26	1,2,3,**4**,5,6,7,8,9,10,11,12,13,14,15,,17,,18,19,20,21,22,23,24,25,26	1,2,3,,5,6,7,8,9,10,11,12,13,14,15,,,,18,19,,21,22,23,,25,26
	C12	1,2,3,,5,6,,,,10,11,12,,14,15,16,,,,19,,21,22,23,,25,	1,2,3,**4**,5,6,7,8,9,10,11,12,13,14,15,,17,,18,19,20,21,22,23,24,25,26	1,2,3,,5,6,,,,10,11,12,,14,15,,,,,19,,21,22,23,,25,
	C13	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,,18,19,,21,22,23,24,25,26	,,,,5,6,7,8,9,10,11,,13,,,,,,18,19,20,,,23,,25,26	,,,,5,6,7,8,9,10,11,,13,,,,,,18,19,,,,23,,25,26
	C14	1,2,3,4,5,6,7,8,9,10,11,12,,14,15,16,17,,18,,20,21,22,23,24,25,26	1,2,3,**4**,5,6,7,8,9,10,11,12,13,14,15,,17,,18,19,20,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,12,,14,15,,17,,18,,20,21,22,23,24,25,26
	C15	1,2,3,,5,6,7,,9,10,11,12,,14,15,16,,,,,21,22,23,,25,	1,2,3,**4**,5,6,7,8,9,10,11,12,13,14,15,,17,,18,19,20,21,22,23,24,25,26	1,2,3,,5,6,7,,9,10,11,12,,14,15,,,,,,21,22,23,,25,
1	C16	,,,,,,,,,,,,,,,16,,,,,,,,,,	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,,18,19,20,21,22,23,24,25,26	,,,,,,,,,,,,,,,16,,,,,,,,,,
	C17	1,2,,4,,6,,,9,10,11,12,,14,15,16,17,,,,21,22,,24,25,	,2,3,4,5,6,7,8,9,10,,,13,14,,,17,,18,19,20,21,,23,24,25,26	,2,,4,,6,,,9,10,,,,14,,,17,,,,,21,,,24,25,
	C18	1,,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,,18,19,,21,22,23,24,25,26	,,,,5,6,7,,,10,11,,13,14,,,,,18,,20,,,23,,25,26	,,,,5,6,7,,,10,11,,13,14,,,,,18,,,,,23,,25,26
	C19	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,,,19,,21,22,23,24,25,	,2,3,4,5,6,7,8,,10,11,12,13,,,,,,18,19,20,21,,23,24,25,26	,2,3,4,5,6,7,8,,10,11,12,13,,,,,,19,,21,,23,24,25,
	C20	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,,18,19,20,21,22,23,24,25,26	,,,,5,6,7,,,10,,,,14,,,,,,,20,,,23,,,26	,,,,5,6,7,,,10,,,,14,,,,,,,20,,,23,,,26
	C21	1,2,3,,5,6,7,8,9,10,11,12,,14,15,16,17,,,19,,21,22,23,,25,	1,2,3,**4**,5,6,7,8,9,10,11,12,13,14,15,,17,,18,19,20,21,22,23,24,25,26	1,2,3,,5,6,7,8,9,10,11,12,,14,15,,17,,,19,,21,22,23,,25,
	C22	1,2,3,,5,6,,,,10,11,12,,14,15,16,,,,,,21,22,23,,25,26	1,2,3,**4**,5,6,7,8,9,10,11,12,13,14,15,,17,,18,19,20,21,22,23,24,25,26	1,2,3,,5,6,,,,10,11,12,,14,15,,,,,,,21,22,23,,25,26
	C23	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,,18,19,20,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,,,,18,19,20,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,,,,18,19,20,21,22,23,24,25,26
	C24	1,2,3,4,5,6,7,,9,10,11,12,,14,15,16,17,,,19,,21,22,23,24,25,	,2,3,4,5,6,7,8,9,10,,,13,14,,,17,,18,19,20,,,23,24,25,26	,2,3,4,5,6,7,,9,10,,,,14,,,17,,,19,,,,23,24,25,
	C25	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,,18,19,,21,22,23,24,25,26	1,2,3,**4**,5,6,7,8,9,10,11,12,13,14,15,,17,,18,19,20,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,,17,,18,,19,,21,22,23,24,25,26
	C26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,,18,19,20,21,22,23,24,25,26	1,2,3,**4**,5,6,7,8,9,10,11,,13,14,,,,,18,,20,,2,2,23,,25,26	1,2,3,4,5,6,7,8,9,10,11,,13,14,,,,,18,,,20,,,22,23,,25,26

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Appendix 3. Determining the six levels of variables in the ISM hierarchy

The second level of variables in the ISM hierarchy				
Level	Cods	Reachability Set	Antecedent Set	Intersection Set
2	C01	1,2,,4,5,6,7,,9,10,11,12,,14,15,,,,,,,21,22,23,,25,26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,,17,,18,19,20,21,22,23,24,25,26	1,2,,4,5,6,7,,9,10,11,12,,14,15,,,,,,,21,22,23,,25,26
2	C02	1,2,3,4,5,6,7,,9,10,11,12,,14,15,,17,,,19,,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,,17,,,19,20,21,22,23,24,25,26	1,2,3,4,5,6,7,,9,10,11,12,,14,15,,17,,,19,,21,22,23,24,25,26
	C03	1,2,3,4,5,6,7,8,9,10,11,12,,14,15,,17,,,19,,21,22,23,24,25,26	,2,3,**4**,5,6,7,8,9,10,11,12,13,14,15,,,,18,19,20,21,22,23,24,25,26	,2,3,4,5,6,7,8,9,10,11,12,,14,15,,,,,19,,21,22,23,24,25,26
	C04	1,2,3,4,5,6,7,,9,10,11,12,,14,15,,17,,,19,,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,,,13,14,,,17,,18,19,20,,,23,24,25,26	1,2,3,4,5,6,7,,9,10,,,,14,,,17,,,19,,,,23,24,25,26
	C05	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,,17,,18,19,20,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,,,,18,19,20,21,22,23,24,25,26	1,2,3,4,5,,6,7,8,9,10,11,12,13,14,15,,,,18,19,20,21,22,23,24,25,26
2	C06	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,,17,,18,19,20,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,,17,,18,19,20,21,22,23,24,25,26	1,2,3,4,5,,6,7,8,9,10,11,12,13,14,15,,17,,18,,19,20,21,22,23,24,25,26
	C07	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,,17,,18,19,20,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,,13,14,15,,,,18,19,20,21,,23,24,25,26	1,2,3,4,5,,6,7,8,9,10,11,,13,14,15,,,,18,19,20,21,,23,24,25,26
	C08	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,,17,,,19,,21,22,23,24,25,26	,,3,,5,6,7,8,9,10,11,,13,14,,,,,18,19,20,21,,23,,25,26	,,3,,5,6,7,,8,9,10,11,,13,14,,,,,,19,,21,,23,,25,26
	C09	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,,17,,,,,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,,13,14,15,,17,,18,19,20,21,,23,24,25,26	1,2,3,4,5,,6,7,8,9,10,11,,13,14,15,,17,,,,,21,,23,24,25,26
2	C10	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,,17,,18,19,20,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,,17,,18,19,20,21,22,23,24,25,26	1,2,3,4,5,,6,7,8,9,10,11,12,13,14,15,,17,,18,,19,20,21,22,23,24,25,26
2	C11	1,2,3,,5,6,7,8,9,10,11,12,13,14,15,,,,18,19,,21,22,23,,25,26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,,17,,18,19,20,21,22,23,24,25,26	1,2,3,,5,6,7,8,9,10,11,12,13,14,15,,,,18,19,,21,22,23,,25,26
2	C12	1,2,3,,5,6,,,,10,11,12,,14,15,,,,,19,,21,22,23,,25,	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,,17,,18,19,20,21,22,23,24,25,26	1,2,3,,5,6,,,,10,11,12,,14,15,,,,,19,,21,22,23,,25,
	C13	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,,17,,18,19,,21,22,23,24,25,26	,,,,5,6,7,8,9,10,11,,13,,,,,,18,19,20,,,23,,25,26	,,,,5,6,7,8,,9,10,11,,13,,,,,,18,19,,,,23,,25,26
2	C14	1,2,3,4,5,6,7,8,9,10,11,12,,14,15,,17,,18,,20,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,,17,,18,19,20,21,22,23,24,25,26	1,2,3,4,5,,6,7,8,9,10,11,12,,14,15,,17,,18,,20,21,22,23,24,25,26
2	C15	1,2,3,,5,6,7,,9,10,11,12,,14,15,,,,,,21,22,23,,25,	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,,17,,18,19,20,21,22,23,24,25,26	1,2,3,,5,6,7,,9,10,11,12,,14,15,,,,,,21,22,23,,25,
	C17	1,2,,4,,6,,,9,10,11,12,,14,15,,17,,,,,21,22,,24,25,	,2,3,4,5,6,7,8,9,10,,,13,14,,,17,,18,19,20,21,,23,24,25,26	,2,,4,,6,,,9,10,,,,14,,,17,,,,,21,,,24,25,
	C18	1,,3,4,5,6,7,8,9,10,11,12,13,14,15,,17,,18,19,,21,22,23,24,25,26	,,,,5,6,7,,,10,11,,13,14,,,,,18,,20,,,23,,25,26	,,,,5,6,7,,,10,11,,13,14,,,,,18,,,,,23,,25,26
	C19	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,,17,,,19,,21,22,23,24,25,	,2,3,**4**,5,6,7,8,,10,11,12,13,,,,,,18,19,20,21,,23,24,25,26	,2,3,4,5,6,7,8,,10,11,12,13,,,,,,,19,,21,,23,24,25,
	C20	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,,17,,18,19,20,21,22,23,24,25,26	,,,,5,6,7,,,10,,,,14,,,,,,,20,,,23,,,26	,,,,5,6,7,,,10,,,,14,,,,,,,20,,,23,,,26
2	C21	1,2,3,,5,6,7,8,9,10,11,12,,14,15,,17,,,19,,21,22,23,,25,	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,,17,,18,19,20,21,22,23,24,25,26	1,2,3,,5,6,7,8,9,10,11,12,,14,15,,17,,,19,,21,22,23,,25,
2	C22	1,2,3,,5,6,,,,10,11,12,,14,15,,,,,,,21,22,23,,25,26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,,17,,18,19,20,21,22,23,24,25,26	1,2,3,,5,6,,,,10,11,12,,14,15,,,,,,,21,22,23,,25,26
	C23	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,,17,,18,19,20,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,,,,18,19,20,21,22,23,24,25,26	1,2,3,4,5,,6,7,8,9,10,11,12,13,14,15,,,,18,19,20,21,22,23,24,25,26
	C24	1,2,3,4,5,6,7,,9,10,11,12,,14,15,,17,,,19,,21,22,23,24,25,	,2,3,4,5,6,7,8,9,10,,,13,14,,,17,,18,19,20,,,23,24,25,26	,2,3,4,5,6,7,,9,10,,,,14,,,17,,,19,,,,23,24,25,
2	C25	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,,17,,18,19,,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,,17,,18,19,20,21,22,23,24,25,26	1,2,3,4,5,,6,7,8,9,10,11,12,13,14,15,,17,,18,,19,,21,22,23,24,25,26
	C26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,,17,,18,19,20,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,,13,14,,,,,18,,20,,22,23,,25,26	1,2,3,4,5,,6,7,8,9,10,11,,13,14,,,,,18,,20,,22,23,,25,26

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[DOI: 10.47176/mjiri.36.35]

Appendix 3. Determining the six levels of variables in the ISM hierarchy

Third level of variables in the ISM hierarchy

Level	Codes	Reachability Set	Antecedent Set	Intersection Set
	C03	„3,4,5„7,8,9„„„„17„„19„„23,24„26	„3,4,5„7,8,9„„13„„„18,19,20„„23,24„26	„3„4,5„7,8,9„„„„„„19„„23,24„26
3	C04	„3,4,5„7„9„„„„„17„„19„„23,24„26	„3,4,5„7,8,9„„13„„„17„18,19,20„„23,24„26	„3,4,5„7„9„„„„„17„„19„„23,24„26
	C05	„3,4,5„7,8,9„„13„„„17„18,19,20„„23,24„26	„3,4,5„7,8,9„„13„„„18,19,20„„23,24„26	„3,4,5„7,8,9„„13„„„18,19,20„„23,24„26
	C07	„3,4,5„7,8,9„„13„„„17„18,19,20„„23,24„26	„3,4,5„7,8,9„„13„„„18,19,20„„23,24„26	„3,4,5„7,8,9„„13„„„18,19,20„„23,24„26
	C08	„3,4,5„7,8,9„„13„„„17„„19„„„23,24„26	„3„5„7,8,9„„13„„„18,19,20„„23„„26	„3„5„7,8,9„„13„„„19„„„23„„26
3	C09	„3,4,5„7,8,9„„13„„„17„„„„„23,24„26	„3,4,5„7,8,9„„13„„„17„18,19,20„„23,24„26	„3„4„5„7,8,9„„13„„„17„„„„„23,24„26
	C13	„3,4,5„7,8,9„„13„„„17„18,19„„„23,24„26	„„„5„7,8,9„„„13„„„„18,19,20„„23„„26	„„„5„7,8,9„„„13„„„„18,19„„„23„„26
3	C17	„„4„„„9„„„„„17„„„„„24„„	„3,4,5„7,8,9„„„13„„„17„18,19,20„„23,24„26	„„4„„„9„„„„„17„„„„„24„„
	C18	„3,4,5„7,8,9„„13„„„17„18,19„„„23,24„26	„„„5„7„„„„13„„„„18„20„„23„„26	„„„5„7„„„„13„„„„18„„„23„„26
	C19	„3,4,5„7,8,9„„13„„„17„„19„„„23,24„„	„3,4,5„7,8„„„13„„„„18,19,20„„23,24„26	„3„4,5„7,8„„„13„„„„19„„„23,24„„
	C20	„3,4,5„7,8,9„„13„„„17„18,19,20„„23,24„26	„„„5„7„„„„„„„„„„20„„23„„26	„„„5„7„„„„„„„„„„20„„23„„26
	C23	„3,4,5„7,8,9„„13„„„17„18,19,20„„23,24„26	„3,4,5„7,8,9„„13„„„18,19,20„„23,24„26	„3,4,5„7,8,9„„13„„„18,19,20„„23,24„26
3	C24	„3,4,5„7„9„„„„„17„„19„„„23,24„„	„3,4,5„7,8,9„„13„„„17„18,19,20„„23,24„26	„3„4,5„7„9„„„„„17„„19„„„23,24„„
	C26	„3,4,5„7,8,9„„13„„„17„18,19,20„„23,24„26	„3,4,5„7,8,9„„13„„„18„20„„23„„26	„3,4„5„7,8,9„„13„„„18„20„„23„„26

The Fourth level of variables in the ISM hierarchy

Level	Cods	Reachability Set	Antecedent Set	Intersection Set
4	C03	„3„5„7,8„„„„„„„19„„23„„26	„3„5„7,8„„„13„„„18,19,20„„23„„26	„3„5„7,8„„„„„„„19„„23„„26
4	C05	„3„5„7,8„„„13„„„18,19,20„„23„„26	„3„5„7,8„„„13„„„18,19,20„„23„„26	„3„5„7,8„„„13„„„18,19,20„„23„„26
4	C07	„3„5„7,8„„„13„„„18,19,20„„23„„26	„3„5„7,8„„„13„„„18,19,20„„23„„26	„3„5„7,8„„„13„„„18,19,20„„23„„26
4	C08	„3„5„7,8„„„13„„„„19„„23„„26	„3„5„7,8„„„13„„„18,19,20„„23„„26	„3„5„7,8„„„13„„„„19„„23„„26
	C13	„3„5„7,8„„„13„„„18,19„„23„„26	„„„5„7,8„„„13„„„18,19,20„„23„„26	„„„5„7,8„„„13„„„18,19„„23„„26
	C18	„3„5„7,8„„„13„„„18,19„„23„„26	„„„5„7„„„13„„„18„20„„23„„26	„„„5„7„„„13„„„18„„„23„„26
4	C19	„3„5„7,8„„„13„„„„19„„23„„	„3„5„7,8„„„13„„„18,19,20„„23„„26	„3„5„7,8„„„13„„„„19„„23„„
	C20	„3„5„7,8„„„13„„„18,19,20„„23„„26	„„„5„7„„„„„„„„„„20„„23„„26	„„„5„7„„„„„„„„„„20„„23„„26
4	C23	„3„5„7,8„„„13„„„18,19,20„„23„„26	„3„5„7,8„„„13„„„18,19,20„„23„„26	„3„5„7,8„„„13„„„18,19,20„„23„„26
	C26	„3„5„7,8„„„13„„„18,19,20„„23„„26	„3„5„7,8„„„13„„„18„20„„23„„26	„3„5„7,8„„„13„„„18„20„„23„„26

The fifth level of variables in the ISM hierarchy

Level	Cods	Reachability Set	Antecedent Set	Intersection Set
5	C13	„„„„„„„13„„„18„„„„26	„„„„„„„13„„„18„20„„„26	„„„„„„„13„„„18„„„„26
5	C18	„„„„„„„13„„„18„„„„26	„„„„„„„13„„„18„20„„„26	„„„„„„„13„„„18„„„„26
	C20	„„„„„„„13„„„18„20„„„26	„„„„„„„„„„„„„20„„„26	„„„„„„„„„„„„„20„„„26
5	C26	„„„„„„„13„„„18„20„„„26	„„„„„„„13„„„18„20„„„26	„„„„„„„13„„„18„20„„„26

The sixth levels of variables in the ISM hierarchy

Level	Cods	Reachability Set	Antecedent Set	Intersection Set
6	C21	„„„„„„„„„„„„„„C21„„„„	„„„„„„„„„„„„„„C21„„„„	„„„„„„„„„„„„„„C21„„„„

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[DOI: 10.47176/mjiri.36.35]