Health Impact Assessment : Quantifying and Modeling to Better Decide

Leonor Bacelar-Nicolau

ÉCOLE DOCTORALE Abbé-Grégoire
Laboratoire Interdisciplinaire de Recherche en Sciences de l'Action
FACULDADE DE MEDICINA DA UNIVERSIDADE DE LISBOA
Instituto de Medicina Preventiva & Saúde Pública e Instituto de Saúde Ambiental

THÈSE présentée par :

Leonor BACELAR-NICOLAU

soutenue le : **19 décembre 2017**

pour obtenir le grade de :

Docteur du Conservatoire National des Arts et Métiers
Discipline : Sciences de Gestion / Spécialité : Économie de la Santé

Doutor pela Universidade de Lisboa
Disciplina: Ciências e Tecnologias da Saúde / Especialidade : Organização e Gestão em Saúde

Health Impact Assessment:
Quantifying and Modeling to Better Decide

THÈSE dirigée par :

SAPORTA Gilbert	Professeur Emérite, Conservatoire National des Arts et Métiers
PEREIRA MIGUEL José	Professeur Emérite, Faculdade de Medicina da Universidade de Lisboa

JURY :

BLIEBERNICHT DUCLA SOARES José Luís	Président du Jury, Professeur, Vice-Président du Conseil Scientifique de Faculdade de Medicina da Universidade de Lisboa
RIBEIRO Ruy	Professeur, Faculdade de Medicina da Universidade de Lisboa
DAB William	Professeur, Conservatoire National des Arts et Métiers
COSTA PEREIRA Altamiro	Professeur, Faculdade de Medicina da Universidade do Porto
VAZ CARNEIRO António	Professeur, Faculdade de Medicina da Universidade de Lisboa
TORGAL DIAS GARCIA Jorge Manuel	Professeur, Faculdade de Ciências Médicas da Universidade Nova de Lisboa (NOVA Medical School)

Universidade de Lisboa
Faculdade de Medicina de Lisboa

Conservatoire National des Arts et Métiers

Avaliação de Impacte na Saúde: Quantificar e Modelizar para Melhor Decidir

Évaluation d'Impact sur la Santé: Quantifier et Modéliser pour Mieux Décider

Health Impact Assessment: Quantifying and Modeling to Better Decide

Leonor Bacelar Valente da Costa Nicolau

Orientadores / Encadrants/ Thesis Supervisors
Prof. Doutor José Pereira Miguel
Prof. Doutor Gilbert Saporta

Tese especialmente elaborada para obtenção do grau de Doutor em Ciências e Tecnologias da Saúde com Especialidade em Organização e Gestão em Saúde pela Universidade de Lisboa

Thèse élaborée pour l'obtention du grade de Docteur en

Sciences de Gestion, Spécialité en Économie de la Santé au Conservatoire des Arts et Métiers

Thesis prepared to obtain the degree of PhD in

Sciences and Health Technologies, Specialty in Health Management from Universidade de Lisboa and Management Sciences, Specialty in Health Economics from Conservatoire National des Arts et Métiers

Júri / Jury /Jury :
Presidente/Président/President :
Doutor José Luís Bliebernicht Ducla Soares, Professor Catedrático em regime de tenure e Vice-Presidente do Conselho Científico da Faculdade de Medicina da Universidade de Lisboa
Vogais/Membres/Members :
Doutor William Dab, Professeur titulaire de la chaire d'Hygiène et Sécurité ; responsable des enseignements de sécurité sanitaire du Conservatoire National des Arts et Métiers ; Directeur de l'École Sciences industrielles et technologies de l'information – SITI, Paris, França ;
Doutor Gilbert Marc Vital Saporta, Professeur Émérite de Statistique Appliquée du Conservatoire National des Arts et Métiers, Paris, França ; (co-Orientador)
Doutor Altamiro Manuel Rodrigues da Costa Pereira, Professor Catedrático da Faculdade de Medicina da Universidade do Porto;
Doutor Jorge Manuel Torgal Dias Garcia, Professor Catedrático da Faculdade de Ciências Médicas da Universidade Nova de Lisboa;
Doutor António Cândido Vaz Carneiro, Professor Associado com Agregação da Faculdade de Medicina da Universidade de Lisboa;
Doutor Ruy Miguel Sousa Soeiro de Figueiredo Ribeiro, Professor Associado com Agregação da Faculdade de Medicina da Universidade de Lisboa.

Partially funded by FCT, QREN, COMPETE (HMSP-ICT/0013/2011) through the CUTEHeart Project

2017

As opiniões expressas nesta publicação são da exclusiva responsabilidade da sua autora.

Les opinions exprimées dans cette publication sont la responsabilité exclusive de l'auteur.

The opinions expressed in this publication are the sole responsibility of its author.

À minha Família

À ma Famille

To my Family

"Life is a travelling to the edge of knowledge,
then a leap taken."
D. H. Lawrence

"Sound policies rest on good information."
Frederick Mosteller

"I find your lack of faith disturbing"
Darth Vader

Foreword and acknowledgements

Family legend says my first PhD jury was faced decades ago inside my mother’s belly in Paris. It also tells us that I was genetically conditioned to follow a professional life where multivariate data analysis would inevitably be present, both from my mother’s and my father’s side. Reality makes it obvious that I would be glad only to be half as brilliant as both my parents are regarding multivariate data analysis. However, one of the most important things I have definitively managed to learn from them was their love and drive to make multivariate statistics and data analysis related methods understandable and useful for all, to make it practical, data-focused, multidisciplinary: a truly visionary way of looking at something that is nowadays called data science.

Through my parents I also had the wonderful opportunity of simultaneously falling in love with travelling and meeting some of the greatest statistical brains from our time. Being a teenager and accompanying them to scientific conferences, I would take advantage of them actually spending their time at the venue and use all their vouchers for the social programmes (usually very rich in every meeting at the time). Languages skills from the Lycée français Charles Lepierre at Lisbon were, from then on, a very useful tool. Meeting all these researchers, including Gilbert Saporta, both in a professional but casual environment, listening to their discussions, interacting and participating in some of the less scientific conversations was a privilege that I then took for granted, only truly valued later in my life, but that I now truly cherish.

An economics “brain wash” at Nova Business School and brilliant teachers such as Pedro Pita Barros and José António Pinheiro confirmed me the power of numbers and statistics and their application to reality: macro and microeconomics settings joined marketing, opportunity costs and sustainability concerns, everything always measurable in terms of money-value, ROI, utilities, willingness-to-pay and risk expectations.

The following professional experiences at INE and Metris (now GfK-Metris) gave me the privilege of understanding how to collect data and transform information into knowledge both in public and private statistical environments. Further experience in the private sector, in my own firm, increased my certainty that data and statistics are most useful to non-statisticians, the more one is able to reach them and show them the added value of understandable, visual statistical results.

In an era of Big Data, of secondary data more and more integrated with primary data, being able to apply reliable and accurate multivariate statistical methods to ever and faster growing amounts of data, generating useful and easy to understand results is of the utmost importance. The challenge is even bigger when one tries to explain all this complexity to non-statisticians and aims to convince them of its usefulness to their everyday professional practice.

Disseminating the practical use of these methodologies within medical education settings is thus vital to guaranty an easier understanding of their value, encourage further research, increase its use in every-day life. Training and teaching statistics and economics to health professionals that so often have engraved an aversion to numbers into their minds and attitude is indeed a constant personal challenge. Since I began my work at FM UL, more than 13 years ago, few things though are more rewarding then one succeeding and suddenly watching understanding and interest illuminating students' eyes, of finding old students, sometimes years later, acknowledging the usefulness of one's classes and taught contents and case studies.

Despite all these clues and professional tracks traveled, my PhD pathway only became clear though when José Pereira Miguel made me see the beauty of public health, health promotion, equity and health policies and interventions as ways to contribute to the wellbeing of many in one go and throughout time in the long run. All these past experiences of multivariate data analysis, economics evaluation, private and public practice, academic and real-world environments seemed to come together when I tried to accomplish this PhD and contribute to further quantification in Health Impact Assessment of public health interventions. It only seemed natural to involve Gilbert Saporta, one of the few statisticians that I know that most successfully incarnates sound multivariate statistics, interdisciplinarity, applicability both academic and in real-world, an unselfish fondness to disseminate knowledge and a data science drive.

Every PhD work is just a beginning, a pathway that lead us forward into other paths, where one has a chance to improve on its research, to expand it to heights one wishes to

be valuable, useful not just for us but to others we may touch and influence with our positive energy. It may seem rather lonely sometimes, but a PhD work is never one person's travel but a team work, feeding on others knowledge, experiences and support.

I thus would like to thank…

… my dear Family for all their love, patience, support and for being who they are and making me who I am: both loves of my life André and Topê, my beloved, admired and cherished parents and sister, Helena, Fernando and Paula, and those loved ones who are always with us in spirit,

… my Mentor José Pereira Miguel, who offered me challenges, wisdom, a role model and trust and contributed so much to increase my sense of perfectionism, pride in the search for professionalism and thirst for knowledge,

… my invaluable Councilor Gilbert Saporta, who trusted my skills, guided me often too patiently for my own good and illuminated my path with his precious and powerful insights,

… my Friend and Colleague Teresa Rodrigues who gave me strength, energies and advise in times of trouble and need,

… my Colleagues, and now Friends, from the CUTEHeart Project who offered me advice, knowledge, experience and support from all the way across rivers and oceans, most often far away in miles but close to my heart, Mariana Lobo, Claudia Nisa and Altamiro Costa Pereira from Porto, Armando Teixeira Pinto from Sydney, Elisabete Fernandes nearest from Lisbon, Vanessa Azzone and Sharon-Lise Normand from Boston,

… my Colleagues Antónia Ferreira for her priceless and relentless help through the administrative pitfalls over the years and Sofia Amador and André Silva for their ever-available support in finding the unfindable through the infinite labyrinth of bibliographical references,

… all Colleagues, Co-workers, Family and Friends, who helped and supported me throughout this sometimes seemingly never-ending story, always believing that I would reach safe port in a near future.

Table of Contents

Figure Index

Chapter 1 – Introduction and Main Research Aims

Chapter 2 – Exploring and Profiling through the State of the Art

Chapter 3 – Contribution of Hierarchical Cluster Analysis to the Health Impact Assessment Screening Step

SubChapter 3.1 – Screening Hospital Reform Policies for Health Impact Assessment: easier decision making through cluster analysis

SubChapter 3.2 – Screening National Health Programs for Health Impact Assessment: targeting policies with cluster analysis

Chapter 4 – Picturing Inequities for Health Impact Assessment: Linked Electronic Records, Mortality and Regional Disparities in Portugal

Table Index

Chapter 1 – Introduction and Main Research Aims

Chapter 2 – Exploring and Profiling through the State of the Art

Chapter 3 – Contribution of Hierarchical Cluster Analysis to the Health Impact Assessment Screening Step

SubChapter 3.1 – Screening Hospital Reform Policies for Health Impact Assessment: easier decision making through cluster analysis

SubChapter 3.2 – Screening National Health Programs for Health Impact Assessment: targeting policies with cluster analysis

Abbreviations

ACSS - Administração Central do Sistema de Saúde (Institution from the Portuguese Ministry of Health)
AIS - Avaliação de Impacte na Saúde
AMI - Acute Myocardial Infarction
BMI - Body Mass Index
CA - Correspondence Analysis
CEA - Cost Effectiveness Analysis
CI95% - 95% Confidence Intervals
CVD - Cardiovascular Disease
DGS - Direção-Geral da Saúde
EqIA - Equality Impact Assessment
EIA - Environmental Impact Assessment
EIS - Évaluation d'Impact sur la Santé
EFHIA - Equity Focused Health Impact Assessment
EHR - Electronic Health Records
EU - European Union
HCA - Hierarchical Cluster Analysis
HIA - Health Impact Assessment
HRIA - Human Rights Impact Assessment
HSIA - Health Systems Impact Assessment
HTA - Health Technology Assessment
IA - Impact Assessment
IAIA - International Association for Impact Assessment
IIA - Integrated Impact Assessment
INSA - Instituto Nacional de Saúde Dr. Ricardo Jorge (Institution from the Portuguese Ministry of Health)
LVT - Lisboa e Vale do Tejo (health region in Portugal)
MCA - Multiple Correspondence Analysis
MHIA - Mental Health Impact Assessment
NHS - National Health Service
NPs - National Health Programs
OECD - Organisation for Economic Co-operation and Development
OR - Odds Ratio
PC - Primary Care
PCA - Principal Components Analysis
PIA - Poverty Impact Assessment
PNCDT - NP against Drugs and Addictions
PNDCV - Programa Nacional de Doenças Cerebro-cardiovasculares / Cerebro-cardiocardiovascular Disease National Program
PNPCDO - NP for Oncological Disease Prevention and Control
PNRPLA - NP for Reducing Alcohol Related Problems
ROAMEF - Rationale, Objectives, Appraisal, Monitoring, Evaluation cycle
SEA - Strategic Environmental Assessment
SOM - Supplemental Online Material (Chapter 4)
SPMS - Serviços Partilhados do Ministério da Saúde (Institution from the Portuguese Ministry of Health)
SS - Sustainability Statement
UK - United Kingdom
USA - United States of America
USF - Unidade de Saúde Familiar (recent primary healthcare units in the Portuguese NHS)
WHO - World Health Organization

Graphical Abstract

Chapter 1: Introduction and Main Research Aims

Context: Health Impact Assessment - HIA
Main Aim: Enrich HIA practice by applying data mining/data science quantified multivariate statistical methodologies, in deeply evidence based context

Chapter 2: Exploring and Profiling through the State of the Art

Aims: Explore recent research on HIA to identify a common scientific approach and assess the pertinence of applying multivariate quantified methodologies within non-environmental public policies impact assessments
Tools: Multiple Correspondence Analysis; Hierarchical Cluster Analysis; Text Mining
Outcomes:

- HIA universal guide may be possible: most common/distinctive features and potential candidates are identified
- Quantification in HIA is still more associated to environmental papers: potential added value to apply it to non-environmental Public Policies exists

Chapter 3.1: Screening Hospital Reform Policies

Aims: Show how hierarchical cluster analysis may contribute to the HIA screening step by prioritizing policies for the health systems Portuguese hospital reform
Tools: Hierarchical Cluster Analysis
Principal Components Analysis
Multiple Correspondence Analysis
Outcomes:

- Policies fundamentally related to management issues and links between hospital and primary care services should be priorities for HIA

Chapter 3.2: Screening National Health Programs

Aims: Show how hierarchical cluster analysis may contribute to the HIA screening step by ranking National Health Programs and select the priority clinical domain for our HIA
Tools: Hierarchical Cluster Analysis
Principal Components Analysis
Multiple Correspondence Analysis
Outcomes:

- Policies related to the Cerebro-Cardiovascular National Program should be priorities for HIA

Chapter 4: Picturing Inequities for Health Impact Assessment

Aims:
Show how multivariate statistical analysis may contribute to conduct a HIA taking equity into consideration
Propose a conceptual quantitative path based on the study of the association between acute myocardial infarction mortality, an Electronic Health Records policy and regional equity
Tools: Stratified Logistic Regression; Adjusted Odds Ratios; Principal Components Analysis; Multiple Correspondence Analysis
Outcomes:

- An adequate application of Electronic Health Records guidelines throughout regions may decrease regional health inequities.
- A path of analysis to study the association between a public policy and associated health impacts while taking equity into account may be put into practice.

Chapter 5: Discussion, Conclusions and Future Perspectives

The future health reforms places the citizen at the core of multisource, various natures Big Data to assure health promotion and disease prevention and to evaluate healthcare based on users' information.
Quantified multivariate HIA is a valuable tool to assure health impacts of public policies are measured taking into consideration health determinants and equity and bringing citizens to the center of the decision-making process.

Abstract

Context

Health Impact Assessment (HIA) is a combination of procedures, methods and tools by which a policy may be judged as to its potential effects and its distribution on a population's health, with thus a particularly strong concern regarding equity issues. It is at its core a decision-making support tool, having as main output recommendations to help decision-makers assure that the policies they implement minimize negative effects on health and equity and maximize positive ones. Throughout the various HIA steps, it is still generally and very often a qualitative approach, very seldom using multivariate statistical methodologies.

Main Aim

To show the usefulness of applying quantified multivariate statistical methodologies to enrich HIA practice, while making the decision-making process easier, in terms of issuing understandable outputs even for non-statisticians, but still in a deeply evidence based context.

Exploring and Profiling through the State of the Art

HIA is born out of two distinct areas of knowledge: environmental assessment and public health. Two questions arise: Are consensus guidelines possible? Are quantitative methods applied throughout both areas?

Profiling the 45 HIA guides studied by Herbert (2012) with hierarchical cluster analysis shows a consensus universal guide would be plausible and 9 candidates are pinpointed to potentially serve as its foundation.

The titles of 247 HIA Journal Papers listed in the Health Impact Assessment Section of the HIA Gateway Bibliography associated to Public Health England from 2012 to 2014, and additionally the available keywords for 170 of these papers, were studied with multivariate text analysis, regarding profiles of year, being published in a more environmental or public health journal and using quantitative methods. It is shown that results based on titles and on keywords are coherent, that 2014 tends to be less related with environmental journals, that HIA in environmental fields is more quantitative (especially in what concerns related risk assessments) and in public health is more qualitative and mainly related to social health determinants and equity concerns.

It is thus pertinent and an added value to current knowledge to encourage the use of quantified, multivariate statistical methods (such as cluster analysis or multivariate text analysis) when assessing health impacts of public policies and related equity issues with HIA.

Contributing with Hierarchical Cluster Analysis to the Health Impact Assessment Screening Step

The screening step of HIA helps us here to choose the area and focus of our research. Hierarchical Cluster Analysis is used as a basic methodology to contribute for improving the HIA screening step, regarding two situations.

A total of 76 Health Reform Policies in Portugal was rated by a panel of 7 international renowned public health experts from Nova University in 2011 on a 10-point scale (1-Very low to 10-Very high) regarding Potential Impact, Ease of implementation and Implementation costs. Cluster analysis allowed us to make scenario analysis regarding all possible cluster priorities and to pinpoint a group of policies with high potential impact and low implementation costs, focusing policies linked to management issues setting a legal background and operational benchmarks improving the link between hospital and primary care services.

A total of 30 National Health Programs from the National Health Plan 2004-2010 were described by datasets of variables in 7 domains. Each domain is ranked according to a previously determined set of criteria for being a potential priority for HIA. Hierarchical cluster analyses results and complementary multivariate methodologies enabled us then to rank each cluster in each partition, within each domain and then taking into account all 7 domains. The policies related to the Cerebro-cardiovascular Program are thus chosen as first priority to apply HIA to, according to various criteria of regional span, concerns of health gains, health systems needs and effectiveness gains, being high-priority for National Health Plans, among others.

These analyses lead us to the choice of the empirical setup used throughout the study of equity below, namely regarding cardiovascular disease and policies concerning hospital-primary care links.

Picturing Inequities for Health Impact Assessment

A conceptual quantitative path of analysis to study the association between a public policy and health impacts while taking equity into account is proposed, showing how one may put it into practice. Data includes 3.776 adults admitted in hospitals for acute myocardial infarction during the second semester of 2012, followed regularly in primary care during 2013, always within the National Health Service in Portugal. The policy whose impact is be assessed in a HIA context is the registry of information regarding indicators Blood Pressure, Cholesterol, Triglycerides, Waist Circumference and Body Mass Index. The health impact of interest is the mortality status at the end of the period of study (December 31 2013). The equity aspect under analysis concerns regional differences in Portugal, since not assuring an even application of the policy throughout all the 5 health regions of residence (Norte, Centro, LVT, Alentejo and Algarve) may increase regional health inequities. Crude and adjusted OR (for sex, age, sex*age, 4 severity hospital admission indicators) are calculated with Logistic Regressions, complemented by exploratory multivariate data analysis such as Principal Components and Multiple Correspondence Analysis.

Firstly, differences are found among regions regarding the registration of health indicators under study. This assures the relevancy of studying the association between the mortality outcome and the registration of health indicators stratified by region. Distinct mortality-registration associations are then found among regions in their association patterns regarding mortality and the registration of the health indicators under study. This hints that the registration of health indicators linking information from Hospital and Primary healthcare, throughout the different regions, may contribute for better health outcomes. The pursuit of delivering research results in a very visually comprehensible approach, given the elected multivariate methodologies used, intends to facilitate decision makers' understanding of outcomes reached.

Discussion, Conclusions and Future Perspectives

Applying data mining and data science methodologies means that even if multivariate statistical methods used are complex, graphical outputs may simplify the understanding of results by decision makers.

The future of healthcare reforms shifts the center of evaluation of health systems from providers to people's individual needs and preferences, by reducing health inequities in access and health outcomes, adapting health systems to new health technologies, using big data linking information from providers to social and economic health determinants. New or innovative statistical and assessment methodologies are needed to set this transformation into motion.

Quantified multivariate HIA thus represents a valuable tool to assure health impacts of public policies are indeed measured taking into consideration health determinants and equity and bringing citizens to the center of the decision-making process.

Keywords

Health Impact Assessment; Equity; Multivariate Data Analysis; Modeling; Decision-Making

Resumo Gráfico

Capítulo 1: Introdução e Principais Objetivos de Investigação

Contexto: Avaliação de Impacte na Saúde - AIS
Objetivo Principal: Enriquecer a prática de AIS aplicando metodologias estatísticas multivariadas associadas a *data mining/data science* num contexto fortemente baseado na evidência

Capítulo 2: Identificando e Explorando Perfis no Estado da Arte

Objetivos: Explorar investigação recente em AIS para identificar uma abordagem científica comum e avaliar a pertinência de aplicar metodologias quantitativas multivariadas a avaliação de impacte de políticas fora do sector ambiental
Ferramentas: Análise de Correspondências Múltiplas; Classificação Hierárquica; *Text Mining*
Resultados:

- Um Guia Universal de AIS pode ser uma realidade: são identificados características comuns e distintivas e potenciais candidatos
- As AIS quantitativas são ainda mais associadas a publicações ambientais: existe um valor acrescentado potencial de aplicação em políticas públicas fora do sector ambiental

Capítulo 3.1: *Screening* de Reformas Hospitalares

Objetivos: Mostrar o contributo da classificação hierárquica na seleção para AIS e priorização de medidas de reforma hospitalar em Portugal
Ferramentas: Classificação Hierárquica, Análise em Componentes Principais, Análise Factorial de Correspondências Múltiplas
Resultados:

- Devem ser prioridades para AIS medidas fundamentalmente associadas a gestão e ligação entre a prestação de serviços de cuidados de saúde primários e hospitalares

Capítulo 3.2: *Screening* de Programas Nacionais

Objetivos: Mostrar o contributo da classificação hierárquica na seleção para AIS de Programas Nacionais de Saúde e priorização de domínios clínicos de aplicação para a nossa AIS
Ferramentas: Classificação Hierárquica, Análise em Componentes Principais, Análise Factorial de Correspondências Múltiplas
Resultados:

- Devem ser prioridades para AIS medidas associadas ao Programa Nacional de Doenças Cerebro-Cardiovasculares

Capítulo 4: Visualizando Inequidades para Avaliação de Impacte na Saúde

Objetivos:
Mostrar o contributo da análise estatística multivariada na tomada em consideração da equidade em AIS
Propor um caminho quantitativo conceptual baseado no estudo da associação entre a mortalidade por enfarte agudo do miocárdio, uma política de registo eletrónico de informação em saúde e a procura de equidade regional
Ferramentas: Regressão Logística Estratificada; *Odds Ratios* Ajustados; Análise em Componentes Principais; Análise Factorial de Correspondências Múltiplas
Resultados:

- A aplicação de *guidelines* sobre registo eletrónico de informação em saúde poderá diminuir inequidades regionais.
- Uma estratégia de análise da associação entre uma política pública, o seu impacte sobre saúde e considerando a equidade pode ser posta em prática.

Capítulo 5: Discussão, Conclusões e Perspetivas Futuras

O futuro das reformas em saúde coloca o cidadão no centro da promoção de saúde e prevenção de doença baseadas em *Big Data* de naturezas e fontes diversas e da construção de indicadores de performance e qualidade da prestação de serviços de saúde. A quantificação em AIS é uma ferramenta valiosa para assegurar que o impacte em saúde de políticas públicas é medido tendo em conta determinantes de saúde e equidade, trazendo os cidadãos para o centro do processo de tomada de decisão.

Resumo

Contexto

A Avaliação de Impacte na Saúde (AIS) é uma combinação de procedimentos, métodos e instrumentos, pelos quais uma política, programa ou projeto, do sector público ou privado, pode ser julgado(a) em termos dos seus potenciais efeitos na saúde da população, bem como quanto à distribuição desses efeitos na mesma população, tendo assim uma forte preocupação relativa a equidade. É na sua base construído como um instrumento de apoio à tomada de decisão, tendo como principais *outputs* recomendações para os decisores assegurarem que as politicas implementadas minimizam efeitos na saúde e na equidade negativos e maximizam positivos. Ao longo das suas diversas fases, a AIS é geralmente e muito frequentemente uma abordagem qualitativa, sendo rara a aplicação de metodologias estatísticas multivariadas.

Objetivo Principal

Mostrar a utilidade de aplicar metodologias estatísticas quantitativas e multivariadas para enriquecer a prática da AIS, tornando o processo de tomada de decisão mais fácil, no sentido de auxiliar a compreensão dos resultados por profissionais não-estatísticos, mas sempre num contexto aprofundadamente baseado na evidência.

Identificando e Explorando Perfis no Estado da Arte

A AIS nasceu de duas áreas distintas do conhecimento: avaliação ambiental e saúde pública. Duas questões surgem ao explorar o estado-da-arte: será possível a criação de um guia universal? Serão as metodologias quantitativas aplicadas de forma corrente em ambas as áreas?

A construção de perfis com classificação hierárquica dos 45 guias de AIS inicialmente estudados por Herbert (2012) mostra que um guia universal seria possível e são identificados 9 candidatos potenciais a servir como base.

Os títulos de 247 artigos científicos listados pela *Health Impact Assessment Section* da *HIA Gateway Bibliography* associada à *Public Health England* de 2012 a 2014, bem como as palavras-chave disponíveis em 170 desses artigos, são estudados com análise textual multivariada, tendo em conta perfis de ano, ser publicado numa publicação ambiental ou numa de saúde pública e usar métodos quantitativos. Os resultados baseados nos títulos e nas palavras-chave revelam-se coerentes, mostrando que o ano 2014 tende a estar mais associado a publicações ambientais, que as AIS em áreas ambientais são mais frequentemente quantitativas (essencialmente no que respeita a avaliação de risco) e que as AIS em áreas de saúde pública são mais qualitativas e sobretudo relacionadas com determinantes sociais de saúde e preocupações de equidade.

Torna-se assim pertinente e representa um valor acrescentado para o estado do conhecimento atual, encorajar a aplicação de métodos quantitativos de estatística multivariada (como

classificação hierárquica ou análise textual multivariada) ao avaliar com AIS o impacte na saúde e na equidade em saúde de políticas em saúde pública.

Contribuindo com Classificação Hierárquica para a fase de Rastreio em AIS

A fase de rastreio (*screening*) em AIS ajuda-nos aqui a selecionar a área de enfoque da nossa investigação. A classificação hierárquica é usada como metodologia de base para contribuir a melhorar a fase de rastreio da AIS em duas situações distintas.

Um total de 76 políticas de reforma hospitalar da saúde em Portugal foram previamente classificadas por um painel de 7 especialistas de renome na área de saúde pública da Universidade Nova de Lisboa, considerando uma escala de 10 pontos (1-Muito baixo a 10-Muito elevado) relativa a Impacte Potencial, Facilidade de Implementação e Custos de Implementação. A classificação hierárquica permitiu-nos agrupar as políticas em classes distintas, realizar uma análise de cenários considerando todas as possíveis priorizações de classes e eleger um grupo específico de políticas como potenciais prioridades para AIS. Esse grupo engloba políticas com elevado impacte e menores custos de implementação, incluindo medidas associadas a gestão e à criação de modelos de *benchmarking* legais e operacionais quanto à ligação entre prestação de serviços de cuidados de saúde primários e hospitalares.

Um total de 30 Programas Nacionais de Saúde enquadrados no Plano Nacional de Saúde 2004-2010 foram descritos por variáveis, agrupadas em 7 domínios. Cada domínio é ordenado de acordo com um conjunto de critérios previamente determinados de acordo com o constituir uma prioridade potencial para AIS. Os resultados da classificação hierárquica e metodologias complementares aplicados em cada domínio permitem-nos então ordenar cada classe de programas de acordo com o potencial esperado para ser prioridade para AIS e, em seguida, ter em conta a ordenação dos domínios. As políticas associadas ao Programa Nacional para as Doenças Cerebro-Cardiovasculares surgem como prioritárias para AIS, de acordo com os diversos critérios de abrangência regional, preocupações com ganhos em saúde, necessidades de sistemas de saúde e ganhos de efetividade, ser um programa prioritário a nível do Plano Nacional de Saúde, entre outros.

Esta análise leva-nos a escolher como contexto de aplicação do estudo da equidade em AIS abaixo a área das doenças cérebro-cardiovasculares, quanto a políticas ligando os cuidados de saúde primários aos hospitalares.

Visualizando Iniquidades para Avaliação de Impacte na Saúde

Propomos um caminho conceptual de análise da associação entre uma política pública e o impacte na saúde tendo em conta preocupações de equidade, mostrando como pode ser posto em prática. Os dados contemplam 3.776 adultos internados em hospitais com um diagnóstico de enfarte agudo do miocárdio durante o segundo semestre de 2012 e seguidos regularmente nos cuidados de saúde primários durante 2013, sempre no Serviço Nacional de Saúde em Portugal. A política avaliada num contexto de AIS é o registo de informação relativo aos indicadores Pressão arterial, Colesterol, Triglicéridos, Perímetro abdominal e Índice de Massa Corporal. O impacte na saúde de interesse é a mortalidade até ao final do período de estudo (31 de Dezembro de 2013). O aspeto de equidade focado respeita às disparidades regionais em Portugal, visto que não aplicar a política de forma adequada nas 5 regiões de residência (Norte, Centro, LVT, Alentejo e Algarve) pode aumentar iniquidades de saúde regional. São estimados OR brutos e ajustados (para sexo, idade, sua interação, 4 indicadores de severidade do internamento) por Regressão Logística, complementada por métodos de análise de dados multivariada exploratória como Análise em Componentes Principais e Análise de Correspondências Múltiplas.

Numa primeira fase, as diferenças encontradas entre regiões quanto ao registo dos indicadores de saúde estudados realçam a relevância de analisar a associação entre a mortalidade e o registo, estratificada por região. Em seguida, a análise revela padrões de associações de mortalidade-registo distintos entre regiões, indiciando que o registo de diferentes indicadores aliando informação hospitalar à de cuidados de saúde primários pode contribuir para melhores *outcomes* de saúde ao longo das diversas regiões. A apresentação gráfica dos resultados gerados pelas metodologias multivariadas aplicadas pode potenciar a compreensão da abordagem, facilitando o entendimento dos resultados pelos decisores.

Discussão, Conclusões e Perspetivas Futuras

A aplicação de métodos estatísticos mais usuais em *data mining* e *data science* implica que mesmo metodologias mais complexas podem gerar resultados gráficos que simplifiquem a compreensão e potenciem a sua adesão à utilização de AIS.

O futuro das reformas dos sistemas de saúde desloca o centro da avaliação dos serviços de saúde dos prestadores para os cidadãos e para as suas necessidades e preferências, reduzindo as iniquidades no acesso à saúde e a ganhos em saúde, adaptando os sistemas de saúde a novas tecnologias, tirando partido de *big data* que associa desde informação dos prestadores a dados sociais e económicos de determinantes de saúde. Torna-se necessário desenvolver e aplicar metodologias estatísticas e de avaliação novas ou inovadoras que ponham em movimento esta transformação.

A AIS que aplique métodos quantificados multivariados representa assim uma ferramenta valiosa para assegurar que o impacte em saúde de políticas públicas é medido tendo em consideração determinantes de saúde e equidade, trazendo os cidadãos para o centro do processo de tomada de decisão.

Palavras-chave

Avaliação de Impacte na Saúde; Equidade; Análise de Dados Multivariada; Modelização; Tomada de decisão

Résumé Graphique

Chapitre 1: Introduction et Objectifs de Recherche

Contexte: Évaluation d'Impact sur la Santé - EIS
Objectif Principal: Enrichir la pratique de EIS par l'application de méthodologies quantitatives statistiques multivariées de *data mining*/*data science*, dans un contexte fortement *evidence-based*.

Chapitre 2: Identifiant et Explorant des Profils d'État de l'Art

Objectifs: Explorer la recherche récente en EIS pour identifier une approche scientifique commune et évaluer la pertinence d'appliquer des méthodologies quantificatives multivariées en EIS de politiques publiques non-environnementales
Outils: Analyse des Correspondances Multiples; Classification Hiérarchique; *Text Mining*
Résultats:
- Un guide universel en EIS est possible: caractéristiques communes/distinctives et candidats potentiels sont identifiés
- La quantification en EIS est encore plus associée aux publications scientifiques environnementales: une valeur ajoutée potentielle de l'appliquer aux politiques non-environnementales existe

Chapitre 3.1: Dépistage de Réformes de Santé

Objectifs: Montrer comment la classification hiérarchique peut contribuer au Dépistage/*Screening* en EIS en priorisant les politiques de reforme hospitalières des systèmes de santé au Portugal
Outils: Classification Hiérarchique
Analyse en Composantes Principales
Analyse des Correspondances Multiples
Résultats:
- Les politiques fondamentalement associées aux aspects de gestion et liens entre soins hospitaliers et primaires devraient constituer des priorités pour EIS

Chapitre 3.2: Dépistage de Programmes Nationaux

Objectifs: Montrer comment la classification hiérarchique peut contribuer au Dépistage/*Screening* en EIS en classant les Programmes Nationaux de Santé et sélectionnant le domaine de priorité clinique pour EIS
Outils: Classification Hiérarchique
Analyse en Composantes Principales
Analyse des Correspondances Multiples
Résultats:
- Les politiques liées au Programme National de Maladies Cerebro-Cardiovasculaires devraient constituer des priorités pour EIS

Chapitre 4: Visualisant les Iniquités en Évaluation d'Impact sur la Santé

Objectifs:
Montrer comment l'analyse statistique multivariée peut contribuer à mieux considérer l'équité en EIS.
Proposer un chemin conceptuel quantitatif basé sur l'étude de l'association entre la mortalité par infarctus aigu du myocarde, une politique d'enregistrement des dossiers cliniques et l'équité régionale
Outils: Régression Logistique Stratifiée; *Odds Ratios* Ajustés; Analyse en Composantes Principales; Analyse des Correspondances Multiples
Résultats:
- L'application adéquate de lignes directrice sur l'enregistrement électronique d'information en santé peut diminuer les iniquités régionales.
- Un chemin d'analyse de l'association entre une politique publique, son impact sur la santé, qui tient en compte l'équité peut être mis en place.

Chapitre 5: Discussion, Conclusions et Perspectives Futures

Le futur des réformes en santé place le citoyen au centre de *big data* de natures et sources diverses pour assurer la promotion de santé et prévention de maladie et pour évaluer les soins ayant pour base les informations des populations. Les EIS quantificatives multivariées sont des outils précieux pour assurer que l'impact des politiques publiques sont mesurés et tiennent en compte les déterminants de santé et l'équité, amenant les citoyens au centre du processus de prise de décision.

Résumé

Contexte

L'Évaluation d'Impact sur la Santé (EIS) est une combination de procédures, méthodes et outils, grâce auxquels une politique, un programme ou un projet, du secteur public ou privé, peut être jugé quant à ses effets potentiels sur la santé de la population, bien quant à la distribution de ses effets dans cette population, ayant ainsi une forte préoccupation d'équité. L'EIS est construite comme un instrument de support à la décision, ayant comme principaux *outputs* des recommandations pour aider les décideurs à assurer que les politiques implémentées minimisent les effets sur la santé négatifs et maximisent les positifs. Au long de ses diverses étapes, l'EIS est généralement et très fréquemment une approche qualitative, l'application de méthodologies statistiques multivariées étant rare.

Objectif Principal

Montrer l'utilité d'appliquer des méthodologies quantitatives et multivariées pour enrichir la pratique de EIS, rendant la prise de décision plus facile, au sens d'assister la compréhension des résultats par des professionnels non-statisticiens, maintenant toujours un contexte profondément basé sur l'évidence.

Identifiant et Explorant des Profils d'État de l'Art

L'EIS est issue de deux domaines distincts : l'évaluation environnementale et la santé publique. Deux questions surgissent en explorant l'état de l'art : est-ce possible de créer un guide universel? Est-ce que les méthodologies quantitatives sont appliquées couramment dans les deux domaines?

La construction de profils par classification hiérarchique de 45 guides de EIS étudiés initialement par Herbert (2012) montre qu'un guide universel serait possible et 9 candidats potentiels sont identifiés à servir comme base.

Les titres de 247 articles scientifiques listés par *Health Impact Assessment Section* de *HIA Gateway Bibliography* associée à *Public Health England* entre 2012 et 2014, bien que les mots-clés disponibles en 170 de ces articles, sont étudiés avec de l'analyse textuelle multivariée, tenant en compte des profils d'année, être publiés dans un journal environnemental ou de santé publique et employer des méthodes quantitatives. Les résultats basés sur les titres et sur les mots-clés s'avèrent cohérents, montrant que l'année 2014 semble plus associée à des publications environnementales, que les EIS en domaines environnementaux sont plus fréquemment quantitatives (essentiellement concernant des évaluations de risques) et que les EIS en domaines de santé publique sont plus souvent qualitatives et surtout associées aux déterminants sociaux de santé et à des soucis d'équité.

Il devient ainsi pertinent et représente une valeur ajoutée pour l'état actuel du savoir d'encourager l'application de méthodes quantitatives de statistique multivariée (comme la

classification hiérarchique ou l'analyse textuelle multivariée) en évaluant par EIS l'impact sur la santé et l'équité de politiques en santé publique.

Contribuant avec la Classification Hiérarchique pour l'étape de dépistage en EIS

L'étape de dépistage (*screening*) en EIS nous aide à sélectionner le domaine d'application de notre recherche. La classification hiérarchique est utilisée comme méthodologie de base pour contribuer à améliorer l'étape de dépistage en EIS en deux situations différentes.

Un total de 76 politiques de réforme hospitalière sanitaire au Portugal a été auparavant classifié par un comité d'experts renommés au domaine de santé publique de Universidade Nova de Lisboa, considérant une échelle de 10 points (1-Très faible à 10-Très élevé) quant à Impact Potentiel, Facilité d'Implémentation et Coûts d'Implémentation. La classification hiérarchique nous permet alors de grouper les politiques en classes distinctes, de réaliser une analyse de scénarios considérant toutes les possibilités d'établissement de priorités pour les différentes classes et de choisir un groupe spécifique de politiques comme potentiels candidats à l'application de EIS. Le groupe élu comporte des politiques à impact élevé et plus faibles coûts d'implémentation, incluant des mesures associées à la gestion et à la création de modèles de benchmarking légaux et opérationnels quant aux liens entre soins primaires et hospitaliers.

Un total de 30 Programmes Nationaux de Santé, encadrés par le Plan National de Santé 2004-2010 ont été décrits par des variables groupées en 7 domaines. Chaque domaine est ordonné suivant un ensemble de critères déterminés au préalable, selon le fait de constituer une priorité potentielle pour EIS. Les résultats de la classification hiérarchique et de méthodologies complémentaires appliquées en chaque domaine séparément nos permettent alors de ranger chaque classe de programmes selon son potentiel attendu pour être une priorité pour EIS et, ensuite, de tenir en compte l'ordre des domaines. Les politiques associées au Programme National pour les Maladies Cerebro-Cardiovasculaires surgissent comme prioritaires pour EIS, selon les divers critères de couverture régionale, préoccupations au sujet de gains de santé, besoins des systèmes de santé et gains d'efficacité, être un programme prioritaire au niveau du Plan National de Santé, entre autres.

Cette analyse nous conduit à choisir comme contexte d'application de l'étude de l'équité en EIS qui se suit le domaine des maladies cerebro-cardiovasculaires, en ce qui concerne des politiques connectant les soins primaires aux hospitaliers.

Visualisant les Iniquités en Évaluation d'Impact sur la Santé

Nous proposons un chemin conceptuel d'analyse de l'association entre une politique publique et son impact sur la santé tenant en compte les soucis d'équité et montrant comment cela peut être mis en pratique. Les données contemplent 3.776 adultes hospitalisés avec diagnostic de l'infarctus aigu du myocarde chez des hôpitaux du Service National de Santé au Portugal pendant le deuxième semestre de 2012 et suivis régulièrement au réseau de soins primaires de santé pendant l'année de 2013. La politique évaluée dans un contexte d'EIS est l'enregistrement d'information des indicateurs de Pression artérielle, Cholestérol, Triglycérides, Circonférence abdominale et Indice de masse corporelle. L'impact sur la santé d'intérêt est la mortalité jusqu'á la fin de la période d'étude (31 Décembre 2013). L'aspect d'équité étudié respecte aux disparités régionales au Portugal, puisque ne pas appliquer la politique de forme adéquate aux 5 régions de résidence (*Norte*, *Centro*, *LVT*, *Alentejo* et *Algarve*) peut augmenter les iniquités de santé régionales. Les OR bruts et ajustés (par sexe, âge, son interaction, 4 indicateurs de sévérité d'hospitalisation) sont estimés par Régression Logistique, complémentée par des méthodes d'analyse de données multivariés exploratoire comme l'Analyse en Composantes Principales ou Analyse des Correspondances Multiples.

Dans une première phase, les différences rencontrées entre régions quant à l'enregistrement de l'information sur les indicateurs de santé étudiés, soulignant la pertinence d'analyser l'association entre mortalité et enregistrement, stratifiée par région.

Ensuite, l'analyse révèle des *patterns* d'associations mortalité-enregistrement distincts entre régions, indiquant que l'enregistrement de différents indicateurs liant l'information hospitalière à celle des soins primaires peut contribuer pour de meilleurs *outcomes* de santé au long des plusieures régions. La représentation graphique des résultats gérés par les méthodologies multivariées appliquées peut potentialiser le discernement de l'approche, facilitant la compréhension des résultats par les décideurs.

Discussion, Conclusions et Perspectives Futures

L'application de méthodes statistiques plus souvent employés en *data mining* et *data science* implique que même des méthodologies plus complexes peuvent gérer des résultats graphiques qui simplifient la compréhension et potentialiser son adhésion à l'utilisation de EIS.

Le futur des reformes des systèmes de santé déplace le centre de l'évaluation des services de santé des fournisseurs aux citoyens, ses besoins et préférences, réduisant les iniquités d'accès à la santé et aux gains de santé, adaptant les systèmes de santé à de nouvelles technologies, exploitant les *big data* qui associent l'information des fournisseurs de soins à des données sociales et économiques de déterminants de santé. Il devient nécessaire de développer et d'appliquer des méthodologies statistiques et d'évaluation nouvelles ou innovantes qui mettent en marche cette transformation.

L'EIS qui applique des méthodes quantifiées multivariées représente ainsi un outil précieux pour assurer que l'impact sur la santé de politiques publiques est mesuré en tenant en considération déterminants de santé et équité, amenant les citoyens au centre des procédures de prise de décision.

Mots-clés

Évaluation d'Impact sur la Santé; Equité; Analyse de Données Multivariée; Modélisation; Prise de décision

Résumé Substantiel en Français

Les figures présentées ici suivent la forme générale, la séquence et numération présentées au texte principal.

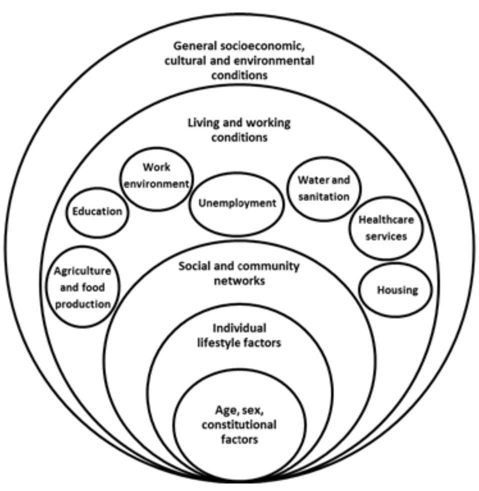
1. Introduction et Objectif Principal

1.1. Introduction

La santé est définie par l'Organisation Mondiale de la Santé (OMS) comme « un état de bien-être complet physique, mental et social, et ne consiste pas seulement en une absence de maladie ou d'infirmité », mais aussi comme « l'étendue qu'un individu ou groupe est capable, d'une part, de réaliser ses aspirations et satisfaire ses besoins et, d'autre part, de modifier ou faire face à son environnement ».

Un des principaux rôles de l'État est de créer un environnement où les individus puissent prospérer et mener leurs vies aussi sainement que possible, appliquant des politiques publiques qui assurent la promotion de la santé et la prévention de la maladie, aux secteurs de la santé et hors-santé. Les gouvernements et institutions publiques doivent être ainsi conscients que toute politique publique a un effet direct et indirect sur la santé des populations au niveau de toutes les strates du modèle de déterminants sociaux de la santé (figure suivante).

Figure 1. Social health determinants model



Adapted from Dahlgren & Whitehead, 1991

L'Évaluation d'Impact sur la Santé (EIS) est une combination de procédures, méthodes et outils, grâce auxquels une politique, un programme ou un projet, du secteur public ou privé, peut être jugé quant à ses effets potentiels sur la santé de la population, bien quant à la distribution de ses effets dans cette population, ayant ainsi une forte préoccupation d'équité. L'EIS est construite comme un instrument de support à la décision, ayant comme principaux outputs des recommandations pour aider les décideurs à assurer que les politiques implémentées minimisent les effets sur la santé négatifs et maximisent les positifs. Au Portugal, comme en France, les efforts des derniers 10-20 ans pour encourager le développement de l'EIS n'ont pas généraliser son utilisation. Au long de ses diverses étapes (voir tableau suivant), l'EIS reste généralement et très fréquemment une approche qualitative, l'application de méthodologies statistiques multivariées étant rare.

Table 1. HIA Steps, their aims and methods used

HIA Steps	General Aims	Methods Used
Screening	While medical screening helps select individuals suffering from a particular disease, HIA screening helps chose relevant policies or projects for which to conduct HIA.	Literature, documentation and database searches, interview process to potential stakeholders or experts
Scoping	Planning the HIA includes defining the underlying terms of reference, identifying potential stakeholders and enhancing their engagement in the HIA process, establishing a steering group.	Project management approaches, communication, networking and negotiation skills
Appraisal	Conducting the assessment includes policy analysis, profiling of communities, qualitative and quantitative data collection, impact analysis, establishing priority impacts, recommendations developing and process evaluation.	Risk and outcomes analyses, public health, survey, statistical and participatory approaches
Reporting to Decision-Makers	The main HIA outputs are recommendations to support decision-making on how to deal with the assessed project or policy, to be presented in reports, workshop or seminars.	Writing, presentation, communication and results dissemination skills
Monitoring and Evaluation	Monitoring the real impact of the project or policy implementation if essential to evaluate the process of conducting the HIA, its impact on the decision-making process and outcome assessment changes in health and health determinants after implementation.	Epidemiology, statistical, survey, information management approaches

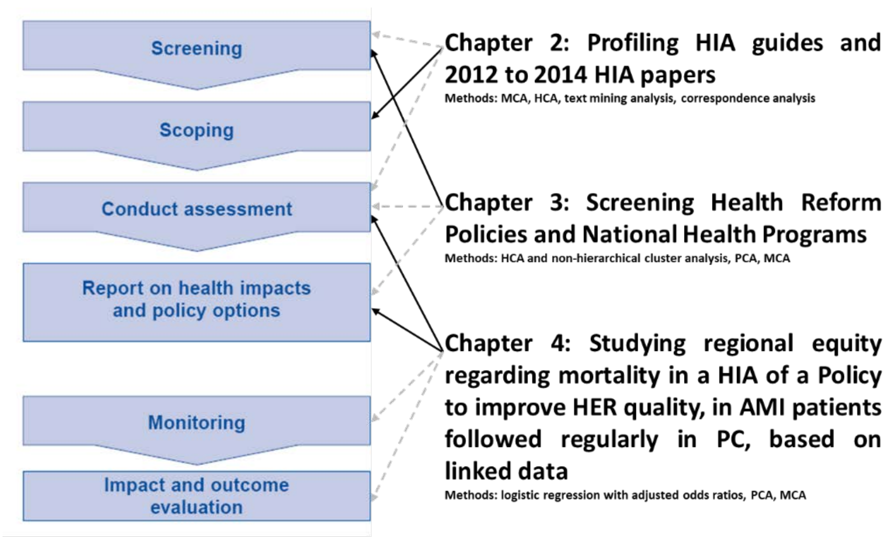
Adapted from Scott-Samuel, Birley & Ardern [14] and O'Mullane & Guliš

1.2. Objectif Principal

L'objectif principal de cette recherche est de montrer l'utilité d'appliquer des méthodologies quantitatives et multivariées pour enrichir la pratique de EIS, rendant la prise de décision plus facile, au sens d'assister la compréhension des résultats par des professionnels non-statisticiens, maintenant toujours un contexte profondément basé sur l'évidence.

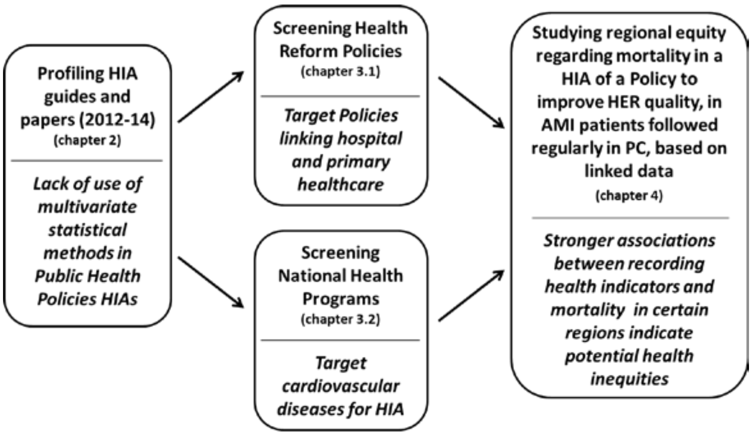
1.3. *Research Path* - Chemin de Recherche

La figure suivante identifie les contributions de notre recherche, et des divers chapitres concernant les résultats, aux diverses étapes de l'EIS, les flèches noires identifiant les liaisons directes au niveau de la thèse et les grises les applications potentielles des méthodologies appliquées.



Merseyside Guidelines (Scott-Samuel et al., 2001)

La figure suivante résume le plan suivit par la thèse, présentant aussi une anticipation prévue des résultats.



2. Identifiant et Explorant des Profils d'État de l'Art

L'EIS est issue de deux domaines distincts : l'évaluation environnementale et la santé publique. Deux questions surgissent en explorant l'état de l'art :

- Est-ce possible de créer un guide universel ?
- Est-ce que les méthodologies quantitatives sont appliquées couramment dans les deux domaines ?

Dans une première phase, 45 guides de EIS étudiés initialement par Herbert (2012) sont analysés et un total de 5 profils/classes est identifié par classification hiérarchique – Figure 1. Cette étude est complémentée par une analyse des correspondances multiples – Figure 2. Les résultats montrent qu'un guide universel serait possible et 9 candidats potentiels sont identifiés à servir comme base, concernant la classe 2, à savoir :

- The Merseyside guidelines for health impact assessment (Scott-Samuel et al./International HIA Consortium)
- A training manual for HIA (University of Birmingham, Department of Public Health and Epidemiology)
- More than a statement of the crushingly obvious: a critical guide to HIA (Kemm/ West Midlands Public Health Observatory)
- HIA intersectoral health policy: theory and application (Penris and den Broeder/Netherlands National Institute for Public Health and the Environment)
- Equity focused HIA framework (Mahoney et al./Australasian Collaboration for Health Equity Impact Assessment)
- HIA: a guide for service providers (Public Health Services, Queensland Health)
- A guide to HIA (Public Health Commission)
- HIA quick guide (NACCHOi)
- UCLA HIA training manual (Agyekum et.al./UCLAj)

Figure 1. HCA Dendrogram of 45 HIA guidelines

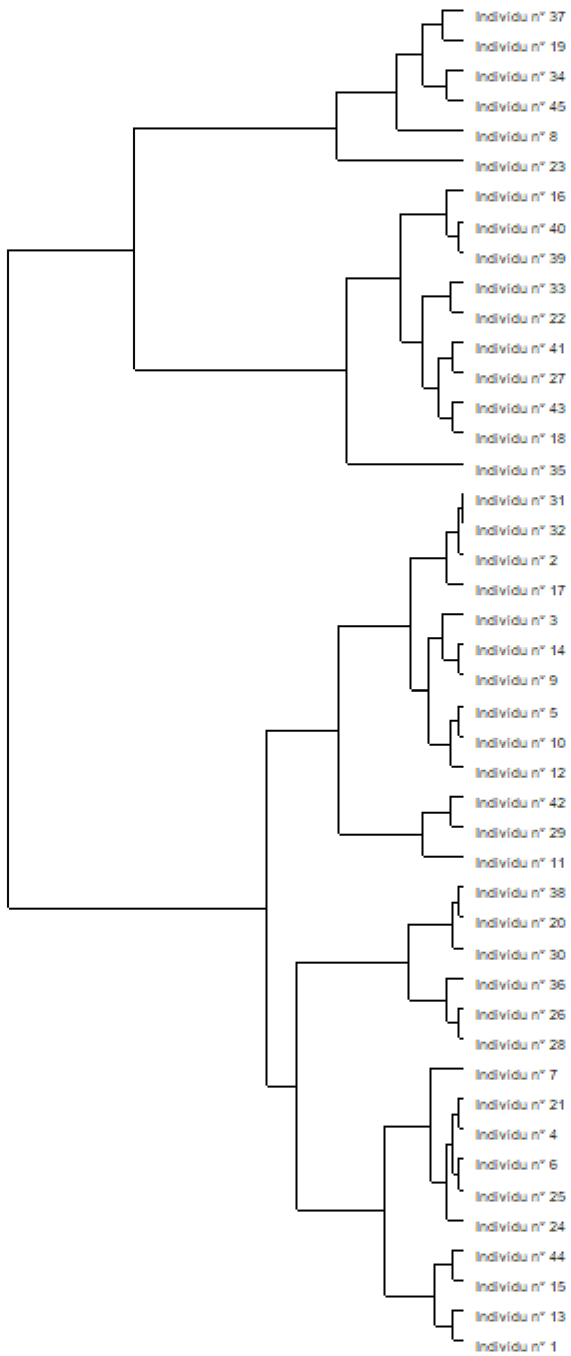
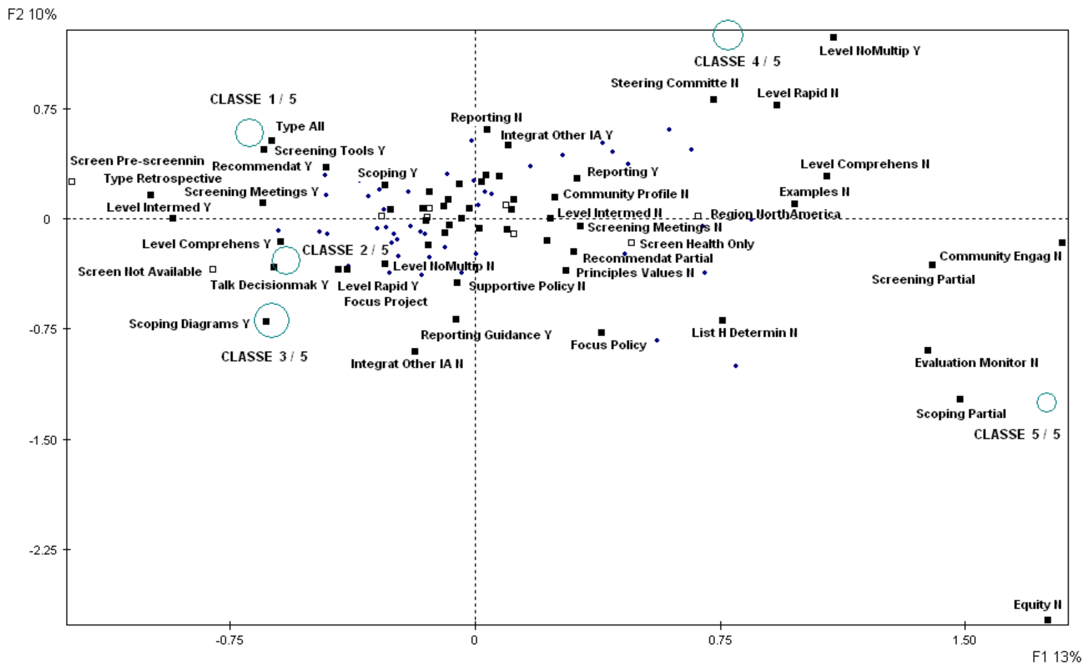


Figure 2. Factorial Plan 1-2 of 45 HIA guidelines

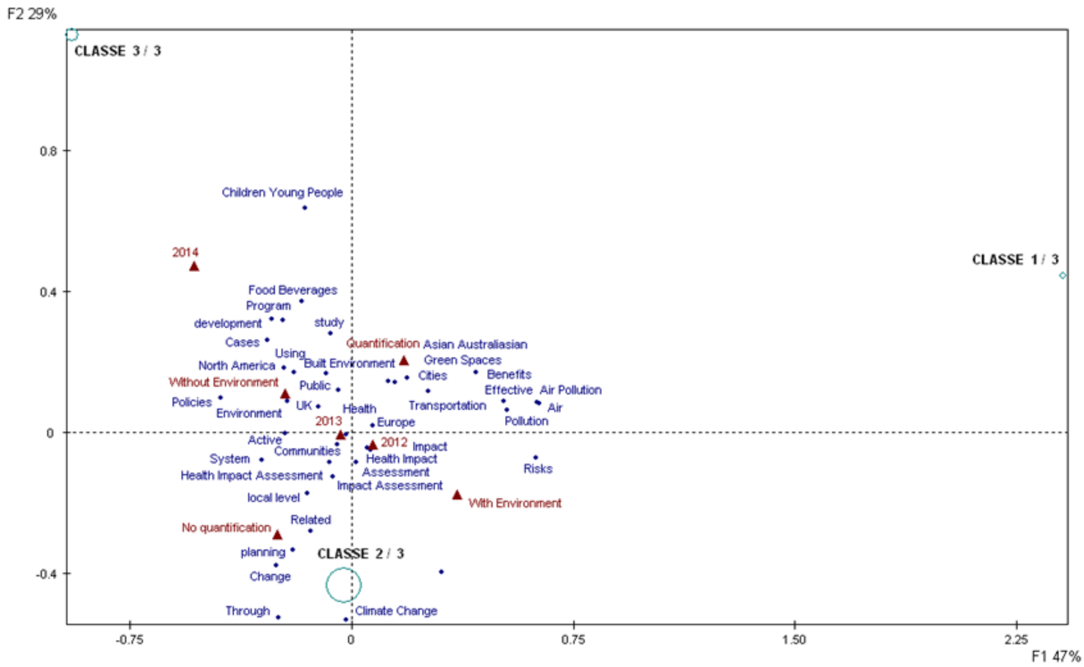


Dans une deuxième phase, les titres de 247 articles scientifiques listés *par Health Impact Assessment Section* de *HIA Gateway Bibliography* associée à *Public Health England* entre 2012 et 2014, bien que les mots-clés disponibles en 170 de ces articles, sont étudiés avec de l'analyse textuelle multivariée, tenant en compte des profils d'année, être publiés dans un journal environnemental ou de santé publique et employer des méthodes quantitatives. L'analyse comprend l'application de méthodes de classification hiérarchique et d'analyse des correspondances, dont la figure 4 suivante est une illustration, permettant d'identifier graphiquement de façon facile les caractéristiques principales qui différencient les typologies.

Les résultats basés sur les titres et sur les mots-clés s'avèrent cohérents, montrant que :

- l'année 2014 semble plus associée à des publications environnementales ;
- les EIS en domaines environnementaux sont plus fréquemment quantitatives (essentiellement concernant des évaluations de risques) ;
- les EIS en domaines de santé publique sont plus souvent qualitatives et surtout associées aux déterminants sociaux de santé et à des soucis d'équité.

Figure 4. Factorial Plan 1-2 of lexical vocabulary of 247 papers from 2012-2014, based on papers' titles



Il devient ainsi pertinent et représente une valeur ajoutée pour l'état actuel du savoir d'encourager l'application de méthodes quantitatives de statistique multivariée (comme la classification hiérarchique ou l'analyse textuelle multivariée) en évaluant par EIS l'impact sur la santé et l'équité de politiques en santé publique.

3. Contribuant avec la Classification Hiérarchique pour l'étape de dépistage en EIS

L'étape de dépistage (*screening*) en EIS nous aide à sélectionner le domaine d'application de notre recherche. La classification hiérarchique est utilisée comme méthodologie de base pour contribuer à améliorer l'étape de dépistage en EIS en deux situations différentes.

3.1 – Dépistage de Politiques de Réforme hospitalière sanitaire

Un total de 76 politiques de réforme hospitalière sanitaire au Portugal a été auparavant classifié par un comité d'experts renommés au domaine de santé publique de Universidade Nova de Lisboa, considérant une échelle de 10 points (1-Très faible à

10-Très élevé) quant à Impact Potentiel, Facilité d'Implémentation et Coûts d'Implémentation.

La classification hiérarchique nous permet alors de grouper les politiques en classes distinctes (Figure 1) et ensuite de les caractériser (Figures 2 à 4).

Figure 1. Hierarchical Cluster Analysis Dendrogram (Squared Euclidean Distance and Ward Linkage Criterion) with 7 clusters partition identified

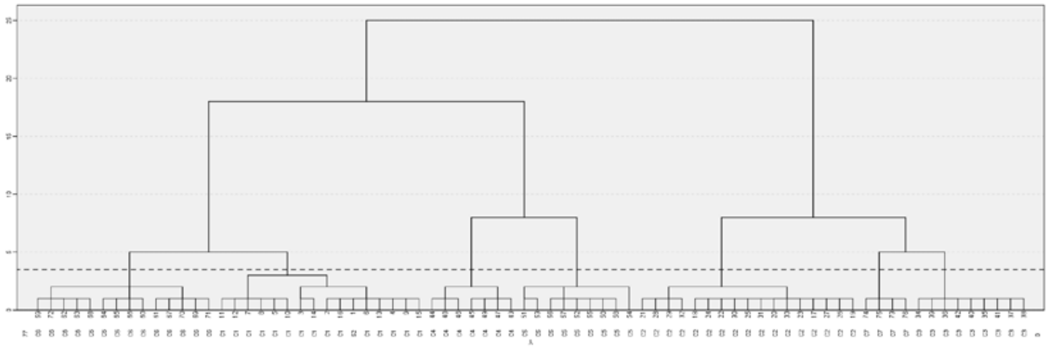


Figure 2. Scatterplots of Potential Impact by Implementation Costs and by Ease of Implementation with cluster identification

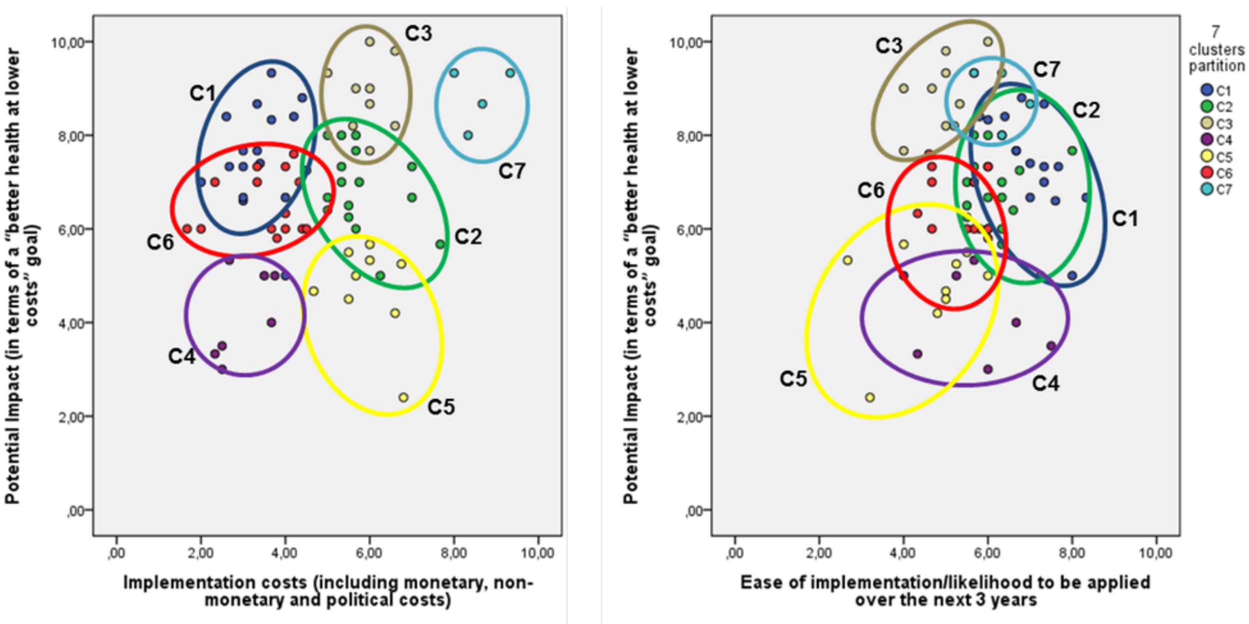


Figure 3. Factorial Plan on policies of a PCA 2 Components Extraction and cluster identification

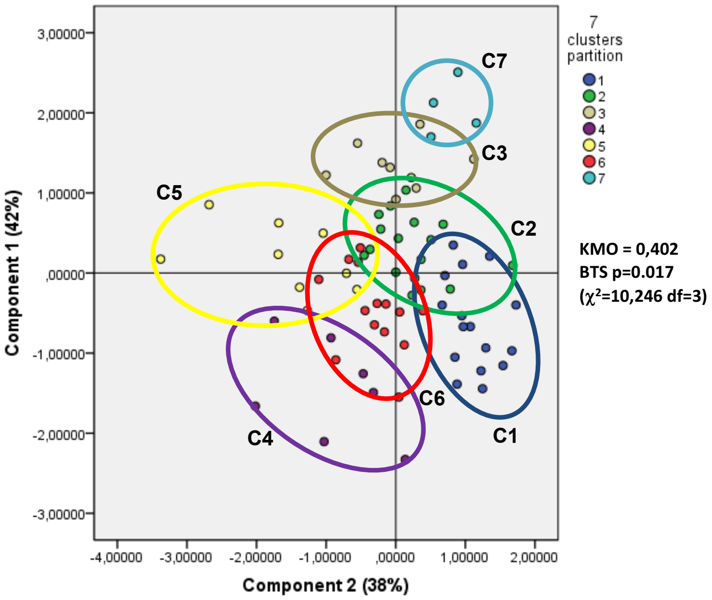
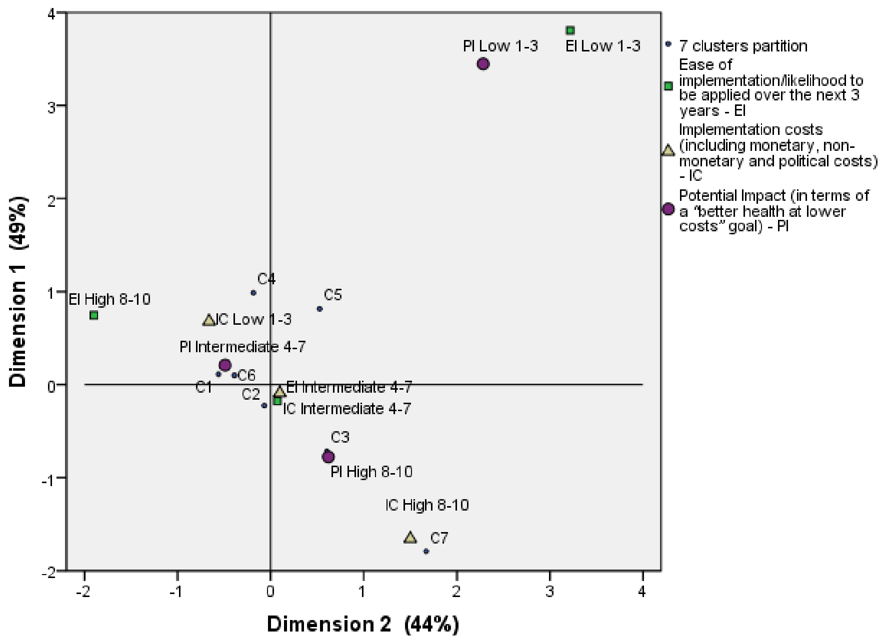
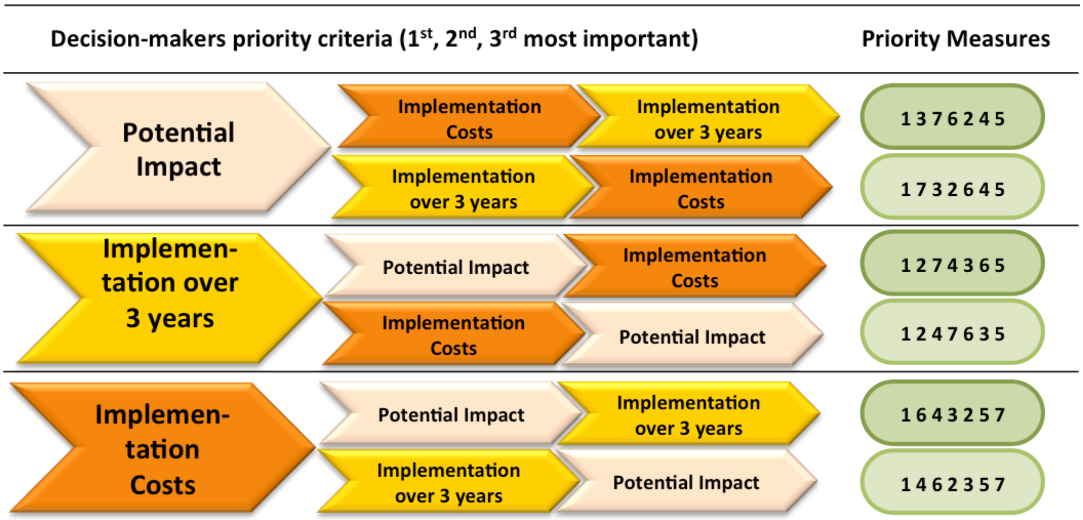


Figure 4. Factorial Plan of a MCA 2 Components Extraction with cluster identification



Une analyse de scénarios est utilisée, considérant toutes les possibilités d'établissement de priorités pour les différentes classes et permet de choisir un groupe spécifique de politiques comme potentiels candidats à l'application de EIS (Figure 5).

Figure 5. Clusters prioritized according to different decision-makers priority criteria

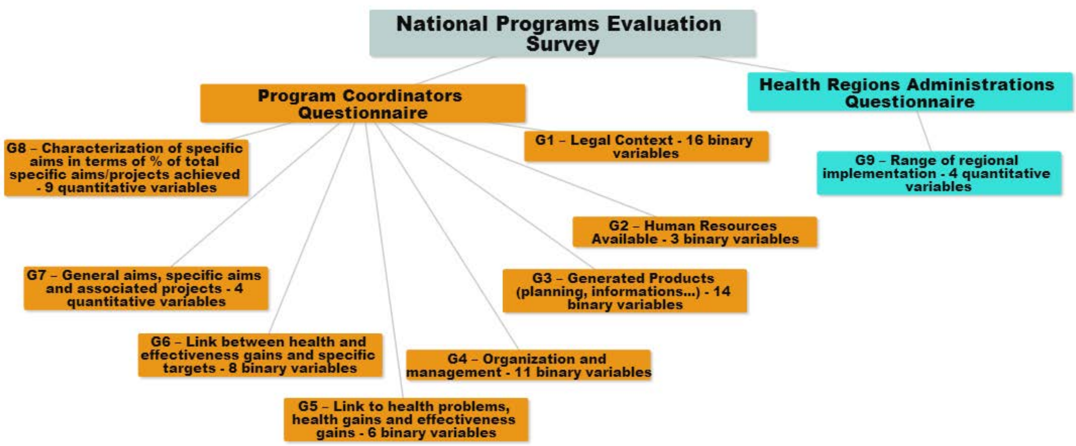


Le groupe élu se situe en première place dans tous les scénarios et comporte des politiques à impact élevé et plus faibles coûts d'implémentation, incluant des mesures associées à la gestion et à la création de modèles de benchmarking légaux et opérationnels quant aux liens entre soins primaires et hospitaliers.

3.2 – Dépistage de Programmes Nationaux de Santé

Un total de 30 Programmes Nationaux de Santé, encadrés par le Plan National de Santé 2004-2010 ont été décrits par des variables groupées en 7 domaines (Figure 1 suivante). Chaque domaine est ordonné suivant un ensemble de critères déterminés au préalable, selon le fait de constituer une priorité potentielle pour EIS.

Figure 1. Areas and associated number and types of variables in the National Program Evaluation Survey



Les résultats de la classification hiérarchique (Figure 2) et de méthodologies complémentaires appliquées en chaque domaine séparément (Figures 3 et 4) nos permettent de choisir une partition de classes dans chaque domaine et de les caractériser.

Figure 2. Dendrograms of hierarchical cluster analysis for each variable group with selected partition and PNDCV identification

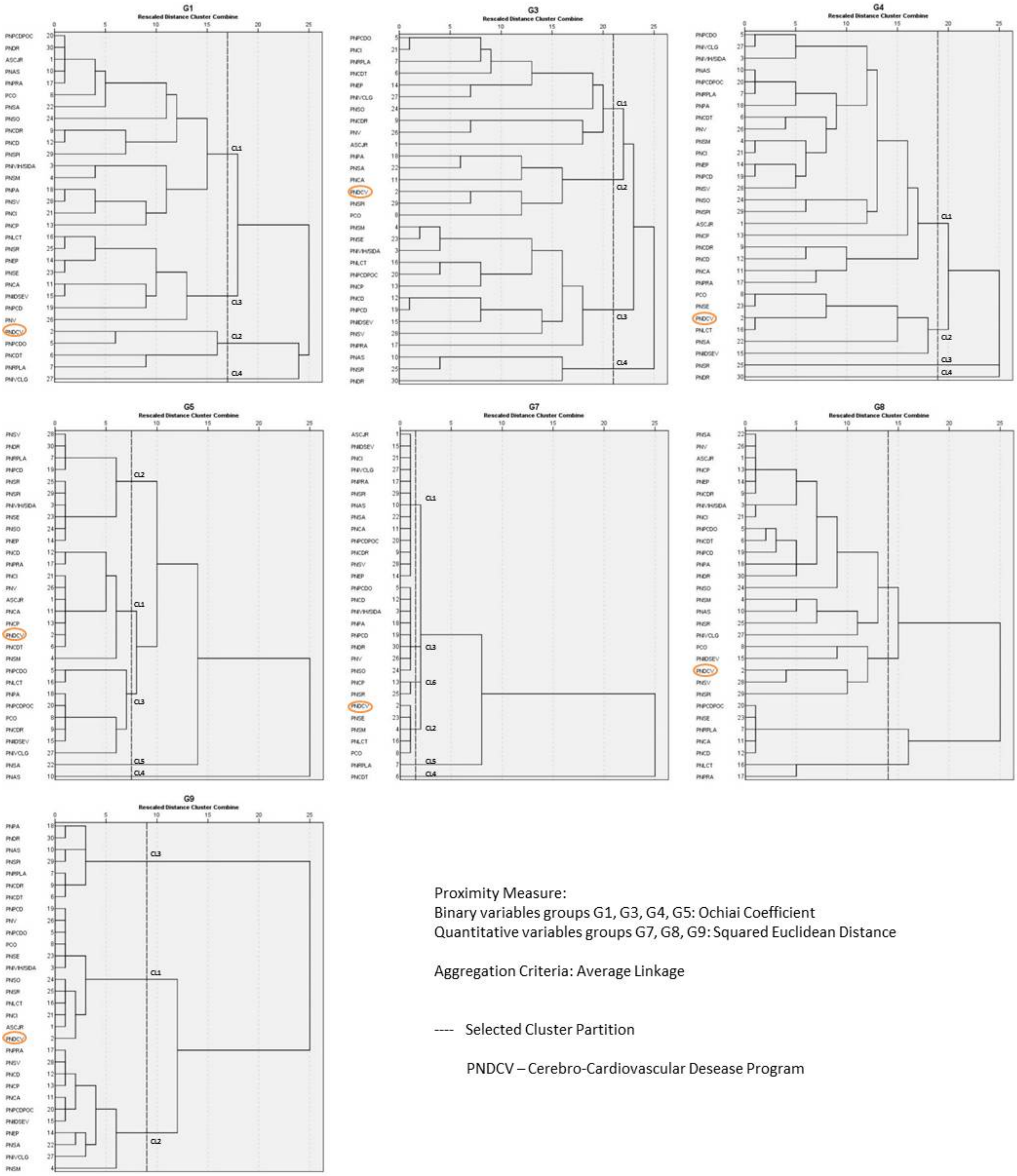


Figure 3. Multiple correspondence analysis (MCA) Factorial Plans for each group of binary variable categories and for cases identified by National Program short name and by associated cluster

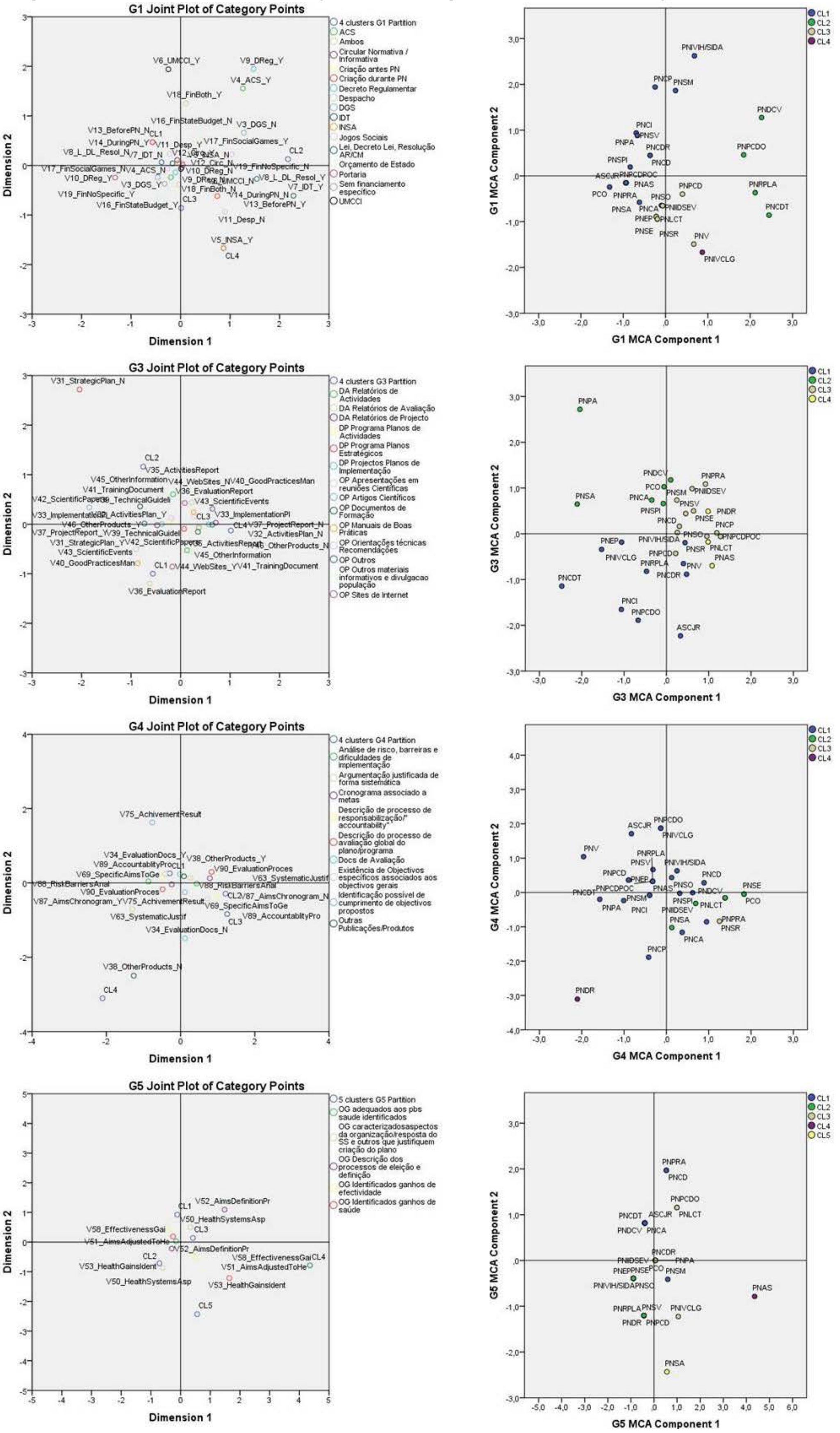
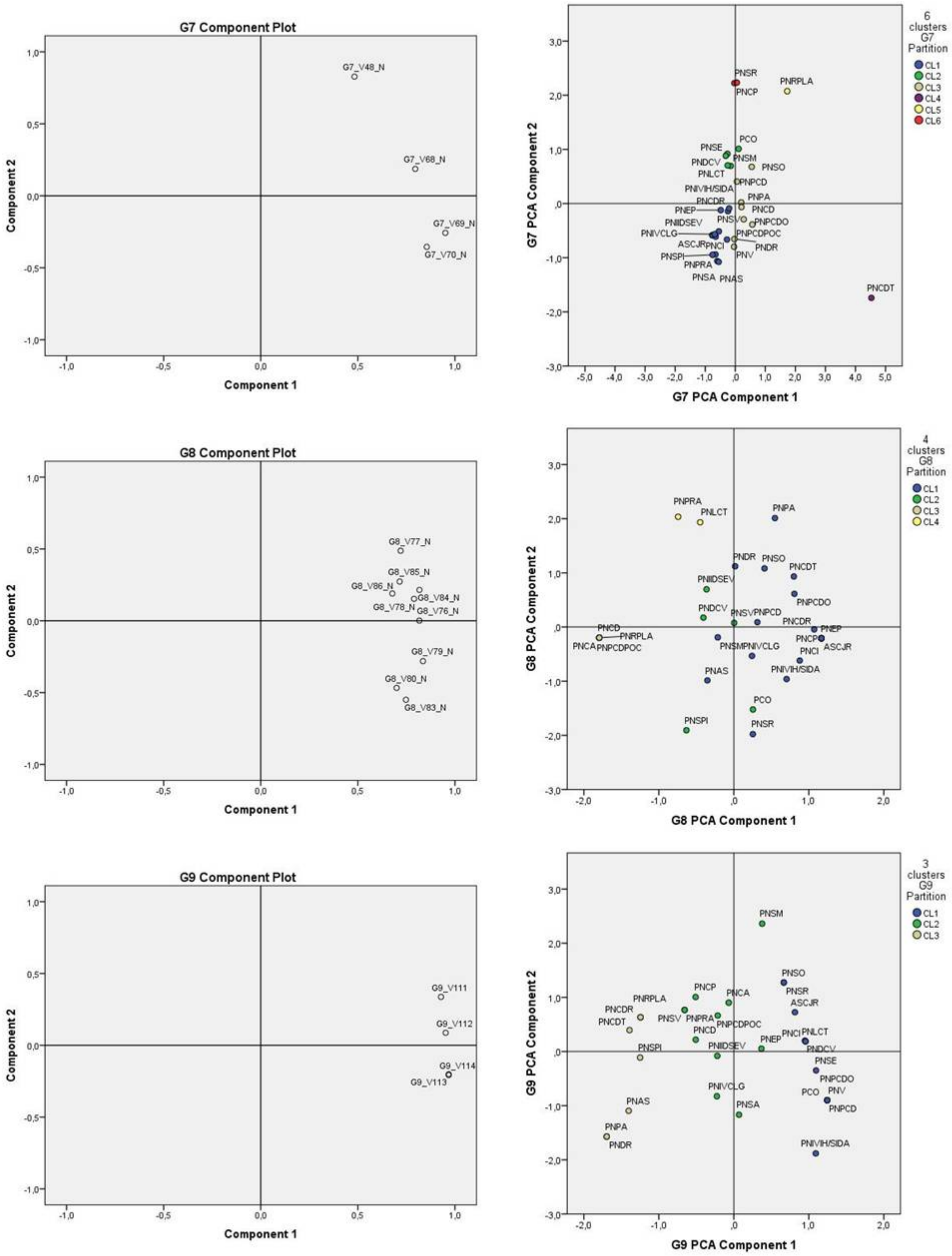


Figure 4. Principal components analysis (PCA) Factorial Plans for each group of quantitative variables and for cases identified by National Program short name and by associated cluster



Ensuite, chaque classe de programmes est rangée selon le potentiel attendu pour être une priorité pour EIS et, ensuite, et tenant en compte l'ordre des domaines (Table 5 et 6).

Table 5. Color ranking priorities for HIA of clusters for each variable group and respective priority criterion

Groups of Variables ranked by importance for our research	Features for being a potential priority for HIA	Chosen partition (number of clusters)	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6
G9 Range of regional implementation	Having a regional span as extended and in depth as possible	3	**+**	+-	-			
G5 Link to health problems and gains	Showing a concern to monitor health gains, health systems needs and effectiveness gains	5	**+**	+-	+-			
G1 Legal Context	Being a high-priority NP according to the National Health Plans 2004-2010 and 2012-2016	4	+-	**+**	+-			
G3 Products	Having a practice of generating a variety of different products to the health professionals, specific groups of the population and the population in general (guidelines, published information, online presence, events, etc)	4	+	**+-**	-	-		
G8 Characterization % of total specific aims/projects achieved	Considering the monitorization and evaluation of the way the aims are being achieved, including resources allocation	4	+	**+-**	-	-		
G4 Management	Listing its planning documents, general aims and linking them to specific aims and/or projects' aims	4	+	**+-**				
G7 General aims, specific aims and associated projects	Presenting an adequate number of aims and projects	6	-	**+-**	+			-

bold	Cluster including PNDCV
+	High priority
+ -	Medium priority
-	Low priority
	Not adequate for comparison: one National Health Program cluster
	Non-existent: the chosen partition includes a lower number of clusters

Table 6. National Programs ranked by priority criterion according to color ranking priorities for HIA of clusters for each variable group of previous table

National Program	G9 Range of regional implementation	G5 Link to health problems and gains	G1 Legal Context	G3 Products	G8 Characterization % of total specific aims/projects achieved	G4 Management	G7 Genera aims, specif aims and associated projects
PNDCV	**CL1**	**CL1**	**CL2**	**CL2**	**CL2**	**CL2**	**CL2**
PNV	CL1	CL1	CL3	CL1	CL1	CL1	CL3
PNPCDO	CL1	CL3	CL2	CL1	CL1	CL1	CL3
PNSO	CL1	CL2	CL1	CL1	CL1	CL1	CL3
PCO	CL1	CL3	CL1	CL2	CL2	CL2	CL2
ASCJR	CL1	CL1	CL1	CL1	CL1	CL1	CL1
PNCI	CL1	CL1	CL1	CL1	CL1	CL1	CL1
PNIVIH/SIDA	CL1	CL2	CL1	CL3	CL1	CL1	CL3
PNPCD	CL1	CL2	CL3	CL3	CL1	CL1	CL3
PNSR	CL1	CL2	CL3	CL4	CL1	CL3	CL6
PNSE	CL1	CL2	CL3	CL3	CL3	CL2	CL2
PNLCT	CL1	CL3	CL3	CL3	CL4	CL2	CL2
PNSM	CL2	CL1	CL1	CL3	CL1	CL1	CL2
PNCA	CL2	CL1	CL3	CL2	CL3	CL1	CL1
PNCP	CL2	CL1	CL1	CL3	CL1	CL1	CL6
PNCD	CL2	CL1	CL1	CL3	CL3	CL1	CL3
PNPRA	CL2	CL1	CL1	CL3	CL4	CL1	CL1
PNEP	CL2	CL2	CL3	CL1	CL1	CL1	CL1
PNPCDPOC	CL2	CL3	CL1	CL3	CL3	CL1	CL1
PNSV	CL2	CL2	CL1	CL3	CL2	CL1	CL1
PNIIDSEV	CL2	CL3	CL3	CL3	CL2	CL2	CL1
PNIVCLG	CL2	CL3	CL4	CL1	CL1	CL1	CL1
PNSA	CL2	CL5	CL1	CL2	CL1	CL2	CL1
PNCDT	CL3	CL1	CL2	CL1	CL1	CL1	CL4
PNRPLA	CL3	CL2	CL2	CL1	CL3	CL1	CL5
PNCDR	CL3	CL3	CL1	CL1	CL1	CL1	CL1
PNPA	CL3	CL3	CL1	CL2	CL1	CL1	CL3
PNSPI	CL3	CL2	CL1	CL2	CL2	CL1	CL1
PNAS	CL3	CL4	CL1	CL4	CL1	CL1	CL1
PNDR	CL3	CL2	CL1	CL4	CL1	CL4	CL3

bold	PNDCV
	Potential National Programs for HIA
+	High priority
+ -	Medium priority
-	Low priority
	Not adequate for comparison: one National Program cluster

Les politiques associées au Programme National pour les Maladies Cerebro-Cardiovasculaires surgissent ainsi comme prioritaires pour EIS, selon les divers critères de couverture régionale, préoccupations au sujet de gains de santé, besoins des systèmes de santé et gains d'efficacité, être un programme prioritaire au niveau du Plan National de Santé, entre autres.

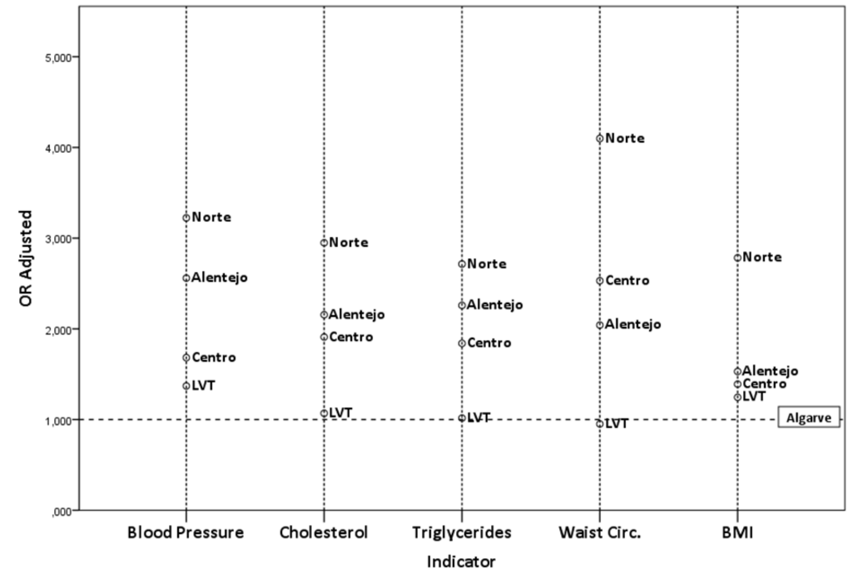
L’analyse du chapitre 3 nous conduit à choisir comme contexte d’application de l’étude de l’équité en EIS qui se suit le domaine des maladies cérébro-cardiovasculaires, en ce qui concerne des politiques connectant les soins primaires aux hospitaliers.

4. Visualisant les Iniquités en Évaluation d’Impact sur la Santé : Donnés Électroniques Liées, Mortalité et Disparités Régionales au Portugal

Nous proposons un chemin conceptuel d’analyse de l’association entre une politique publique et son impact sur la santé tenant en compte les soucis d’équité et montrant comment cela peut être mis en pratique. Les données contemplent 3.776 adultes hospitalisés avec diagnostic de l'infarctus aigu du myocarde chez des hôpitaux du Service National de Santé au Portugal pendant le deuxième semestre de 2012 et suivis régulièrement au réseau de soins primaires de santé pendant l’année de 2013. La politique évaluée dans un contexte d’EIS est l’enregistrement d’information des indicateurs de Pression artérielle, Cholestérol, Triglycérides, Circonférence abdominale et Indice de masse corporelle. L’impact sur la santé d’intérêt est la mortalité jusqu’á la fin de la période d’étude (31 Décembre 2013). L’aspect d’équité étudié respecte aux disparités régionales au Portugal, puisque ne pas appliquer la politique de forme adéquate aux 5 régions de résidence (Norte, Centro, LVT, Alentejo et Algarve) peut augmenter les iniquités de santé régionales. Les OR bruts et ajustés (par sexe, âge, son interaction, 4 indicateurs de sévérité d’hospitalisation) sont estimés par Régression Logistique, complémentée par des méthodes d’analyse de données multivariés exploratoire comme l'Analyse en Composantes Principales ou Analyse des Correspondances Multiples.

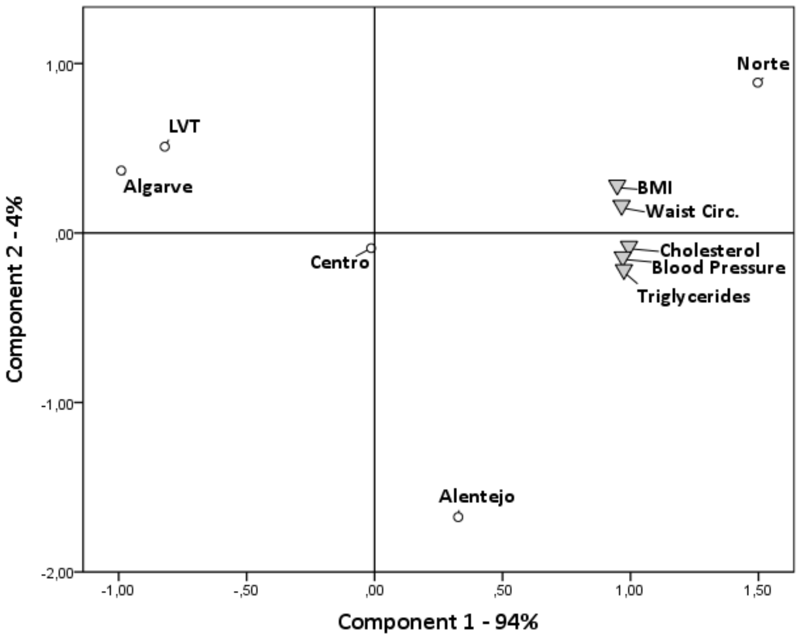
Dans une première phase, les différences rencontrées entre régions quant à l'enregistrement de l'information sur les indicateurs de santé étudiés, soulignent la pertinence d'analyser l'association entre mortalité et enregistrement, stratifiée par région (Figures 1 et 2).

Figure 1. Association between registration of each health indicator and health regions of residence - adjusted OR



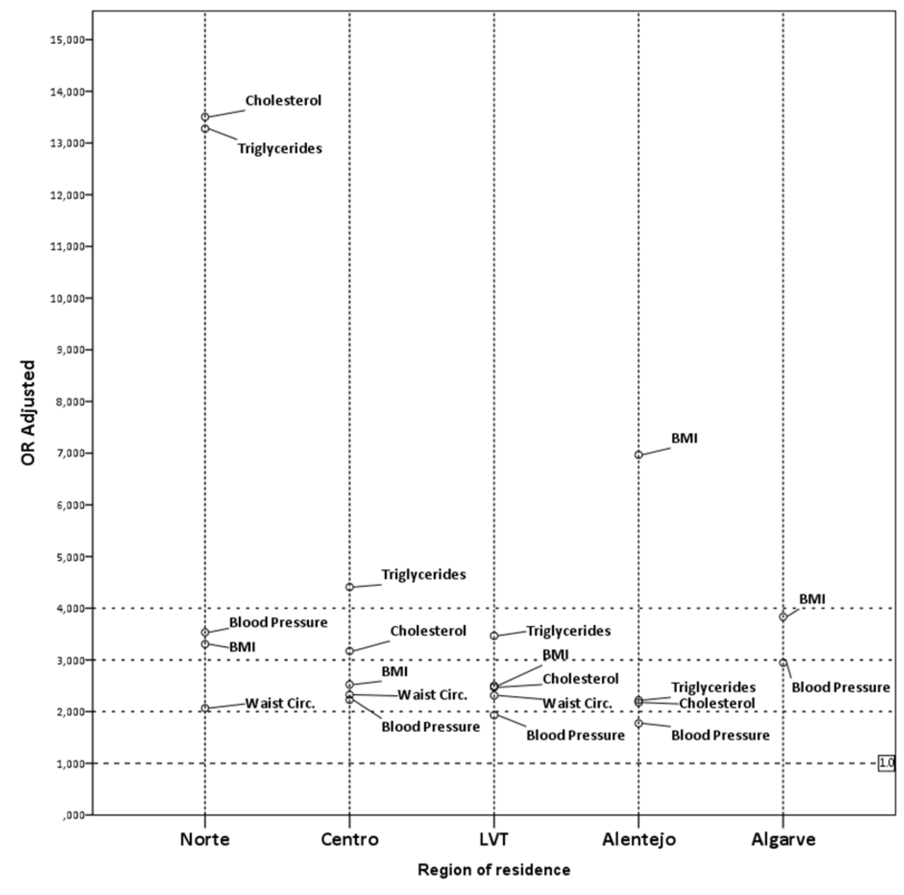
(1) After controlling for Sex, Age, Sex*Age (2) Algarve as Reference Category

Figure 2. Principal Components Analysis Factorial Plans 1-2 based on Registered Indicators and Regions OR



Ensuite, l’analyse révèle des *patterns* d’associations mortalité-enregistrement distincts entre régions, indiquant que l’enregistrement de différents indicateurs liant l’information hospitalière à celle des soins primaires peut contribuer pour de meilleurs *outcomes* de santé au long des diverses régions (Figure 3).

Figure 3. Association between mortality and registration of each health indicator stratified by health region of residence - adjusted OR



(1) After controlling for Sex, Age, Sex*Age and Hospital Admission Severity Indicators
(2) Stratified Models by Region
(3) Not Applicable for Waist Circumference in Alentejo and Algarve and for Triglycerides and Cholesterol in Algarve

La représentation graphique des résultats gérés par les méthodologies multivariées appliquées peut potentialiser le discernement de l’approche, facilitant la compréhension des résultats par les décideurs (Figure 4).

Un chemin conceptuel d’analyse est proposé pour étudier l’association entre politique et impact en santé tout en tenant en compte l’équité en santé, illustré par le *case study* appliqué (Figure 5).

Figure 4. Multiple Correspondence Analysis Factorial Plan 1-2

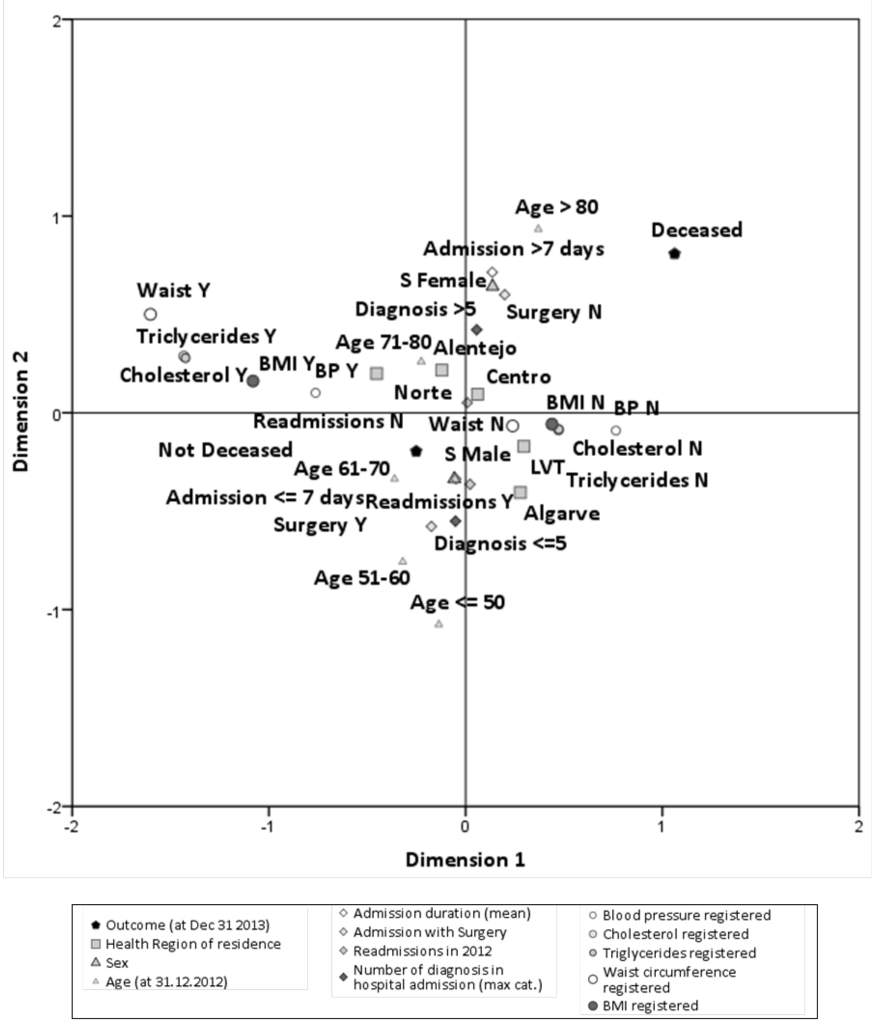
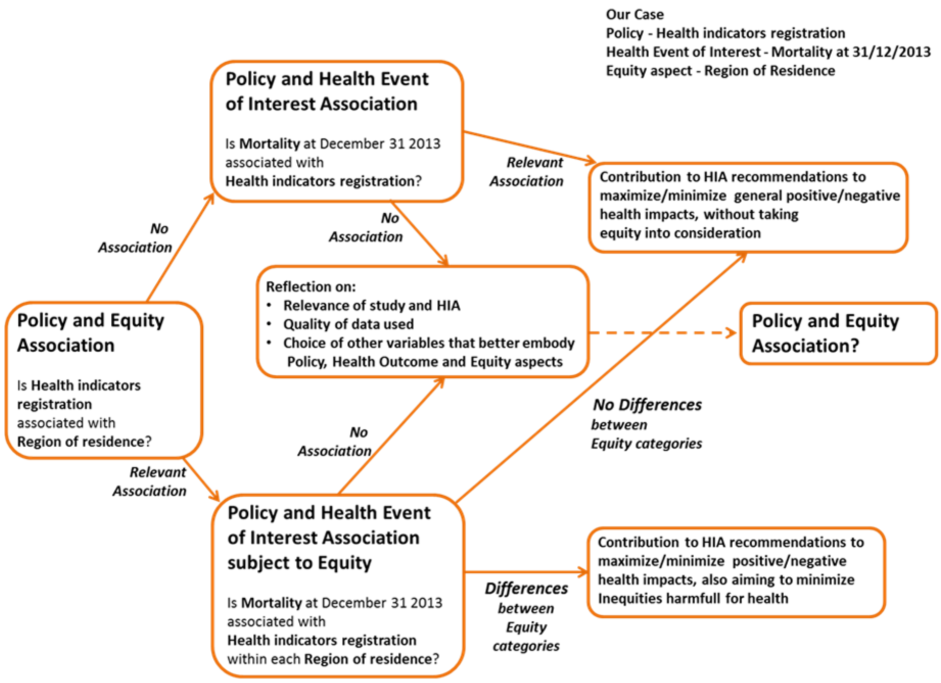


Figure 5. Putting concept into practice



5. Discussion, Conclusions et Perspectives Futures

L'application de méthodes statistiques plus souvent employées en *data mining* et *data science* implique que même des méthodologies plus complexes peuvent gérer des résultats graphiques qui simplifient la compréhension et potentialiser son adhésion à l'utilisation de EIS.

Le futur des reformes des systèmes de santé déplace le centre de l'évaluation des services de santé des fournisseurs aux citoyens, ses besoins et préférences, réduisant les iniquités d'accès à la santé et aux gains de santé, adaptant les systèmes de santé à de nouvelles technologies, exploitant les big data qui associent l'information des fournisseurs de soins à des données sociales et économiques de déterminants de santé.

Il devient nécessaire de développer et d'appliquer des méthodologies statistiques et d'évaluation nouvelles ou innovantes qui mettent en marche cette transformation.

L'EIS qui applique des méthodes quantifiées multivariées représente ainsi un outil précieux pour assurer que l'impact sur la santé de politiques publiques est mesuré en tenant en considération déterminants de santé et équité, amenant les citoyens au centre des procédures de prise de décision.

Chapter 1 – Introduction and Main Research Aims

CONTENTS

Chapter 1 – Introduction and Main Research Aims

"The beginning is always today." Mary Shelley

"Space: the final frontier. These are the voyages of the starship Enterprise. Its five-year mission: to explore strange new worlds; to seek out new life and new civilizations; to boldly go where no man has gone before" - Captain James T. Kirk

"A journey is a person in itself; no two are alike. And all plans, safeguards, policing, and coercion are fruitless. We find that after years of struggle that we do not take a trip; a trip takes us." John Steinbeck

A PhD research is a journey to add value to a particular body of knowledge. The trip we take depends firstly on our aims, but also on the underlying values we choose to abide to. We thus begin here by introducing the main principles that give context to our research, what our study seeks to add to current knowledge and the aims we aspire to reach.

1. Introduction

1.1. Health and Determinants of Health

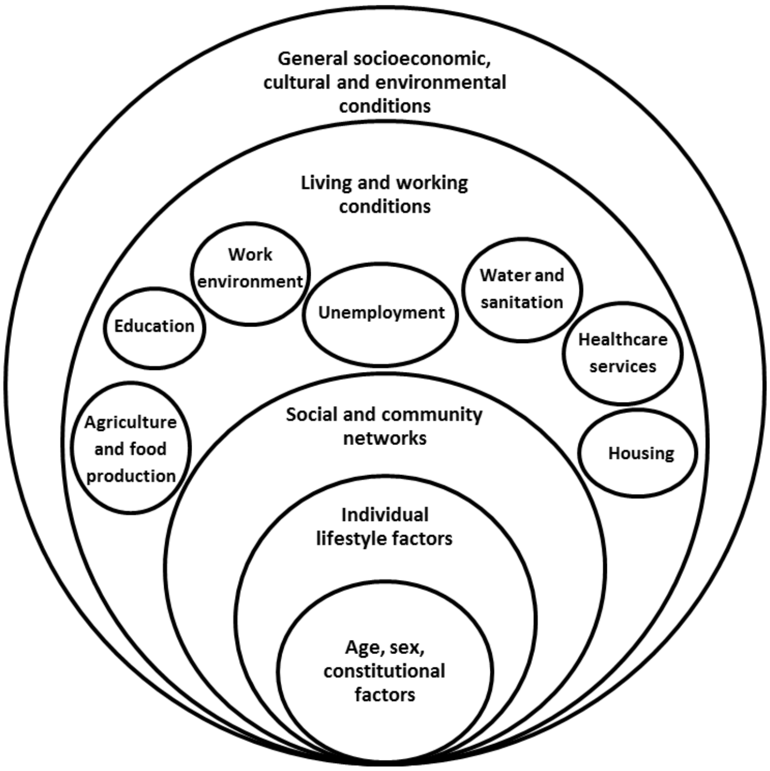
Health is defined by the World Health Organization (WHO) as "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity" [1], but also as "the extent to which an individual or group is able, on the one hand, to realize aspirations and satisfy needs, and, on the other, to change or cope with the environment" [2]. This holistic definition puts health at the epicenter of complex interrelations between social, economic, political, cultural and environmental health determinants.

There forward although health is primarily an individual responsibility, there may be limits as to the ability of individuals by themselves to influence their own health, since there are health determinants beyond their control. "The context of people's lives determines their health, and so blaming individuals for having poor health or crediting them for good health is inappropriate. Individuals are unlikely to be able to directly control many of the determinants of health." [3].

One of the main roles of Governments entails providing citizens accurate and appropriate information so they can protect themselves [4]. But even when individuals have access to reliable information and are aware of all human and non-human activities affecting their health, they are frequently unable to change the conditions affecting their health status by their own will. Hence the Governments' job also consists on helping to create an environment that will enable individuals to thrive and lead their life as healthy as possible. Policies and actions to influence health determinants become the essential base for health promotion and disease prevention.

Thus, Governments also have to be conscious that all public policies from health and non-health sectors will have a direct or indirect impact on peoples' health at all layers of the social determinants model of figure 1 [5]. Being able to assess the health impact of public policies is thus crucial to try and minimize negative effects and maximize positive ones.

Figure 1. Social health determinants model



Adapted from Dahlgren & Whitehead, 1991 [5]

1.2. Social health determinants and health inequality and inequity

Evaluating the health impact of public policies on the whole of a population affected is therefore crucial, but this impact must be also appraised throughout different groups of this population, since these effects may not be uniform and may be damaging for health equity.

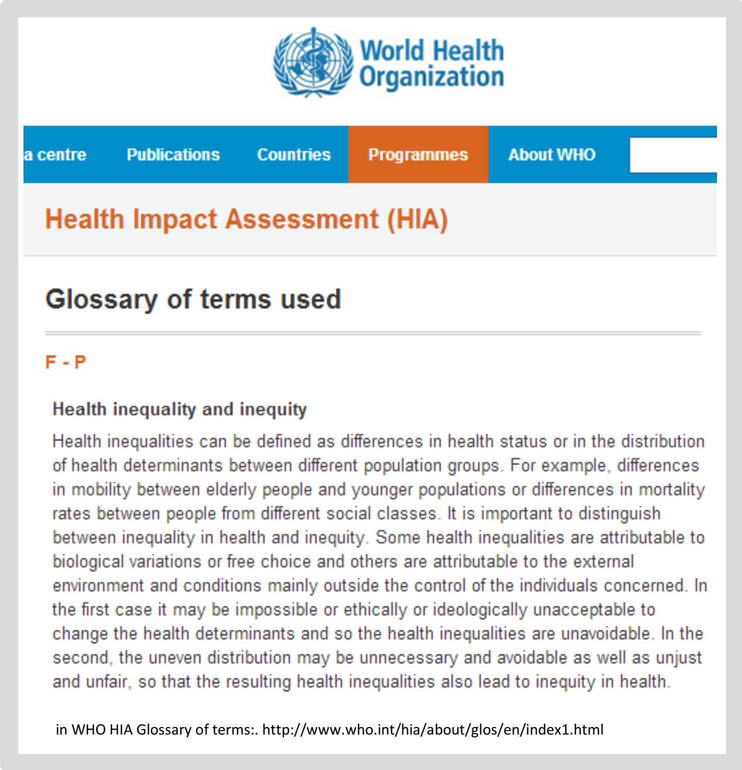
The impact of policies on equity is made essentially through social determinants of health. “Social determinants of health are the conditions in which people are born, grow, live, work and age. These circumstances are shaped by the distribution of money, power and resources at global, national and local levels. The social determinants of health are mostly responsible for health inequities - the unfair and avoidable differences in health status seen within and between countries” [3].

The WHO Commission on Social Determinants of Health warns about huge differences in life expectancy between countries (80 years in Japan and Sweden, to 72 in Brazil, 63 in India, less than 50 years in several African countries), but also in morbidity, even within the same country, linked frequently to a social gradient effect [6]. People in higher socioeconomic groups are thus more likely to live longer and enjoy more years of good health, than those in lower socioeconomic groups.

Nonetheless, other social determinants also contribute to equity concerns, such as gender differences for instance, and are often specific to certain regions, sub-populations, life styles. These specificities have to be taken into account when one sets out to assess health impacts of public policies.

It is however important to make a distinction between what are considered health inequalities and health inequities. Health inequalities may always occur and be natural and non-harmful to people, just a matter of biological variations or free choice. Inequity though may exist whenever inequalities are present that are unnecessary, unjust or unfair and that could be avoided. Public policies should aim to decrease or at least not increase inequities, but not necessarily have any impact on other inequalities (figure 2).

Figure 2. WHO HIA Definition



World Health Organization

a centre | Publications | Countries | Programmes | About WHO

Health Impact Assessment (HIA)

Glossary of terms used

F - P

Health inequality and inequity

Health inequalities can be defined as differences in health status or in the distribution of health determinants between different population groups. For example, differences in mobility between elderly people and younger populations or differences in mortality rates between people from different social classes. It is important to distinguish between inequality in health and inequity. Some health inequalities are attributable to biological variations or free choice and others are attributable to the external environment and conditions mainly outside the control of the individuals concerned. In the first case it may be impossible or ethically or ideologically unacceptable to change the health determinants and so the health inequalities are unavoidable. In the second, the uneven distribution may be unnecessary and avoidable as well as unjust and unfair, so that the resulting health inequalities also lead to inequity in health.

in WHO HIA Glossary of terms:. http://www.who.int/hia/about/glos/en/index1.html

1.3. Health Impact Assessment - definition

Health impact assessment (HIA) is according to WHO a “combination of procedures, methods and tools by which a policy, programme or project may be judged as to its potential effects on the health of a population, and the distribution of those effects within the population” [7]. The International Association for Impact Assessment (IAIA) added that “HIA identifies appropriate action to manage those effects’ (i.e. the effects on health and distribution of health)” [8].

Any project or policy (at international, national, regional or local levels), in any activity sector, generates positive and/or negative impacts on the health of human populations [9,10]. These impacts produce in turn consequences in other areas, ultimately affecting the global economic and social prosperity. HIA methodologies help the decision-making process, regarding going forward or not with a project or policy and in the way that it is done [11,12].

HIA thus aims to inform and improve the decision-making process in favor of health and health equity, maximizing potential positive health impacts and minimizing potential negative health impacts of a proposal [13].

The HIA methodology generally follows the steps below (table 1) and will be applied partially or in its whole depending on the study [14].

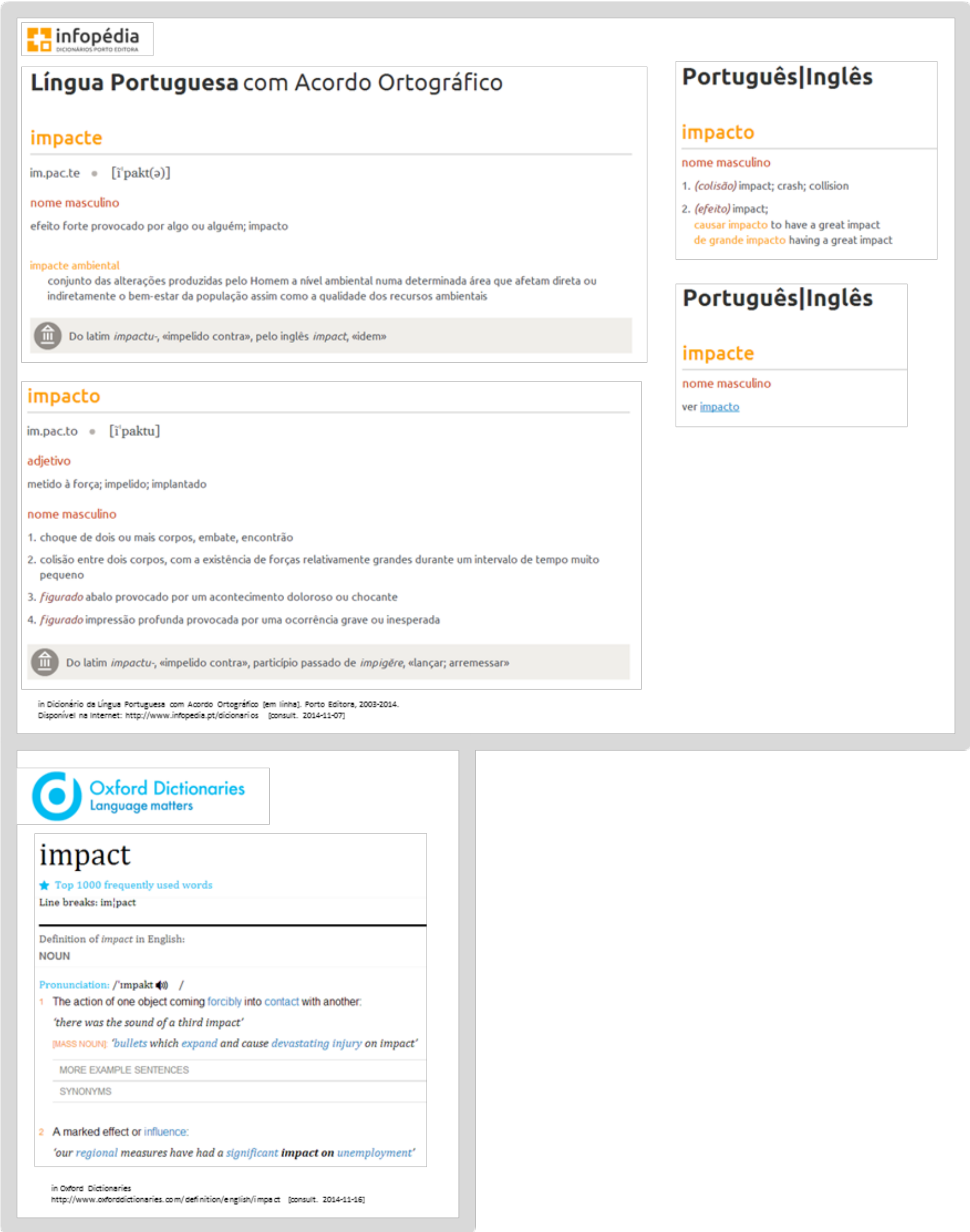
Table 1. HIA Steps, their aims and methods used

HIA Steps	**General Aims**	**Methods Used**
Screening	While medical screening helps select individuals suffering from a particular disease, HIA screening helps chose relevant policies or projects for which to conduct HIA.	Literature, documentation and database searches, interview process to potential stakeholders or experts
Scoping	Planning the HIA includes defining the underlying terms of reference, identifying potential stakeholders and enhancing their engagement in the HIA process, establishing a steering group.	Project management approaches, communication, networking and negotiation skills
Appraisal	Conducting the assessment includes policy analysis, profiling of communities, qualitative and quantitative data collection, impact analysis, establishing priority impacts, recommendations developing and process evaluation.	Risk and outcomes analyses, public health, survey, statistical and participatory approaches
Reporting to Decision-Makers	The main HIA outputs are recommendations to support decision-making on how to deal with the assessed project or policy, to be presented in reports, workshop or seminars.	Writing, presentation, communication and results dissemination skills
Monitoring and Evaluation	Monitoring the real impact of the project or policy implementation if essential to evaluate the process of conducting the HIA, its impact on the decision-making process and outcome assessment changes in health and health determinants after implementation.	Epidemiology, statistical, survey, information management approaches

Adapted from Scott-Samuel, Birley & Ardern [14] and O'Mullane & Guliš [15]

Regarding the right terminology to be used in Portugal and although our report here is written in English, the discussion of what should be the correct translation of "Health Impact Assessment" to Portuguese became pertinent throughout our research [16]. In English the word "impact" either means "the action of one object coming forcibly into contact with another" or "a marked effect or influence" [17] as figure 3 shows. The Portuguese language however has two words, "impacto" and "impacte" [18], frequently used as synonyms, but that may reflect the two different "impact" meanings of the English language. "Impacto" may be considered closer to the "action of one object coming forcibly into contact with another" meaning, while "impacte" may be closer to the "marked effect or influence" meaning. Therefore, we will use as a more adequate translation for "Health Impact Assessment" the Portuguese expression "Avaliação de Impacte na Saúde" (AIS) [16,19].

Figure 3. "Impact", "Impacte" and "Impacto" definition and translation



1.4. HIA of policies from the health sector versus other sectors

Although HIA frequently intends to access health impacts of policies external to the health sector, it is also used increasingly to access health impacts of health policies, especially concerning health services and infrastructures [13,20,21].

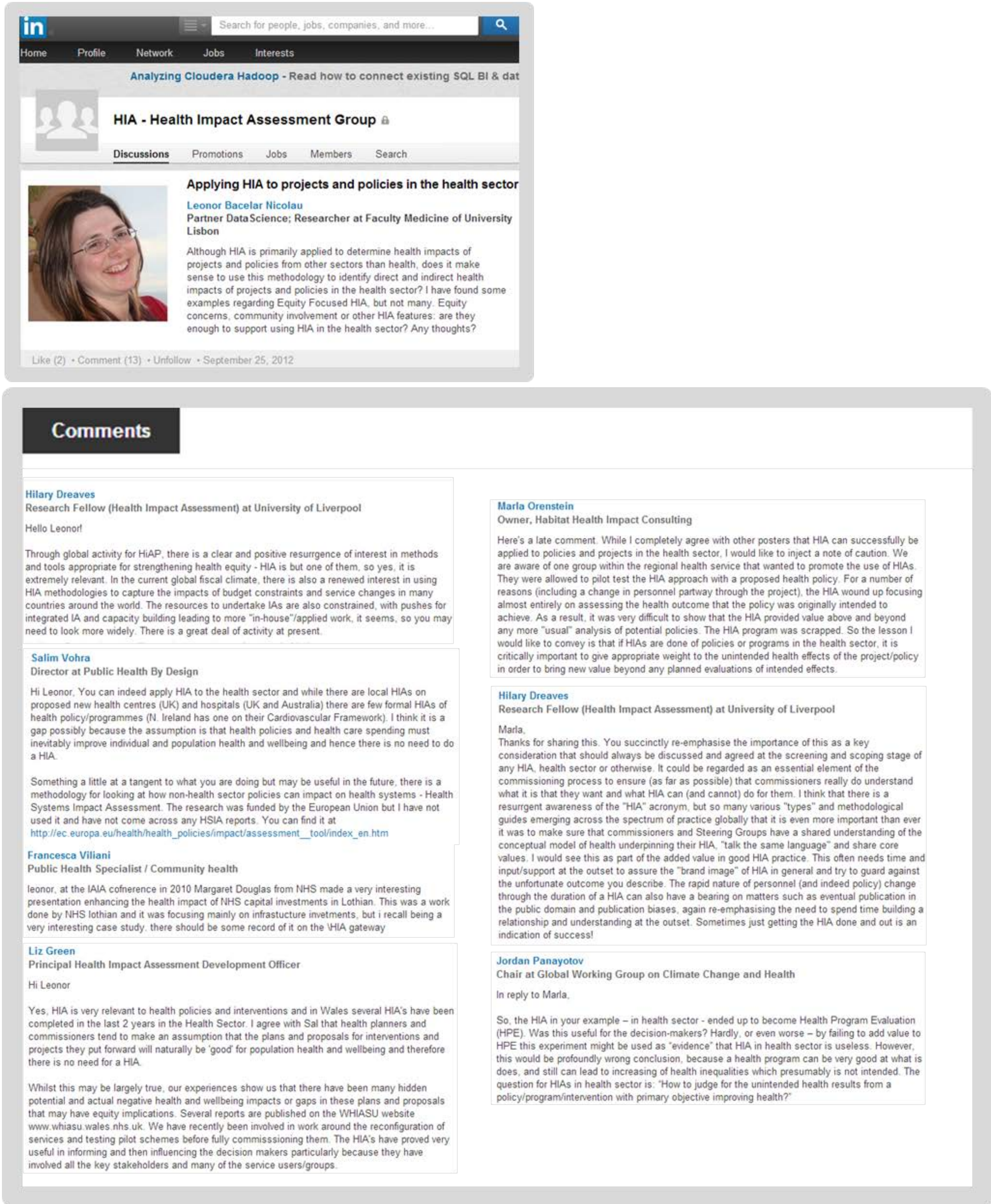
A discussion was started by us back in September 2012 on the Health Impact Assessment Group of the social network LinkedIn to try and learn what HIA experts thought of using this methodology to assess the impact of health policies [22].

During the following month, some very interesting replies from group members confirmed our expectations and enlightened also us on some research issues to bear in mind, as can be seen in the figure below.

It may consequently be concluded from the discussion that it is indeed possible to use HIA for health policies, especially when health equity, health systems impacts or integrated impacts are an issue. Nevertheless, one needs to be careful and account for unexpected, as well as expected, effects of the policies, involving the HIA commissioners and Steering Groups right at the early screening and scoping stages of the process.

The use of HIA on health sector proposals, in its general form or specific form of Equity focused health impact assessment, has been acknowledge and justified by mainly enhancing the advantages of fully integrating health equity concerns into the decision-making process [23].

Figure 4. Selected comments from the HIA of health policies discussion on the HIA Group of LinkedIn website



in
Search for people, jobs, companies, and more...
Home Profile Network Jobs Interests
Analyzing Cloudera Hadoop - Read how to connect existing SQL BI & dat

HIA - Health Impact Assessment Group
Discussions Promotions Jobs Members Search

Applying HIA to projects and policies in the health sector
Leonor Bacelar Nicolau
Partner DataScience; Researcher at Faculty Medicine of University Lisbon

Although HIA is primarily applied to determine health impacts of projects and policies from other sectors than health, does it make sense to use this methodology to identify direct and indirect health impacts of projects and policies in the health sector? I have found some examples regarding Equity Focused HIA, but not many. Equity concerns, community involvement or other HIA features: are they enough to support using HIA in the health sector? Any thoughts?

Like (2) • Comment (13) • Unfollow • September 25, 2012

Comments

Hilary Dreaves
Research Fellow (Health Impact Assessment) at University of Liverpool

Hello Leonor!

Through global activity for HiAP, there is a clear and positive resurrgence of interest in methods and tools appropriate for strengthening health equity - HIA is but one of them, so yes, it is extremely relevant. In the current global fiscal climate, there is also a renewed interest in using HIA methodologies to capture the impacts of budget constraints and service changes in many countries around the world. The resources to undertake IAs are also constrained, with pushes for integrated IA and capacity building leading to more "in-house"/applied work, it seems, so you may need to look more widely. There is a great deal of activity at present.

Salim Vohra
Director at Public Health By Design

Hi Leonor, You can indeed apply HIA to the health sector and while there are local HIAs on proposed new health centres (UK) and hospitals (UK and Australia) there are few formal HIAs of health policy/programmes (N. Ireland has one on their Cardiovascular Framework). I think it is a gap possibly because the assumption is that health policies and health care spending must inevitably improve individual and population health and wellbeing and hence there is no need to do a HIA.

Something a little at a tangent to what you are doing but may be useful in the future, there is a methodology for looking at how non-health sector policies can impact on health systems - Health Systems Impact Assessment. The research was funded by the European Union but I have not used it and have not come across any HSIA reports. You can find it at http://ec.europa.eu/health/health_policies/impact/assessment__tool/index_en.htm

Francesca Viliani
Public Health Specialist / Community health

leonor, at the IAIA cofnerence in 2010 Margaret Douglas from NHS made a very interesting presentation enhancing the health impact of NHS capital investments in Lothian. This was a work done by NHS lothian and it was focusing mainly on infrastucture invetments, but i recall being a very interesting case study. there should be some record of it on the \HIA gateway

Liz Green
Principal Health Impact Assessment Development Officer

Hi Leonor

Yes, HIA is very relevant to health policies and interventions and in Wales several HIA's have been completed in the last 2 years in the Health Sector. I agree with Sal that health planners and commissioners tend to make an assumption that the plans and proposals for interventions and projects they put forward will naturally be 'good' for population health and wellbeing and therefore there is no need for a HIA.

Whilst this may be largely true, our experiences show us that there have been many hidden potential and actual negative health and wellbeing impacts or gaps in these plans and proposals that may have equity implications. Several reports are published on the WHIASU website www.whiasu.wales.nhs.uk. We have recently been involved in work around the reconfiguration of services and testing pilot schemes before fully commisssioning them. The HIA's have proved very useful in informing and then influencing the decision makers particularly because they have involved all the key stakeholders and many of the service users/groups.

Marla Orenstein
Owner, Habitat Health Impact Consulting

Here's a late comment. While I completely agree with other posters that HIA can successfully be applied to policies and projects in the health sector, I would like to inject a note of caution. We are aware of one group within the regional health service that wanted to promote the use of HIAs. They were allowed to pilot test the HIA approach with a proposed health policy. For a number of reasons (including a change in personnel partway through the project), the HIA wound up focusing almost entirely on assessing the health outcome that the policy was originally intended to achieve. As a result, it was very difficult to show that the HIA provided value above and beyond any more "usual" analysis of potential policies. The HIA program was scrapped. So the lesson I would like to convey is that if HIAs are done of policies or programs in the health sector, it is critically important to give appropriate weight to the unintended health effects of the project/policy in order to bring new value beyond any planned evaluations of intended effects.

Hilary Dreaves
Research Fellow (Health Impact Assessment) at University of Liverpool

Marla,
Thanks for sharing this. You succinctly re-emphasise the importance of this as a key consideration that should always be discussed and agreed at the screening and scoping stage of any HIA, health sector or otherwise. It could be regarded as an essential element of the commissioning process to ensure (as far as possible) that commissioners really do understand what it is that they want and what HIA can (and cannot) do for them. I think that there is a resurrgent awareness of the "HIA" acronym, but so many various "types" and methodological guides emerging across the spectrum of practice globally that it is even more important than ever it was to make sure that commissioners and Steering Groups have a shared understanding of the conceptual model of health underpinning their HIA, "talk the same language" and share core values. I would see this as part of the added value in good HIA practice. This often needs time and input/support at the outset to assure the "brand image" of HIA in general and try to guard against the unfortunate outcome you describe. The rapid nature of personnel (and indeed policy) change through the duration of a HIA can also have a bearing on matters such as eventual publication in the public domain and publication biases, again re-emphasising the need to spend time building a relationship and understanding at the outset. Sometimes just getting the HIA done and out is an indication of success!

Jordan Panayotov
Chair at Global Working Group on Climate Change and Health

In reply to Marla,

So, the HIA in your example – in health sector - ended up to become Health Program Evaluation (HPE). Was this useful for the decision-makers? Hardly, or even worse – by failing to add value to HPE this experiment might be used as "evidence" that HIA in health sector is useless. However, this would be profoundly wrong conclusion, because a health program can be very good at what is does, and still can lead to increasing of health inequalities which presumably is not intended. The question for HIAs in health sector is: "How to judge for the unintended health results from a policy/program/intervention with primary objective improving health?"

1.5. Timings of HIA: prospective, concurrent or retrospective

HIA can be defined as prospective, concurrent or retrospective, depending on its timing. Ideally and at first glance, HIA should be carried out prospectively, before or while a proposal is being developed, to maximize the potential of incorporating HIA recommendations into the draft proposal. A concurrent HIA executed while the policy is being implemented may however inform a review process to improve its health effects in the future and may benefit from having already some additional available data. A retrospective HIA may also be applied after a policy has already been implemented and may be especially useful when a similar proposal is being developed or changes in the previous policy are being considered [13].

Nevertheless it has been argued that if HIA concerns predicting health impacts, then HIA is always 'prospective' and 'retrospective HIAs' should be referred as 'evaluation', while 'concurrent HIAs' are actually monitoring [21].

In the Portuguese language, the word "avaliação" refers to the action of "avaliar" that means both to "evaluate" and to "assess" as may be seen in figure 6 [18]. During the "Capacity building workshop on equity-focused HIA" in Lisbon on January 2013, organized by WHO Regional Office for Europe and the Ministry of Health of Portugal, DGS and INSA, facilitator Ben Cave noted this language issue could explain why Portuguese accepted so naturally that HIA could be applied retrospectively, as well as prospectively or concurrently, while many people from English speaking countries favored a prospective timing.

Additionally, "a retrospective HIA differs from evaluation as it focuses on how health has been affected which may not have been an explicit objective of the policy, programme or project" [13].

Moreover, as quantification becomes increasingly important in HIA, the more relevant it becomes to use HIA in a first apparently non-prospective scenario, that may then become prospective, whenever changes in policies are wanted. Using data from the present and the past enriches the process of estimating health effects and predicting the future [24-26].

Figure 5. **Portuguese-English Translation of "Avaliar"**


infopédia
DICIONÁRIOS PORTO EDITORA

Português|Inglês

avaliar

conjugação

verbo transitivo

1. *(apreciar)* to evaluate; to assess; to judge;
   avaliar a situação to evaluate the situation
   avaliar os resultados to evaluate the results
   avaliar as necessidades to assess the needs
   avaliar alguma coisa mal to misjudge something, to be mistaken in one's assessment of something
2. (aluno) to assess
3. (trabalhador) to appraise
4. *(determinar o valor de)* to value [em, at]; to appraise *EUA* [em, at];
   avaliaram o quadro em 700 euros they've valued the painting at 700 euros
   mandar avaliar algo por um perito to have something valued by an expert
5. *(calcular)* to assess [em, at]; to estimate [em, at];
   avaliar os prejuízos to assess the damage
6. (quantidade, tamanho) to estimate; to judge;
   avaliar a distância to judge the distance
7. (sentimentos, atitudes) to gauge
8. *(tomar em consideração)* to weigh (up);
   avaliar os benefícios to weigh up the benefits
9. *(compreender)* to appreciate;
   avaliar a importância de to appreciate the importance of
10. *(considerar, reputar)* to regard [por, as]

avaliar in Dicionário de Português|Inglês [em linha]. Porto: Porto Editora, 2003-2014. [consult. 2014-11-16 17:12:39].
Disponível na Internet: http://www.infopedia.pt/dicionarios/portugues-ingles/avaliar

1.6. Quantification

HIA is regularly being used in many countries such as the UK, the Netherlands, Australia, New Zealand, Thailand, the USA and others, more often with a qualitative emphasis [21,27]. Quantifying health estimations within HIA was however very early in HIA history identified as potentially more informative and influential with decision-makers [21,26], complementing qualitative analyses to achieve more robust, evidence-based and whole estimations of health impacts that would include the nature of these impacts, as well as their direction, magnitude and distribution.

Nevertheless, it has been recognized that quantification within HIA is rarely done, since it "is often hard or impossible" because of a lack of information regarding initial conditions, effects of the proposal, and the theoretical framework linking conditions to health outcomes [21].

Generally, two different approaches to HIA quantification have been followed, one based on health economic evaluation and another on risk assessment [28]. Quantified HIA based on health economic evaluation relies on health technology assessment methods, estimating indirect costs and health-related quality of life indicators [29] and dealing with equity for instance by applying weights to account for inequalities when calculating health gains or by estimating health benefits separately by relevant population sub-groups [30]. The HIA quantification based on risk assessment is grounded in environmental and public health research experience of estimating risk exposure, frequently relying on epidemiology modelling [21,28]. Other HIA related quantification experiences include profiling individuals, screening policies [31-33] and evaluating HIA effectiveness [23,24,34,35].

An assortment of computational tools for HIA quantification has been made available: some more generic, others more specific to certain determinants or diseases; some more related to environmental health risk assessments, others more in tune with public health risk factor-outcome modelling; most not very user-friendly without support from the original developers. Further tool development is no longer considered a priority, but improvements are needed regarding two aspects: its application in various real-life contexts and especially in “whether and how they estimate impacts on health inequalities” [15,28,36].

The fact is that HIA still quite seldom uses multivariate statistical methods to estimate health impacts while taking equity into account and providing easy to understand visual outputs [15,26,37].

Among the difficulties, a major one is to find available and reliable data to model interrelations, explicitly between health determinants, health impacts, policies and related costs [24,28,36,38]. Another barrier is that complex statistical methodologies used frequently generate results difficult to understand by non-statisticians, including decision-makers [28,37], who often do not have a deep technical and statistical background [39].

1.7. Integration with other methodological approaches

Although HIA as an assessment may be used on its own, it is quite regularly used as a complement to other related methodologies and tools (such as environmental or integrated assessments, or even economic evaluation) or giving emphasis to particular areas within it [24]. The HIA methodology itself finds parallels and overlaps with other impact assessments such as Environmental Impact Assessment (EIA), Sustainability Statement (SS), Poverty Impact Assessment (PIA), Human Rights Impact Assessment (HRIA), Equality Impact Assessment (EqIA), Mental Health Impact Assessment (MHIA), Strategic Environmental Assessment (SEA) or Integrated Impact Assessment (IIA) [13,40].

We highlight the following assessments as particularly relevant for us to complement HIA:

- Equity Focused Health Impact Assessment (EFHIA) concentrates, even more than HIA, on identifying any health inequities in particular groups or sub-populations and generally on the search for equity when implementing a project or policy [20];
- Health Systems Impact Assessment (HSIA) is often applied in the context of Integrated Impact Assessment, incorporating also economic, social and environmental impacts [19,41,42];
- Economic evaluation like Cost Effectiveness Analysis (CEA) assesses positive and negative health effects, when comparing the relative costs and outcomes of two or more possible courses of action [43,44];
- Health Technology Assessment (HTA) has as main purpose to inform policy decision-makers on the best limited funds allocation regarding health interventions and technologies, taking into account related clinical, social, economic, organizational and ethical issues [16].

Being able to pick out aspects of these complementary areas and use these in a multivariate and integrated way may be useful to expand knowledge on interrelations between health determinants, health impact and economic outcomes. It may also be valuable to show how investing in health may offer a return in terms of economy, prosperity and well-being for society. Investing in health has indeed direct and indirect consequences through health systems in a country’s gross domestic product, affecting its competitiveness via labor costs, labor market flexibility and resource allocation at macroeconomic level [45]. This is a particularly important area regarding the pressing need to engage other sectors than health in HIA, since the return of a potential health investment may be quantified regarding these other areas.

1.8. Reaching out to decision makers

The growing importance of HIA and associated methodologies in the present and in the future is to be expected in the light of international documents such as the "Adelaide Statement on Health in All Policies - moving towards a shared governance for health and well-being" [46], the "Rio Political Declaration on Social Determinants of Health" [47] or the Health 2020 European Policy Framework and Strategy for the 21st Century [48].

Among advantages of systematically adopting health impact assessment in decision making, we highlight [13,24,25,37,49];

- Raising awareness among decision makers of interrelations between health and physical, social and economic environments;
- Increasing awareness among decision makers and other stakeholders on how a policy, program or project may affect health of a given population;
- Providing precise recommendations on how a policy, program or project could be modified to maximize health gains and minimize health losses;
- Increasing the number and quality of informed and evidence based decision making processes;
- Carrying out projects and policies with always present concerns of reaching precise goals, of underlying planning, of analyzing health effects, before, during and after its implementation.
- Helping, whenever possible, those affected by the policy, program or project to participate in the proposal planning and creation, thus contributing to decision-making, but also to a clearer and more transparent process;
- Linking, whenever possible, health impacts to specific costs of each project or policy.

Hence, HIA has a very practical goal of informing and helping decision-makers reach a decision of going further with a policy (or not) and in what way. This means that even if it is used in a more quantified and multivariate way, it has to take into account that, although statistical methodologies used may be complex, obtained outputs have to be comprehensible, simple to visualize, interpret and lead to clear recommendations.

1.9. Practice in Portugal and in other countries

Internationally, even if many HIAs are presently undertaken outside legislative or regulatory requirements, most voluntary HIAs are conducted within the public sector [24]. Whenever HIA is supported by policy or regulation, two broad approaches are identified: specific provisions are created for the use of HIA through laws, regulatory mandates or supportive policies; health concerns are included within whole-of-government decision-making processes, which may or may not include HIA.

Therefore, frequently the use of HIA is mandatory as part of EIAs or other impact assessments, as for instance in Alaska or as stated in the USA's National Environmental Policy Act [50,51], but also compulsory through legislation for certain projects in specific sectors and beyond a certain scale [52]. However, in some countries using HIA comes from a general requirement of government proposals being appraised for their health effects, such as in The Netherlands [53], Canada [4] or Australia [54]. In Europe, most European Commission initiatives have to comply with official impact assessment guidelines, including health and health systems impacts [55]. A specific EU Health Systems Impact Assessment webtool has even been developed, to be used as part of the European Commission's Impact Assessment, although it is not clear from the list of impact assessment reports available online how often it is used [19,41,56].

In Portugal, the need of using HIA has been clearly stated since the National Health Plan 2004-2010 [19]. A few conferences and workshops have taken place such as the "European meeting on Health and Health Systems Impact Assessment" (Lisbon, November 5-6 2007) during the Portuguese Presidency of the European Union Council, the "I National Workshop on Health Impact Assessment – concepts and practice" (Lisbon, November 20 2009) or the "Capacity building workshop on equity-focused Health Impact Assessment" (Lisbon, January 28-30 2013), that encouraged for example an equity-focused HIA of Changes on Portuguese Tobacco legislation [57,58]. There also seems to be a wish to develop HIA linked to health promotion in healthy cities [59], to environmental health [60], and to contribute to policies assessment and quantification in HIA [31-33,61,62].

Nevertheless, despite all these efforts and activities, the widespread use of HIA doesn't seem to really take off in Portugal, the health sector still doesn't get very much involved with activities from other sectors, health impacts linked to equity concerns are still not a current concern that translates into using HIA in everyday practice [16].

This situation is not very different from France, where the *Institut national de prévention et d'éducation pour la santé* has been encouraging the use of HIA roughly through the past 10 years [63], but where HIA is still considered a new practice, an emergent initiative, easier to undertake at local level, rather than at national level, but with an increasing strong concern regarding equity [64-66].

1.10. What this research adds

The holistic definition of health that guides this research, stated in section 1.1, puts health as the focal point of multifaceted interdependencies with all health determinants. Hence, this naturally leads to an aspiration to use multivariate statistical methodologies to capture at least part of these complex interrelations.

The concern of taking into account not only the general health impact of policies on a population but also the variability of the impact throughout that population and its link to inequities (section 1.2) is at the heart of what HIA stands for (section 1.3). Multivariate statistical methodologies studying the interconnections between health determinants and health impacts, and simultaneously identifying potentially different risk groups of individuals, seem to be fitting.

The impact of public policies within the health sector that may not be directly related to clinical issues, but to the way health services are organized and managed should be taken into account by HIA (section 1.4). However, the wish not to do a HIA *per se*, but to propose statistical methodologies and procedures to improve the HIA process within several of its steps, as well as to use real data to do so, sets this research in a non-prospective context (section 1.5). The methodological proposals that arise from this research however may be used in any kind of HIA timing.

Applying multivariate statistical methodologies to enrich the HIA process, also contributes to set HIA onto the path of an increased quantification (section 1.6), that may also even be useful to other impact assessments and related areas (section 1.7). Inversely, it also may bring features of those other assessments into HIA, such as evaluating impacts of health systems policies and their effects on the health of a particular population of health systems users, linking those to costs and economic evaluation.

Finally, the kind of multivariate statistical methodologies to be applied, however complex, should take into consideration that the ultimate goal of HIA is to make life easier on decision makers, and should thus generate comprehensible outputs: simple to visualize and to interpret, leading to clear and useful recommendations (section 1.8). Hopefully our research will add its contribution to a more extensive and current use of HIA, not only at a Portuguese level but also expectantly at an international level (section 1.9).

The present research should bring value to the use of HIA and be helpful for decision-makers, by making a contribution to:

- Show how to apply HIA in a multivariate context, to take into account complex interrelations between social, economic, political, cultural and environmental health determinants and thus contribute to build a solid base for health promotion;
- Develop easy but reliable ways of identifying subgroups within the populations whose health is more and less affected by policies to undertake, thus promoting equity and controlling inequities;
- Show how the use of quantified data, already collected for other purposes from different sources, may be invaluable to the HIA process, as an evidence-base for screening policies and modelling health impacts while bearing in mind subgroups of the population;
- Show how quantification and multivariate statistical methodologies lead to evidence-based results easy to grasp by public health experts, epidemiologists and decision-makers;
- Contribute, especially in Portugal, to incorporate further within the decision-making process an evidence-based practice of planning, modelling, monitoring and evaluating policies;
- Emphasize that HIA may evaluate policies outside the health sector, but also policies within the health sector, especially whenever health promotion is an

issue, since it considers health determinants from very different natures, or policies regarding the organization and management of health systems are at stake;

- Remember that investing in health improves the general wellbeing of society, and through HIA, by minimizing negative health impacts and maximizing positive health impacts of policies within or outside the health sector, we are indirectly investing in health and contributing to improve economy, prosperity and well-being for the all of society.

2. Research Aims

2.1. Main Aim

The main aim of this research is to show the usefulness of applying quantified multivariate statistical methodologies with helpful visualization approaches, to enrich the HIA practice, while making the decision-making process easier, in terms of issuing understandable outputs even for non-statisticians, in a deeply evidence based context.

2.2. General Goals

Our general goals are to:

- Identify throughout different HIA steps (screening, impact and outcome evaluation), the potential added-value of applying certain multivariate statistical methodologies and thus enrich the way HIA is presently done.
- Use complementary multivariate methodologies such as hierarchical cluster analysis, multiple correspondence analysis and others in HIA in a Portuguese context, applicable in the future to other situations at national and international level, studying interrelations between health impact sources and its effects, contributing to equity promotion.

- Integrate in our research equity aspects, identifying subpopulations where health impact magnitudes are different and more severe and show how this may be taken into account in decision making for a particular policy.
- Show how results may be presented in a visual, graphical way, so that conclusions may be understandable even for non-statisticians, although in a deeply evidence based context.

2.3. Stages and Chapters

To achieve these goals, we will follow a path across the next different stages:

- Explore recent research on HIA to identify current and future possible paths to follow (chapter 2);
- Show how using hierarchical cluster analysis may contribute to the HIA screening step (chapter 3), as a way to:
  - identify groups of policies more pertinent for decision makers as potential candidates for the HIA process, which may be especially appropriate in countries where HIA is non-mandatory, by prioritizing different policies regarding the health systems Portuguese hospital reform to identify those more relevant to apply HIA to;
  - Screen through different national health programs to select the context within which to apply HIA, electing the Cerebro-cardiovascular disease national health program as the more appropriate according to a particular set of criteria;
- Illustrate how the use of multivariate statistical analysis may make a valuable contribution when conducting an HIA, especially (chapter 4):
  - whenever regional or other equity issues are at stake,
  - while integrating multi source health information (hospitals and primary healthcare, pharmaceutical consumption and mortality),
  - in the context of a particular National Health Program (Cerebro-cardiovascular disease),

- when estimating health impacts of policies regarding the hospital reform and its links to primary healthcare.

Each of these stages will be presented within its own chapter further on, with its specific aims, methods, results, discussion and conclusions (chapters 2 to 4), as well as references and appendices. A final chapter will discuss and integrate main findings regarding each stage and conclude and issue recommendations on how to use applied quantified multivariate statistical methodologies to enrich the HIA process (chapter 5). A methods section that presents and summarizes the various statistical methods used may be consulted in general appendices.

References

1. World Health Organization. Preamble to the Constitution of the World Health Organization as adopted by the International Health Conference, New York, 19-22 June, 1946; signed on 22 July 1946 by the representatives of 61 States (Official Records of the World Health Organization, no. 2, p. 100) and entered into force on 7 April 1948, 1948.
2. WHO Concepts and Principles of Health Promotion Working Group. Annex 1: A Discussion Document on the Concept and Principles of Health Promotion 9-13 July 1984. In: Organization WH, ed. Milestones in Health Promotion - Statements from Global Conferences: WHO; 2009.
3. World Health Organization. Health Impact Assessment - The Determinants of Health. 8/13/2015. http://www.who.int/hia/evidence/doh/en/ (accessed 8/13/2015).
4. Health Canada. Canadian Handbook on Health Impact Assessment - Volume 1: The Basics. In: Canada H, editor. Canada: Canadian Ministry of Health; 2004.
5. Dahlgren G, Whitehead M. Policies and strategies to promote social equity in health. Stockholm, 1991.
6. WHO CSDH. Closing the gap in a generation: health equity through action on the social determinants of health. *Final Report of the Commission on Social Determinants of Health.* Geneva, Switzerland: World Health Organization; 2008.
7. European Centre for Health Policy. Health Impact Assessment - main concepts and suggested approach. Gothenburg Consensus Paper. Göteborg, Sweden: ECHP World Health Organization Regional Office for Europe; 1999.
8. Quigley R, den Broeder L, Furo P, Bond A, Cave B, Bos R. Health Impact Assessment International Best Practice Principles. *IAIA* 2006; (Special Publication Nº5).
9. WHO Regional Office for Europe. Health 21: The health for all policies framework for the WHO European Region: World Health Organization; 1999.
10. Stahl T, Wismar M, Ollila E, Lahtinen E, Leppo K, editors. Health in All Policies - Prospects and Potentials: Ministry of Social Affairs, Finland ; European Observatory on Health Systems and Policies; 2006.
11. Project Group EPHIA, editor. European Policy Health Impact Assessment EPHIA: a Guide: Health and Consumer Protection DG of the European Commission; 2004.
12. Lehto J, Ritsatakis A. Health Impact Assessment as a tool for inter-sectoral health policy: a discussion paper for a seminar at Gothenburg, Sweden. Brussels, Belgium, 1999.

13. Metcalfe O, Higgins C, Lavin T. Health Impact Assessment Guidance: Institute of Public Health in Ireland; 2009.
14. Scott-Samuel A, Birley M, Ardern K. The Merseyside Guidelines for Health Impact Assessment. 2nd ed: International Health Impact Assessment Consortium; 2001.
15. Fehr R, Viliani F, Nowacki J, Martuzzi M, editors. Health in Impact Assessments: Opportunities not to be missed. Copenhagen: WHO Regional Office for Europe; 2014.
16. Bacelar-Nicolau L, Heitor M, Pereira Miguel J. 7.3 Avaliação de Impacte na Saúde. In: Feijó A, Ferrão J, Monteiro S, Pinto Paixão J, eds. Metodologias de Avaliação de Políticas Públicas (in press). Lisboa: Imprensa da Universidade de Lisboa; 2017.
17. Oxford Dictionaries. Oxford Dictionaries definition of Impact. 11/16/2014. http://www.oxforddictionaries.com/definition/english/impact (accessed 11/16/2014).
18. Porto Editora. Dicionário da Lingua Portuguesa com acordo ortográfico [em linha]. 11/7/2014. http://www.infopedia.pt/dicionarios (accessed 11/7/2014).
19. Heitor MJ, Pereira Miguel J. Avaliação do Impacte de políticas de diferentes sectores na saúde e nos sistemas de saúde: um ponto de situação. *Revista Portuguesa de Saúde Pública* 2009; **27**(1): 5-17.
20. Mahoney M, Simpson S, Harris E, Aldrich R, Stewart-Williams J. Equity-focused health impact assessment Framework: the Australasian Collaboration for Health Equity Impact Assessment (ACHEIA); 2004.
21. Kemm J, editor. Health Impact Assessment: Past Achievements, Current Understanding and Future Progress: Oxford University Press; 2013.
22. Bacelar-Nicolau L. Applying HIA to Projects and Policies in the Health Sector. 9/25/2012 2012. https://www.linkedin.com/groups?gid=2144549&trk=my_groups-b-grp-v (accessed 9/25/2012 2012).
23. Harris-Roxas B, Haigh F, Travaglia J, Kemp L. Evaluating the impact of equity focused health impact assessment on health service planning: three case studies. *BMC Health Serv Res* 2014; **14**: 371.
24. Harris-Roxas B, Viliani F, Bond A, Cave B, Divall MJ, Furu P, Harris P, Soeberg M, Wernham A, Winkler M. Health impact assessment: the state of the art. *Impact Assessment and Project Appraisal* 2012; **30**(1): 43-52.
25. Kemm J. The future challenges for HIA. *Environmental Impact Assessment Review* 2005; **25**(7-8): 799-807.
26. Mindell J, Hansell A, Morrison D, Douglas M, Joffe M. What do we need for robust, quantitative health impact assessment? *Journal of Public Health Medicine* 2001; **23**(3): 173-8.
27. World Health Organization. Examples of HIA. 8/13/2015. http://www.who.int/hia/examples/en/ (accessed 8/12/2015).
28. Fehr R, Hurley F, Mekel OC, Mackenbach JP. Quantitative health impact assessment: taking stock and moving forward. *J Epidemiol Community Health* 2012; **66**(12): 1088-91.
29. Brodin H, Hodge S. A guide to Quantitative Methods in Health Impact Assessment. Stockholm, Sweden: STATENS FOLKHÄLSOINSTITUT, Östersund / Swedish National Institute of Public Health; 2008.
30. Glover D, Henderson J. Quantifying health impacts of governement policies, 2010.
31. Bacelar-Nicolau L, Pereira Miguel J, Saporta G. The Added Value of Multivariate Statistical Data Analysis in Policy HIA – A Quantitative Way of Profiling Subjects (Poster). HIA08 Health Impact Assessment and Sustainable Well-being - 9th Conference on Health Impact Assessment, 9-10 October 2008; 2008 10/9/2008; Liverpool, UK; 2008.
32. Bacelar-Nicolau L, Pereira Miguel J, Saporta G. Screening Policies for Health Impact Assessment: cluster analysis for easier decision making. *European Journal of Public Health* 2015; **25**(suppl_3): 133-4.
33. Bacelar-Nicolau L, Pereira Miguel J, Saporta G. Screening Policies in Health Impact Assessment: easier decision making through cluster analysis. European Journal of Epidemiology

European Congress of Epidemiology Healthy Living 2015: Bols E.; Smits L.; Weijenberg M. (Eds.); 2015. p. 852-.
34. Haigh F, Harris E, Harris-Roxas B, Baum F, Dannenberg AL, Harris MF, Keleher H, Kemp L, Morgan R, Ng Chok H, Spickett J. What makes health impact assessments successful? Factors contributing to effectiveness in Australia and New Zealand. *BMC Public Health* 2015; **15**(1009): 1009.
35. Veerman JL, Mackenbach JP, Barendregt JJ. Validity of predictions in health impact assessment. *J Epidemiol Community Health* 2007; **61**(4): 362-6.
36. Fehr R, Mekel OCL, Hurley JF, Mackenbach JP. Health impact assessment - A survey on quantifying tools. *Environmental Impact Assessment Review* 2016; **57**: 178-86.
37. Veerman JL, Barendregt JJ, Mackenbach JP. Quantitative health impact assessment: current practice and future directions. *J Epidemiol Community Health* 2005; **59**(5): 361-70.
38. Kemm J. Comments on HIA forecast: cloudy with sunny spells. *European Journal of Public Health* 2008; **18**(5): 438-9.
39. Veerman JL. Quantitative health impact assessment: an exploration of methods and validity; 2007.
40. Mills J. Local Development Framework: Health Impact assessment - Supplementary Planning Document, 2011.
41. Deltour A, Hedin A, Koho A, van Elk B, Lathinen E, Liaudanskiené R, Pereira Miguel J. Working Group on Health Impact Assessment and Health Systems: Towards Health Systems Impact Assessment, 2004.
42. Albuquerque JM, Pereira Miguel J. Health Systems Impact Assessment and the High Level Group on Health Services and Medical Care. EU Ministerial Conference "Health in All Policies: Achievements and Challenges"; 2007 12/18/2007; Rome, Italy; 2007.
43. Merkur S, Sassi F, McDaid D. Promoting health, preventing disease: is there an economic case?: WHO Regional Office for Europe and European Observatory on Health Systems and Policies; 2013.
44. WHO Regional Office for Europe and European Observatory on Health Systems and Policies. Health Systems, Health Wealth and Societal Well-being: Assessing the case for investing in health systems: WHO Regional Office for Europe and European Observatory on Health Systems and Policies; 2012.
45. Suhrcke M, Mckee M, Sauto-Arce R, Tsolova S, Mortensen J. The contribution of health to the economy in the European Union: Health&Consumer Protection Directorate-General - European Commission - European Communities; 2005.
46. Adelaide statement on health in all policies: moving towards a shared governance for health and well-being. Adelaide, Australia; 2010.
47. Rio Political Declaration on Social Determinants of Health. Rio de Janeiro, Brazil; 2011.
48. WHO Regional Office for Europe. Health 2020: A European Policy Framework and Strategy for the 21st Century: World Health Organization; 2013.
49. Kemm J, Parry J, Palmer S, editors. Health Impact Assessment: Concepts, Theory, Techniques, and Applications. Oxford: Oxford University Press; 2004.
50. Bhatia R, Wernham A. Integrating human health into environmental impact assessment: an unrealized opportunity for environmental health and justice. *Environ Health Perspect* 2008; **116**(8): 991-1000.
51. Wernham A. Inupiat health and proposed Alaskan oil development: Results of the first integrated Health Impact Assessment/Environmental Impact Statement for proposed oil development on Alaska's North Slope. *Ecohealth* 2007; **4**(4): 500-13.
52. Health Impact Assessment Coordinating Unit. Thailand's Rules and Procedures for the Health Impact Assessment of Public Policies. Thailand, 2010.
53. den Broeder L, Penris M, Put GV. Soft data, hard effects. Strategies for effective policy on health impact assessment--an example from the Netherlands. *Bull World Health Organ* 2003; **81**(6): 404-7.

54. Harris P, Harris-Roxas B, Harris E, Kemp L. Health Impact Assessment: A Practical Guide. Sydney: Centre for Health Equity Training, Research and Evaluation (CHETRE). Part of the UNSW Research Centre for Primary Health Care and Equity, UNSW.; 2007.
55. European Commission. European Comission's Health in all policies - Impact. 30/10/2017. https://ec.europa.eu/health/health_policies/impact_en (accessed 30/10/2017).
56. European Commission. European Commission's list of Final Impact Assessment reports. 10/01/2017. http://ec.europa.eu/smart-regulation/impact/ia_carried_out/cia_2016_en.htm (accessed 24/10/2017).
57. Direção de Serviços de Prevenção da Doença e Promoção da Saúde. Avaliação de Impacto da Lei do Tabaco com foco na equidade. Portugal, 2014.
58. Costa A, Cortes M, Sena C, Nunes E, Nogueira P, Shivaji T. Equity-focused health impact assessment of Portuguese tobacco control legislation. *Health Promot Int* 2016: 1-9.
59. Loureiro I, Miranda N, Pereira Miguel J. Promoção da saúde e desenvolvimento local em Portugal: reflectir para agir. *Revista Portuguesa de Saúde Pública* 2013; **31**(1): 23-31.
60. Dias D, Tchepel O, Carvalho A, Miranda AI, Borrego C. Particulate matter and health risk under a changing climate: assessment for Portugal. *ScientificWorldJournal* 2012; **2012**(Article ID 409546,): 409546.
61. Bacelar-Nicolau L, Barbosa P, Sakellarides C. Part II: Country profiles of health system responses to the crisis - Portugal. In: Maresso A, Mladovsky P, Thomson S, Sagan A, Karanikolos M, Richardson E, Cylus J, Evetovits T, Jowett M, Figueras J, Kluge H, eds. Economic crisis, health systems and health in Europe – Country experience: Maidenhead: Open University Press on behalf of the European Observatory on Health Systems and Policies and World Health Organization Regional Office for Europe; 2015: 460-5.
62. Bacelar-Nicolau L, Rodrigues T, Fernandes E, Lobo MF, Nisa C, Azzone V, Teixeira-Pinto A, Rocha-Gonçalves FN, Azevedo LF, Freitas A, Normand ST, Costa-Pereira A, Pereira Miguel J. Helping Decision-Makers Visualize Inequities In Health Impact Assessment: Linked Electronic Records, Mortality And Regional Disparities In Portugal. Value in Health: Elsevier; 2016. p. A623.
63. INPES. Évaluation en santé publique. 11/23/2015. http://www.inpes.sante.fr/evaluation/default.asp.
64. Valentini H, Saint-Pierre L. L'évaluation d'impact de la santé, une démarche structurée pour instaurer de la santé dans toutes les politiques. *Santé Publique* 2012; **24**(2012/6): 479-82.
65. Lang T, Bidault E, Villeval M, Alias F, Gandouet B, Servat M, Theis I, Breton E, Haschar-Noe N, Grosclaude P. A health equity impact assessment umbrella program (AAPRISS) to tackle social inequalities in health: program description. *Glob Health Promot* 2016; **23**(3): 54-62.
66. Villeval M, Bidault E, Lang T, pour le groupe A. Évaluation d'impact sur la santé et évaluation d'impact sur l'équité en santé : éventail de pratiques et questions de recherche. *Glob Health Promot* 2016; **23**(3): 86-94.

Chapter 2 –Exploring and Profiling through the State of the Art

CONTENTS

Chapter 2 –Exploring and Profiling through the State of the Art

“So you will see us continue to advance the state of the art or take information that we have in our response data bases and have that drive automation or an automated response by some of our products.” John W. Thompson

“Technology gives us power, but it does not and cannot tell us how to use that power. Thanks to technology, we can instantly communicate across the world, but it still doesn't help us know what to say.” Jonathan Sacks

“The first rule of any technology used in a business is that automation applied to an efficient operation will magnify the efficiency. The second is that automation applied to an inefficient operation will magnify the inefficiency.” Bill Gates

Chapter 1 introduced what HIA is about and the scope of our interest in it throughout our research. Several very complete papers, books and guides regarding HIA state-of-the-art have been published since its earlier applications [1-6]. We went beyond these analyses to add innovative useful ways of extracting knowledge when analyzing a bulk of potentially interesting publications and we thus used multivariate data analysis to profile HIA guides and HIA papers published during the period 2012-2014.

Abstract

Introduction: When needing to perceive the state-of-the-art about a particular body of knowledge, one often systematically reviews existent bibliography, gathering relevant publications on that specific subject and analyzing them in-depth or building a table of characteristics each paper has or doesn’t have. This is typically a more qualitative analysis. Our aim is to help this review process using multivariate quantitative methods that allow for useful graphic representations.

Materials and Methods: Two datasets are considered. Firstly, a table characterizing 45 Health Impact Assessment (HIA) guides proposed by authors Hebert et al. of paper “Health impact assessment: A comparison of 45 local, national and international guidelines”. Multivariate Correspondence Analysis and Hierarchical Cluster Analysis were applied to identify common and distinct features between guides and create similar guide

profiles. Secondly, profiles of 247 HIA papers from 2012 to 2014 included on the list of HIA Bibliography published and updated regularly by the HIA Gateway associated to Public Health England were built, taking titles of those papers on the one hand, and keywords when available on the other hand. Text mining analysis was applied to obtain a lexical contingency table, which was then related to only 3 characteristics registered by us for each paper (publication year, whether the title of the journal where it was published had the word "environment" and if it applied some quantification methods and results) through hierarchical cluster analysis and correspondence analysis.

Results: Regarding the sample of HIA guides, findings confirmed main conclusions from original authors that a universal HIA guide could be a reality, but identified most common and differentiating features in a more immediate and graphic way, going even further to select potential candidates to universal guides. Regarding the sample of HIA papers, three different profiles arisen, but only one, more linked to environmental papers, was more related to the use of quantification, showing the need to further adopt quantified methodologies when assessing health impact of non-environmental public policies.

Highlights: Using multivariate data analysis to extract main patterns from a table describing features of a group of publications may save time, potentially decreases subjectivity biases regarding interpretation of results and summarizes in quite an easy way to visualize common and distinctive characteristics.

Taking the automation process even further and applying text mining analysis methods, based even on elementary string information such as paper titles or keywords, consists an innovative useful way of extracting knowledge when analyzing a bulk of potentially interesting publications, quite instantly allowing for the identification of main underlying profiles.

The immediate visualization these methodologies allow may make knowledge acquisition easier for non-statisticians, potentially helping fruitful dialogue among multidisciplinary teams and namely between public health experts and decision-makers.

1. Introduction

The expression state-of-the-art is defined as "the most recent stage in the development of a product, incorporating the newest ideas and features" [7]. Frequently, when one needs to perceive the state-of-the-art about a particular body of knowledge, one does a systematic review of existent bibliography, gathering a relevant group of publications on that specific subject and analyzing those publications in-depth [8]. That is typically a more qualitative analysis. Often authors build a table of characteristics each paper has or does not have [6] to help them systemize information and more easily identify differences and similarities between various publications.

However, it would be helpful to make the process of getting and summarizing main points of information within these papers easier, quicker and in a more automated way, hopefully less permeable to subjectivity. One way would be to use a visualization technique to help perceive, at a glance, the more relevant results, instead of (or as a complement to) writing an extensive text analyzing and interpreting information. Hence one could use quantitative methods that allow for graphic representation. With that thought in mind we propose 2 different approaches.

First we take the table authors of paper "Health impact assessment: A comparison of 45 local, national and international guidelines" [6], published in online appendixes, characterizing 45 HIA guides, and applied exploratory multivariate statistical analysis to profile these publications. Our aim is to obtain results showing the main conclusions authors found in a more immediate and graphic way to perceive.

Nevertheless, building a table describing a group of selected publications may yet take up a considerable amount of time. Furthermore, characterizing publications on some of the variables may sometimes be a quite subjective process, which may become a problem especially when several different people are involved in the systematic classification and registering process of information into table format [9].

Consequently, we propose a second approach now to make the process of characterizing a group of papers more automatic, and hopefully speedier and simultaneously more objective, by using text mining analysis methods [10,11]. Our aim is to obtain profiles of 247 HIA papers from 2012 to 2014, taking titles of those papers, on the one hand, and keywords when available, on the other hand, and relating them to only 3 characteristics registered for each paper: publication year, whether the title of the journal where it was published had the word “environment” (or closely related word such ‘environmental’ for example) and if it applied some quantification in methods and results.

2. Data and Methodologies

2.1. HIA Guides Dataset

The first dataset used was based on the table of characteristics published by authors of paper “Health impact assessment: A comparison of 45 local, national and international guidelines” [6], describing 45 selected HIA guides, published from 1995 to 2011. Qualitative characteristics were recoded into 26 nominal active variables and 2 additional supplementary variables were included, from our own analysis of the sample, regarding the region of origin and the kind of screening procedures presented within each HIA Guide (table 1). Exploratory univariate statistical analysis was performed (see appendices tables 4 to 9), to validate the adapted dataset and compare our results with those of the original paper. Multivariate statistical methods were then applied, namely Multiple Correspondence Analysis (MCA) and Hierarchical Cluster Analysis (HCA), to identify common and distinct features between guides and create similar guide profiles [12-14]. SPAD software version 3.5 was used for this analysis [15].

Table 1. Features characterizing sample of 45 HIA guidelines

Variables and their categories	
Active Variables	
Focus of HIA	**Includes_List_Health_Determinants**
Focus All / Focus Policy / Focus Project	List H Determin Y / List H Determin N
Type of HIA	**Includes_Examples_CaseStudies_Resources**
Type All / Type Prospective / Type Retrospective	Examples Y / Examples N
Level Rapid	**Screening_Partial**
Level Rapid Y / Level Rapid N	Screening Y / Screening Partial
Level Intermediate	**Screening_Meetings**
Level Intermed Y / Level Intermed N	Screening Meetings Y / Screening Meetings N
Level Comprehensive	**Screening_ComprehensiveTools**
Level Comprehens Y / Level Comprehens N	Screening Tools Y / Screening Tools N
Level NoMultiple	**Scoping_Partial**
Level NoMultip Y / Level NoMultip N	Scoping Y / Scoping Partial
Discusses_Integration_with_other_IA	**Scoping_DiagramsLevel**
Integrat Other IA Y / Integrat Other IA N	Scoping Diagrams Y / Scoping Diagrams N
Mentions_Supportive_Policy_Authority	**Assessment_Partial**
Supportive Policy Y / Supportive Policy N	Assessment Y / Assessment Partial
Includes_Principles_or_Values	**Recommendations_Partial**
Principles Values Y / Principles Values N	Recommendat Y / Recommendat Partial
Considers_Equity_Inequalities_across_Population	**Reporting**
Equity Y / Equity N	Reporting Y / Reporting Partial / Reporting N
Encourages_Community_Engagement	**Reporting_Guidance**
Community Engag Y / Community Engag N	Reporting Guidance Y / Reporting Guidance N
Includes_Steering_Committee	**Evaluation_Monitoring**
Steering Committe Y / Steering Committe N	Evaluation Monitor Y / Evaluation Monitor Partial / Evaluation Monitor N
Recommends_Community_Profile	**Evaluation_Monitoring_TalkDecisionmakers**
Community Profile Y / Community Profile N	Talk Decisionmak Y / Talk Decisionmak N
Supplementary Variables	
Screening based on	**Region**
Screen Health Only	Region International
Screen Vague Other	Region Europe
Screen PoliticFinanc	Region AustralAsia
Screen Pre-screennin	Region NorthAmerica
Screen Not Available	

2.2. HIA Papers Dataset

The second dataset was based on the list of HIA Bibliography published and updated regularly by the HIA Gateway associated to Public Health England [16], last updated in March 2014.

Inclusion criteria were: being a paper from the Health Impact Assessment Section of the HIA Gateway Bibliography published in a scientific journal during 2012 to 2014 with available abstract and/or complete text. Exclusion criteria were: being a book (4 references) or a conference abstract (17 references); being published on a different year than 2012, 2013 or 2014 (erroneously catalogued in the HIA Gateway Bibliography – 4 references); not having available simultaneously an abstract nor complete text (1 reference); being duplicated in the original bibliography (5 pairs of references, usually because dates of online publication preceded dates of paper publication).

A total of 29 references were thus eliminated from the initial 276 references, which means 247 abstracts were analyzed: 136 references from 2012, 98 references from 2013 and 13 references from 2014. From these, 230 had the original papers also available (93%). Note that only references until March 2014 were considered in the original HIA Gateway document.

Text mining analysis methods were applied [10,11], regarding two string variables separately: the title of the paper, obviously present for all 247 papers, and the list of keywords, available for only 170 papers. For each string variable, a vocabulary of repeated words and expressions or segments of words from the text data was automatically defined and the frequency of appearance of words/segments was calculated. Only words and segments with a total frequency of 10 or over were taken for analysis. Table 2 presents the number of words and associated frequency for each step of the analysis.

A lexical contingency table was then automatically generated with these repeated words and segments in rows and the groups defined by categories of selected nominal variables in columns. The nominal variables crossed with word/segments were: Publication year (2012, 2013 or 2014); Journal Title with or without “Environment”; Quantification of methods and results (Quantification or No quantification) – appendixes tables 15 and 16. These variables were created by going through the information usually available publicly for all papers: titles, keywords and abstracts. Note that some journals without “Environment” in the title may be also considered journals in a more environmental area and journals in a more public health area may include so called environmental papers. That is a limitation of this study that could confound the following multivariate results and could be solved by a deeper analysis of the complete papers themselves. Yet it would be time-consuming and the goal was to show that even a rapid analysis could be helpful, so it was preferred to acknowledge but leave the limitation, not solving it unless results would be clearly biased.

Hierarchical cluster analysis (HCA) and correspondence analysis (CA) were applied to both lexical contingency tables built [11]. The software used for statistical analysis was IBM-SPSS 22 for the initial database construction and descriptive analysis and SPAD software version 3.5 for text mining analysis [15,17].

Table 2. Process of building the lexical vocabulary

	Number of words / segments	**Total frequency**
Titles for 247 Papers		
Initial vocabulary only with single words	969	2386
Phase 1: Modified vocabulary only with single words	594	1677 (70% of frequency of initial vocabulary only with single words)
Phase 2: Modified vocabulary with single words and repeated text segments	655	2026
Phase 3: Modified vocabulary with frequency >=10	40	1017 (53% of frequency of total frequency of modified vocabulary with single words and repeated text segments)
Keywords for 170 papers		
Initial vocabulary only with single words	719	1581
Phase 1: Modified vocabulary only with single words	451	1535 (97% of frequency of initial vocabulary only with single words)
Phase 2: Modified vocabulary with single words and repeated text segments	513	1956
Phase 3: Modified vocabulary with frequency >=10	49	1296 (66% of frequency of total frequency of modified vocabulary with single words and repeated text segments)

3. Results

3.1. Summarizing systematic reviews in a more "visual" way

The 45 HIA guides under study were issued between 1995 and 2011, about half of them being published after 2004 (53%) and mostly coming from Europe (56%) [6]. The authors from the original paper aimed to identify "commonalities and differences within HIA guides to discuss the plausibility of consensus guidelines and to inform guideline development". They did a detailed and extensive comparison of all guides' features and concluded that "a universal guide is possible and could become a crucial component to growing the HIA discipline". The alternative way here proposed to profile HIA guides with multivariate statistical analysis, such as MCA and HCA, aims to answer these questions in a more immediate way and show how one can even go further in this study, selecting potential candidates as universal guides.

The MCA factors represent non-correlated dimensions of variability within data, ranked by their importance to global variability within a dataset. Choosing the first 3 factors for analysis means 32% of the initial variability will be studied, since factor 1, 2 and 3 explain, respectively 13%, 10% and 9% of global variability. These low percentages associated with main factors are, one the one hand, due to the MCA methodology itself that tends to generate factors with percentages of explanation lower than other factorial methods, such as principal component analysis or simple correspondence analysis. On the other hand, it is also related to the guides being quite similar to each other, not generating clear large dimensions that distinguish them.

A factorial plan embodies the variability associated with a pair of factors, one factor represented on the horizontal axis of the plan and the other factor on the vertical axis: features more similar throughout guides gather near the center or origin of the plan, whereas features distinguishing guides position themselves further away from the center.

Taking the factorial plan 1-2, regarding the first 2 factors, similar features would be the ones visible when zooming on the center of the plan (figure 3), whereas features discriminating guides would be the ones farther from the center, towards right and left regarding factor 1 and towards up and down concerning factor 2 (figure 2).

The hierarchical cluster analysis dendrogram (figure 1) identifies partitions from 2 to 5 clusters of guides as candidates for analysis. To have more detailed guide profiles, a partition of 5 clusters was selected. Each cluster is a group of guides with a similar profile. Appendices table 11 identifies the guides belonging to each cluster.

Appendices Table 10 identifies features more and less common within each cluster:

- Cluster 1 groups 9 guides, that are all from Europe and mention policy authority, but mostly have not a whole Assessment Step described, usually not including a matrix or other tool for prioritizing impacts nor organizing information;
- Cluster 2 includes 9 guides that do not have particularly distinctive features from the total sample;
- Cluster 3 groups 11 guides that tend not to include all 3 HIA usual focus areas (policy, programs, projects), but integrate comprehensive scoping diagrams to determine the adequate HIA level to conduct, provide guidance on what to include or not when reporting results, adapting that report to the target audiences and recommend talking to decision-makers so that the process may be evaluated and its usefulness appraised;
- Cluster 4 comprises 10 guides that all discuss integration of HIA with other Impact Assessments and debate the different levels of HIA, without giving importance to a particular level (not focusing particularly rapid nor comprehensive HIA levels);
- Cluster 5 includes 6 guides that do not present whole descriptions of both the screening and scoping steps, also tending to ignore the evaluation and monitor HIA step.

The fact that both features and clusters of guides may generally be found near the center of the various factorial plans means that guides are mostly very similar to each other.

The aim of the authors of the original paper to identify common and different features would thus be quite simple too reach with MCA. It is very clear to identify both these types of features from visual observation of the factorial plans.

Whenever one has a table of qualitative features (nominal variables) describing a sample of publications, one may use MCA and HCA to check their overall resemblance and create profiles, groups of similar publications, identifying their main common and distinctive characteristics.

Figure 1. HCA Dendrogram of 45 HIA guidelines

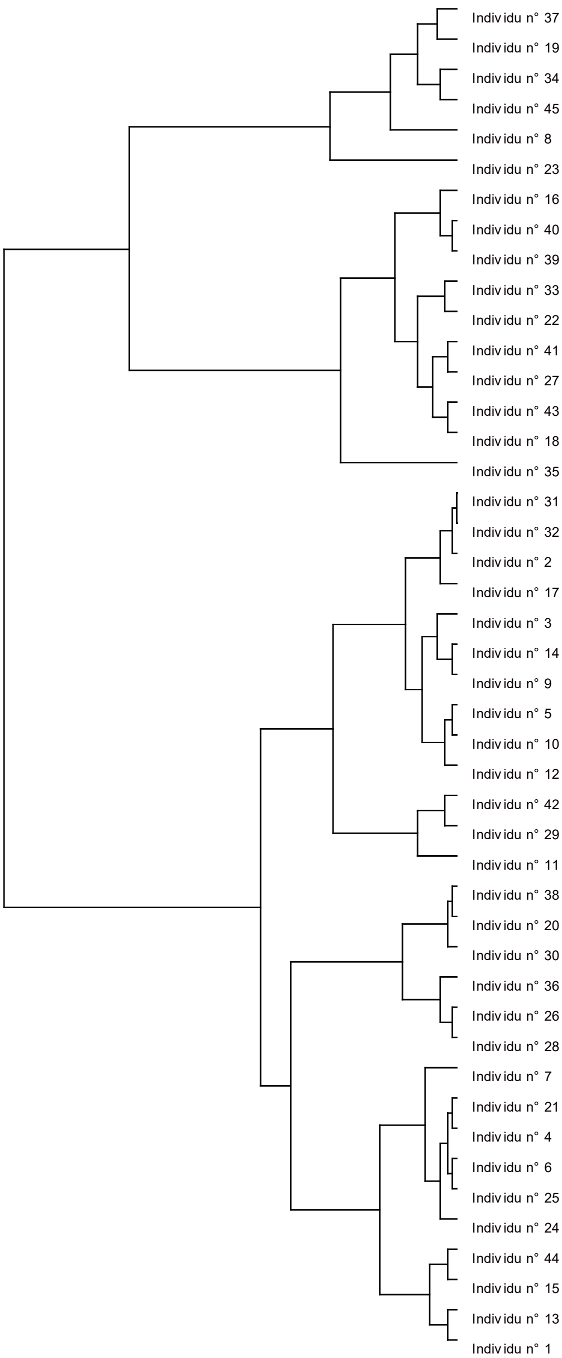


Figure 2. Factorial Plan 1-2 of 45 HIA guidelines

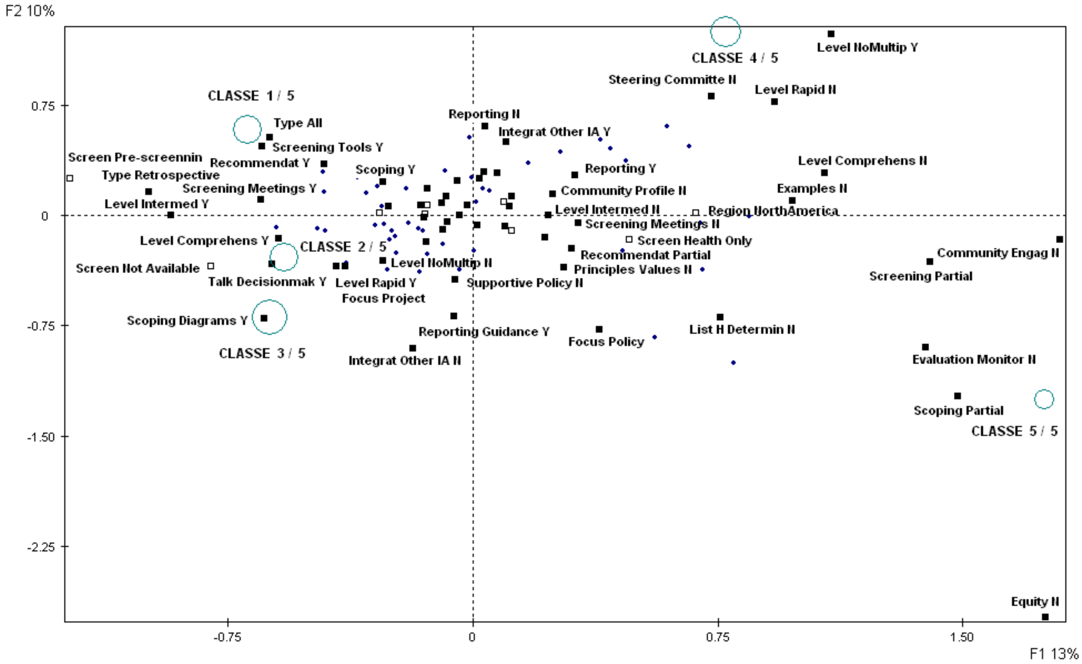
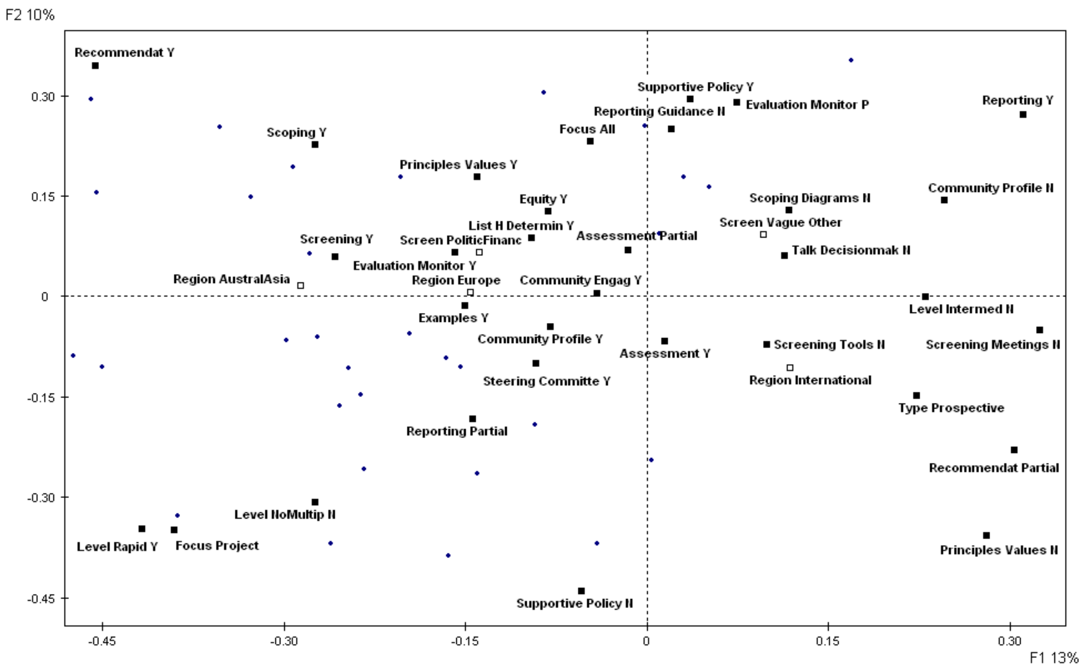


Figure 3. Factorial Plan 1-2 of 45 HIA guidelines - zoom



3.2. Going even further in automatizing and visualizing systematic reviews' information

Whenever one does not wish to build a table of publication characteristics similar to the one used in section 3.1, one may profile HIA papers with text mining analysis methods from any of the usual text available for each paper, including the title of the paper, the mentioned keywords or the abstract itself. Here titles and then keywords were considered to obtain word/segment profiles and then linked to 3 nominal variables: Publication year (2012, 2013 or 2014); Journal Title with or without "Environment"; Quantification of methods and results (Quantification or No quantification) – table 3.

The choice of these particular variables aimed to determine if text mining analysis using paper titles would give different results from text mining analysis using paper keywords, if different years would have distinct word profiles, if papers in journals having or not "Environment" in the title could be more or less related to the use of quantification in methods and results.

Table 3. Aspects to link with the created lexical vocabulary

		Count	%
Publication Year	2012	136	55,1%
	2013	98	39,7%
	2014	13	5,3%
	Total	247	100,0%
Journal Title	Journal Title with 'Environment'	75	30,4%
	Journal Title without 'Environment'	172	69,6%
	Total	247	100,0%
Quantification	Quantification	136	55,1%
	No quantification	107	43,3%
	Undetermined	4	1,6%
	Total	247	100,0%

3.2.1. Text mining analysis on the Titles of papers

The first factor of Correspondence Analysis (CA) explains almost half of the global variability contained in the data (47%) – Figure 4. On the right side of the factorial plan are words more associated to papers where quantification is present and that tend to include "Environment" in the title of the journal where they are published. Inversely, on the left side of the factorial plan are words more associated to papers where no quantification is present and that tend not to include "Environment" in the title of the journal where they are published.

The location of years 2012 and 2013 near the origin of the plan means that paper profiles from both these years do not seem to be very different. The location of the year 2014 towards the upper left side indicates that the few papers published from this year present in the HIA Gateway Bibliography tend not to include "environment" in the title of the journal where they were published. In fact, only 3 out of the 14 papers available during 2014 were published in journals with "environment" in their titles. Therefore, the HIA papers published in 2014 had a different profile than those published during 2012 and 2013, which may be explained by the small number of papers from that year present in the sample, since they were published only during the first quarter of 2014.

More important than the different profile from 2014 papers is the fact that papers from 2012 and 2013 do not seem to be different regarding their year of publication. It is also very interesting that two different profiles arise that associate the use of quantification more to environmental journals than to non-environmental journals (public health, epidemiology and spatial planning, for instance). This means there is a shortcoming of using quantified methods and results in non-environmental publications.

Looking at the way words group when hierarchical cluster analysis (HCA) is applied, 3 main groups are identified (figure 5):

- Group 1 of words/segments includes expressions more clearly related to papers with quantification and environment in the journal titles: Benefits, Effective, Pollution, Risks, Air Pollution and Air;

- Group 2 of words/segments includes expressions more clearly related to papers with no quantification and contains: climate change, local level, planning, space planning, Health Impact Assessment, Public;
- Group 3 is more associated with papers not having “Environment” in the journal title and integrates 2 subgroups of words/segments:
    - Subgroup 3.1 with: Policies, Environment, Cases, Development, Children and young People;
    - Subgroup 3.2 with more words: North America, Built Environment, Active, Food & Beverages, Program, System, Communities, Green spaces, Europe, Asian & Australasian, Cities, Transportation.

Figure 4. Factorial Plan 1-2 of lexical vocabulary of 247 papers from 2012-2014, based on papers' titles

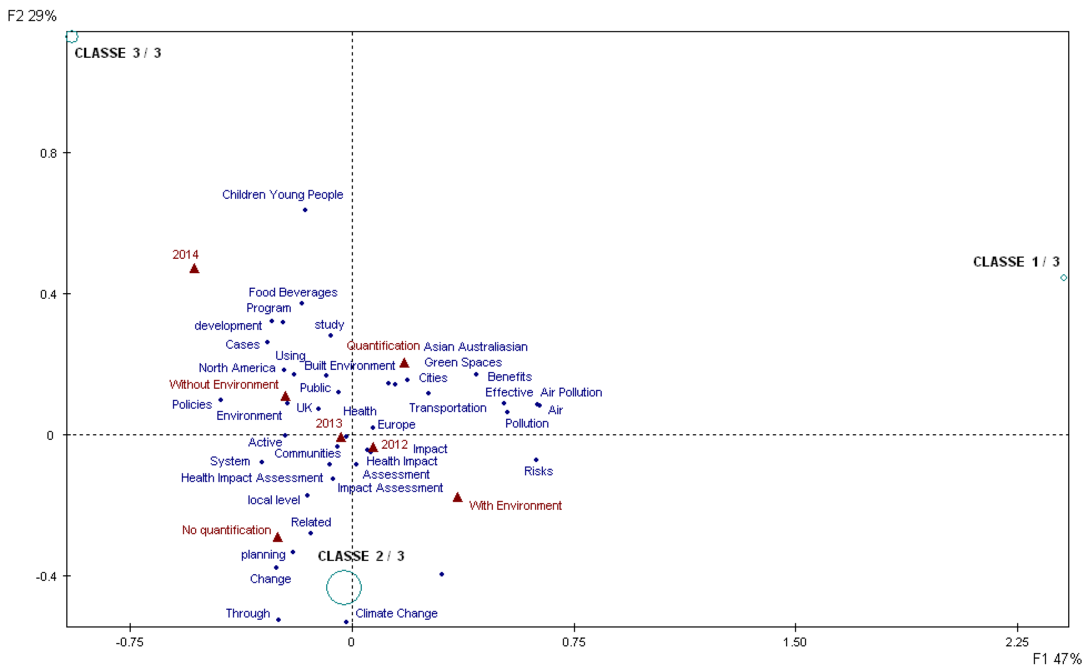
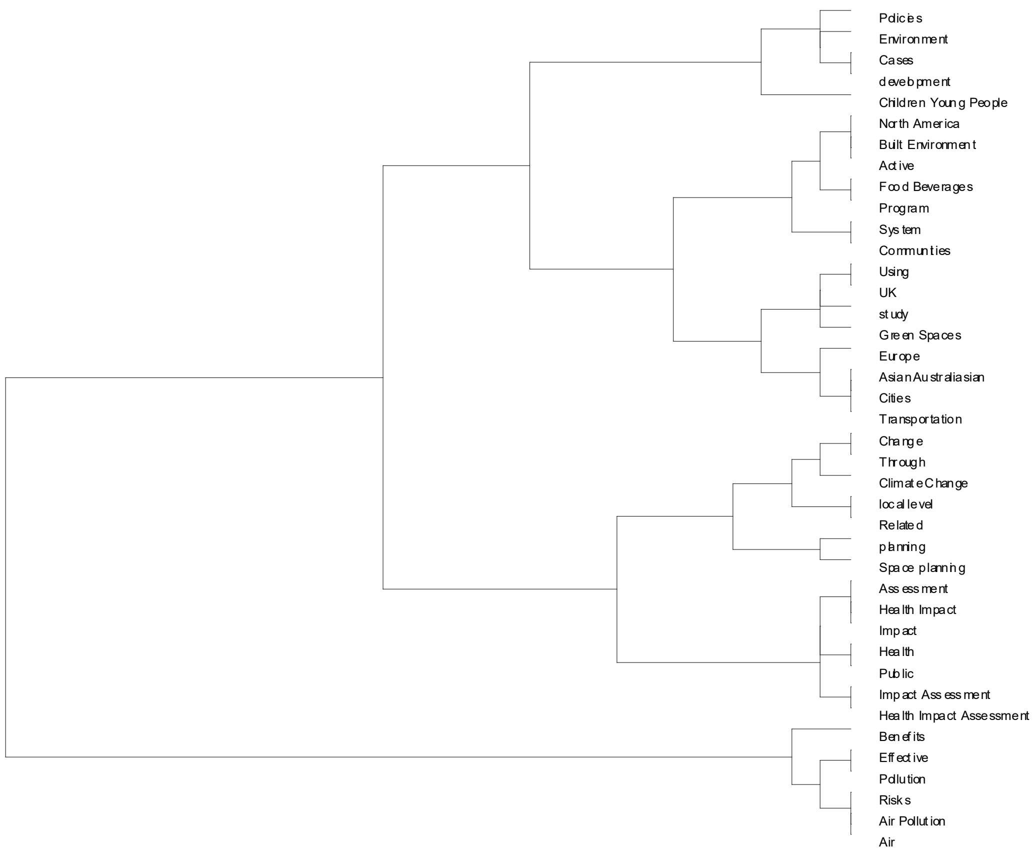


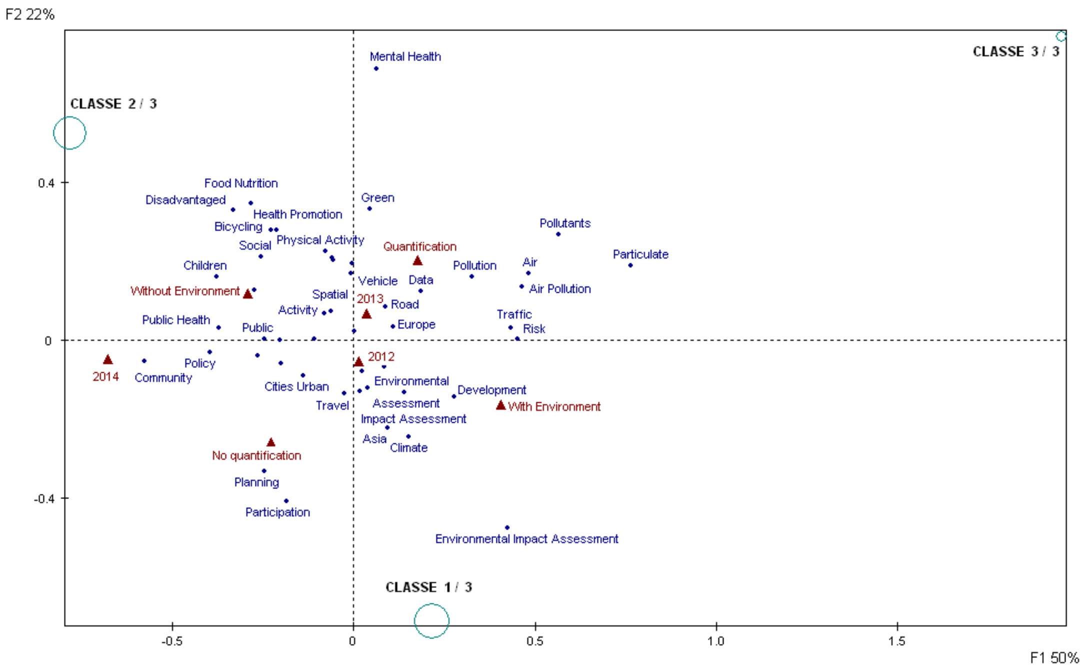
Figure 5. HCA Dendrogram of lexical vocabulary of 247 papers from 2012-2014, based on papers' titles



3.2.2. Text mining analysis on the Keywords of papers

Although words are different when analyzing titles or keywords of papers, results of HCA are not very unlike in terms of the importance of the first factor, regarding its weight in total variability (50%), and of the way categories of year, quantification, environment in the journal titles are scattered on the factorial plan (figure 6). Thus, on the right side of the factorial plan are keywords more associated to papers where quantification is present and that tend to include "Environment" in the title of the journal where they are published. Inversely, on the left side of the factorial plan are keywords more associated to papers where no quantification is present and that tend not to include "Environment" in the title of the journal where they are published. Years 2012 and 2013 are again located near the origin of the plan meaning that paper profiles from both these years may not be very different. The location of year 2014 on the left side indicates that the few papers published from this year present in the HIA Gateway Bibliography tend not to include "environment" in the title of the journal where they were published, neither have quantification regarding methods and results.

Figure 6. Factorial Plan 1-2 of lexical vocabulary of 170 papers from 2012-2014, based on papers' keywords

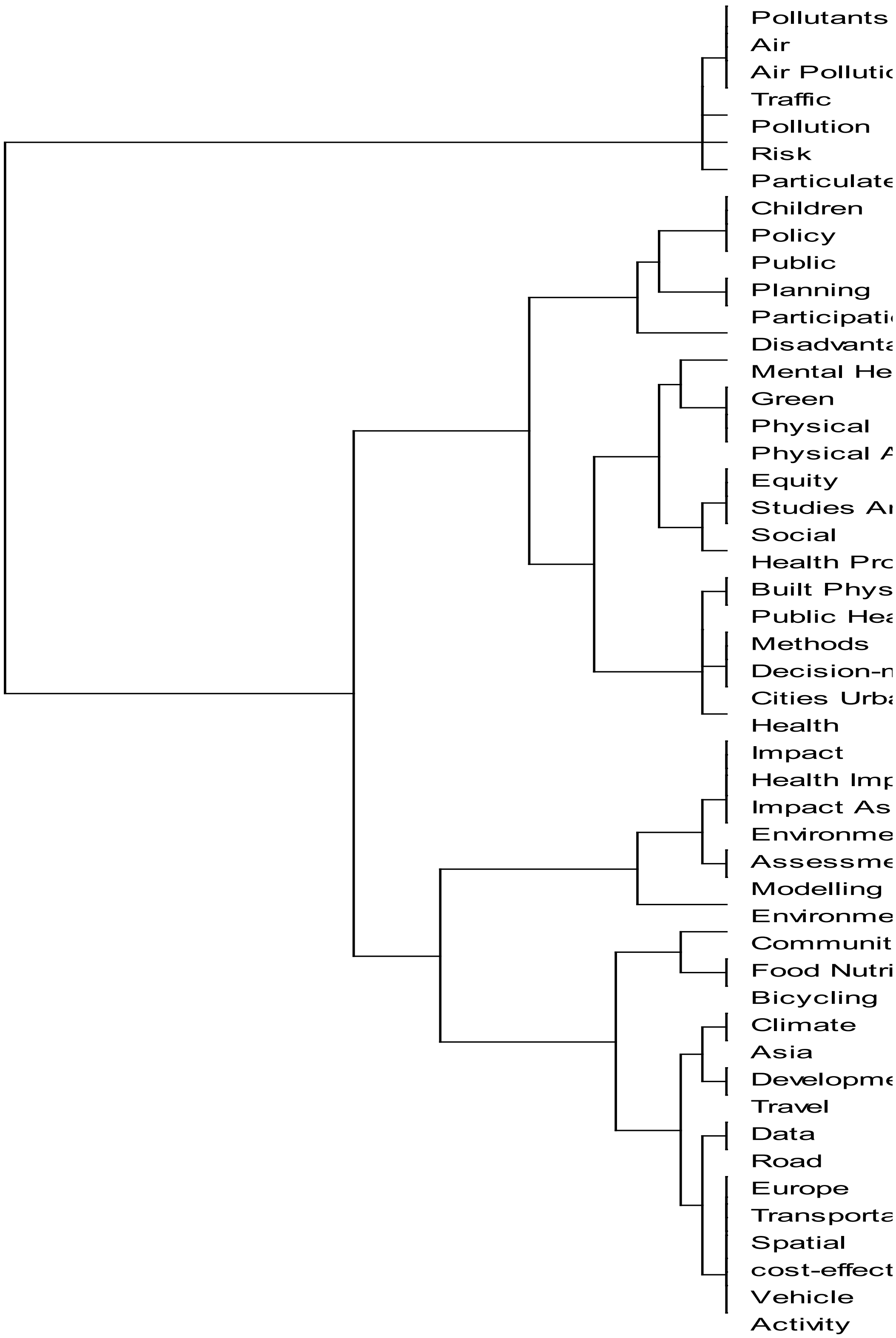


The way words group when applying HCA is somewhat different than when one considers keywords instead of titles, although a partition of 3 groups is also chosen as more adequate for analysis (figure 7):

- Group 1 of keywords is more related to papers with "environment" in the journal titles but no quantification in methods and results and includes:
  - Subgroup 1.1 with: Children, Policy, Public, Planning, Participation, Disadvantaged;
  - Subgroup 1.2 with: Mental Health, Green, Physical Activity, Equity, Studies Analysis, Social, Health promotion, Built Physical Environment, Public Health, Methods, Decision-making, Cities Urban, Health;

- Group 2 is more related to papers without environment in the journal titles and includes 2 subgroups of words/segments:
  - Subgroup 2.1 with: Health Impact Assessment, Environmental Impact Assessment, Assessment, Assessment, Modeling;
  - Subgroup 2.2 with: Community, Food Nutrition, Bicycling, Climate, Development, Asia, Travel, Data, Road, Europe, Transportation, Spatial, Cost-effectiveness, Vehicle, Activity;
- Group 3 is more related to papers with environment in the journal titles and also with quantification regarding methods and results: Pollutants, Air Pollution, Pollution, Traffic, Risk, Particulate.

Figure 7. HCA Dendrogram of lexical vocabulary of 170 papers from 2012-2014, based on papers' keywords



4. Discussion

When one wishes to review literature and builds a table describing features of a group of publications, it may be time consuming and hard to analyse each variable and its association with the other variables by using univariate or bivariate statistical analysis. Using exploratory multivariate data analysis methods such as hierarchical cluster analysis and/or multiple correspondence analysis may be very helpful.

4.1. Automation towards effectiveness

Taking the table published by authors of paper "Health impact assessment: A comparison of 45 local, national and international guidelines" [6], the use of these methodologies easily gave a very visual and immediate answer to those authors' goals of finding if a universal HIA guide could be a reality and identifying common and different features in the sample of 45 guides.

The fact that both features and clusters of guides were generally found near the center of the various factorial plans means that guides are mostly very similar to each other. This indicates that similarities among guides are more common than dissimilarities, opening the way for the possibility of indeed creating a universal HIA guide. But by using these multivariate methods, one may go beyond this and identify more clearly that guides of Cluster 2 are the most similar to others within the whole sample and could represent the base for a universal guide.

The original paper presented an exhaustive comparison of all the guides along all considered features, making it sometimes hard to identify the really essential aspects that distinguished those publications. Through MCA and HCA, one may easily identify the key features that differentiate guides. Thus, one may quite effortlessly evaluate if discriminating specificities regarding clusters 1, 3, 4 and 5 are worth integrating in a possible universal guide or not. Therefore, guides of cluster 3 seem to be more "Client-oriented", wanting to answer to more practical needs and concerns of decision-makers when planning the HIA in the scoping step, but also when delivering results and proposing recommendations. Guides in cluster 4 show a particular attention to the usefulness of integrating HIA with other impact assessments. Guides in cluster 1 present an interesting feature regarding the political and legal framework of HIA and the eventual need to be considered mandatory in certain cases. Finally guides in cluster 5 seem to be rather more incomplete in their approach, so possibly not to be used as a base to a universal guide. It is curious to acknowledge that these discriminating features from clusters 1, 3 and 4 find an echo on the weaknesses and opportunities pointed out to HIA [2], being somehow aspects to integrate an universal broad future HIA guide.

4.2. Even further automation towards effectiveness

Aiming at making the reviewing process even less "human-dependent", not having to rely on building a table of qualitative features describing a sample of publications, an even more automated approach was adopted, using text mining analysis to profile a group of published HIA papers based on titles and keywords. This represents a gain in processing time and hopefully in the objectivity of the analysis process, especially if the alternative involves several different people collecting and registering the information into a table describing the reviewed publications.

Text profiles obtained based on titles are not very different from the ones found based on keywords, although the sample is much larger in the first case (247 papers versus 170 papers). This means that titles embody the main aspects of the paper itself. It also may mean that keywords tend to be rather redundant in a paper.

Regarding the year of publication, papers from 2012 and 2013 don't present a very different profile between them. Papers from 2014 appear to have a different profile from those of previous years, but the sample is too small to indicate any kind of trend.

Three different profiles arise among papers, but only one of them is more linked to the use of quantification. Papers more associated to the use of quantification in methods and results are thus also more often published in journals with "environment" in the title and tend to focus on air pollution risks, often regarding traffic and measuring particulate concentrations. Inversely, a more "no-quantification" profile arises including papers concerned with spatial and urban planning, often also regarding mental health and physical activity issues. A third profile concerns "no-environment" in the journal title papers and is more linked to the impact of policies, especially in developed countries taking again into account issues like built environment, green spaces, transportation and physical activity, but also nutrition concerns, community involvement and children and young people as focus.

Hence there tends to be a shortcoming of use of quantified methods and results in non-environmental publications, especially when considering impacts of public health policies, both at general and local levels. More environmental publications drink from the often mandatory Environmental Impact Assessment tradition of quantifying impacts and may be fueled by a higher availability of data on physical environmental factors (such as air, water, noise pollutants) and their association to health effects [18]. More public health related publications still lack quantification as support to evaluation of health impacts. Available data on health (such as hospital, primary healthcare) and social health determinants (such as education, employment, healthy and non-healthy behaviors) is growing frequently linked through national registries [19,20]. However, integrating this information into HIA is still seldom a reality.

4.3. Linking quantification to monetary costs

Additionally, although quantification is used, predicted related monetary costs are still quite rarely found in all papers published during this period (only 13 papers had some sort of quantified related monetary costs). This may be especially important when one considers HIA as a potential advocacy tool [21-23], but also when one considers that it primarily intends to help decision-makers reaching a decision whether to go forward or not with a policy and in what terms. Always with budget constraints, political decisions have increasingly to be based on cost effectiveness criteria and whenever possible direct and indirect health costs should be part of the equation [2]. A bridge between HIA and other economic evaluation assessments, such as health technology assessments or cost-effectiveness assessments, should be incentivized [24]. It could thus be a way to demonstrate further the effectiveness of HIA in changing decisions and implement policies. Additionally it could contribute to the decision-makers concerns of guarantying the existence of quantified and evidence based potential health impacts before investing resources and acting according to HIA's recommendations [2].

4.4. Limitations and Future Activities

No matter how much automation is brought to the publishing reviewing process, there is (and should be) always an element of human interpretation and thus potential subjectivity, for instance when choosing the related words/segments to aggregate into a common theme.

Both proposed approaches to automate further the publishing reviewing process may be complementary: depending on research aims, a table describing publications' features may be built and paper profiles created regarding text variables directly from that table, not having to create a contingency table of words and segments.

By simplifying the publications analysis, there is always a loss of information, for instance when only taking word/segments with frequencies over 10. Even if one tries and aggregates more words/segments in common themes, which may also increase subjectivity of the process, one may be creating over-simplification and interpretation biases. However, by taking a more automated approach in an early step of analysis, one may more easily identify differentiating aspects and focus a more detailed exploration onto those most important aspects.

Future activities will involve trying to minimize these restrictions, so that possible biases are controlled and limited.

5. Conclusions

Using multivariate data analysis such as MCA and HCA to extract main patterns from a table describing features of a group of publications saves time, potentially decreases subjectivity biases regarding interpretation of results and summarizes in quite an easy way to grasp the main points of information contained in these documents.

Taking the automation process even further and applying text mining analysis methods, based even on elementary string information such as paper titles or keywords, consists an innovative useful way of extracting knowledge when analyzing a bulk of potentially interesting publications, quite instantly allowing for the visualization of the main underlying profiles.

The immediate visualization these methodologies allow makes knowledge acquisition easier for non-statisticians, potentially helping fruitful dialogue among multidisciplinary teams and namely between public health experts and decision-makers.

References

1. Cole BL, Fielding JE. Health impact assessment: a tool to help policy makers understand health beyond health care. *Annu Rev Public Health* 2007; **28**: 393-412.
2. Harris-Roxas B, Viliani F, Bond A, Cave B, Divall MJ, Furu P, Harris P, Soeberg M, Wernham A, Winkler M. Health impact assessment: the state of the art. *Impact Assessment and Project Appraisal* 2012; **30**(1): 43-52.
3. Heitor MJ, Pereira Miguel J. Avaliação do Impacte de políticas de diferentes sectores na saúde e nos sistemas de saúde: um ponto de situação. *Revista Portuguesa de Saúde Pública* 2009; **27**(1): 5-17.
4. Kemm J, Parry J, Palmer S, editors. Health Impact Assessment: Concepts, Theory, Techniques, and Applications. Oxford: Oxford University Press; 2004.
5. Metcalfe O, Higgins C, Lavin T. Health Impact Assessment Guidance: Institute of Public Health in Ireland; 2009.
6. Hebert KA, Wendel AM, Kennedy SK, Dannenberg AL. Health impact assessment: A comparison of 45 local, national, and international guidelines. *Environmental Impact Assessment Review* 2012; **34**: 74-82.
7. Oxford Dictionaries. Oxford Dictionaries definition of State-of-the-art. http://www.oxforddictionaries.com/definition/english/state-of-the-art (accessed 11/16/2014).
8. Veerman JL, Barendregt JJ, Mackenbach JP. Quantitative health impact assessment: current practice and future directions. *J Epidemiol Community Health* 2005; **59**(5): 361-70.
9. Burnard P, Gill P, Stewart K, Treasure E, Chadwick B. Analysing and presenting qualitative data. *Br Dent J* 2008; **204**(8): 429-32.
10. Coheris Spad. Data Miner Guide - Text Mining: Coheris Spad; 2013.
11. Lebart L, Salem A. Statistique Textuelle: Dunod; 1994.
12. Hair JF, Black B, Babin B, Anderson RE, Tatham RL. Multivariate Data Analysis. 6th ed: Prentice Hall; 2006.
13. Lebart L, Piron M, Morineau A. Statistique Exploratoire Multidimentionnelle. 4ème ed. Paris: Dunod; 2006.
14. Saporta G. Probabilités, Analyse des Données et Statistique. 3e édition ed: Éditions Technip; 2011.
15. CISIA CERESTA. SPAD for Windows Version 3.5. Montreuil, France: CISIA CERESTA; 1998.
16. Gateway H. HIA, MWIA and SEA Bibliography 21. HIA Gateway, West Midlands Public Health Observatory; 2014.
17. IBM Corp. IBM SPSS Statistics for Windows, Version 22.0. Armonk, New York, USA: IBM Corp.; 2013.
18. Kemm J, editor. Health Impact Assessment: Past Achievements, Current Understanding and Future Progress: Oxford University Press; 2013.
19. Fehr R, Viliani F, Nowacki J, Martuzzi M, editors. Health in Impact Assessments: Opportunities not to be missed. Copenhagen: WHO Regional Office for Europe; 2014.

20. Capacity Building in Environment and Health (CBEH) Project, editor. Using impact assessment in environment and health: a framework. Copenhagen: WHO Regional Office for Europe; 2013.
21. Parker LA, Lumbreras B, Hernandez-Aguado I. Health information and advocacy for "Health in All Policies": a research agenda. *J Epidemiol Community Health* 2010; **64**(2): 114-6.
22. Veerman JL, Bekker MP, Mackenbach JP. Health impact assessment and advocacy: a challenging combination. *Soz Praventivmed* 2006; **51**(3): 151-2.
23. Smith K, Stewart E. Influencing policy--public health advocacy and health inequalities. *J R Coll Physicians Edinb* 2014; **44**(4): 316-21.
24. Gottlieb LM, Fielding JE, Braveman PA. Health Impact Assessment: Necessary but Not Sufficient for Healthy Public Policy. *Public Health Reports* 2012; **127**: 156-62.

Chapter 3 – Contribution of Hierarchical Cluster Analysis to the Health Impact Assessment Screening Step

SubChapter 3.1 – Screening Hospital Reform Policies for Health Impact Assessment: easier decision making through cluster analysis

CONTENTS

Chapter 3 – Contribution of Hierarchical Cluster Analysis to the HIA Screening Step

"What is freedom? Freedom is the right to choose: the right to create for oneself the alternatives of choice." Archibald MacLeish

"An inner process stands in need of outward criteria." Ludwig Wittgenstein

"It is our choices… that show what we truly are, far more than our abilities." Albus Dumbledore / JK Rowling

The first step of HIA is usually the screening step, when policies are screened to identify candidates worth selecting for HIA. This is generally a qualitative step. Our aim here is to show how multivariate statistical methods such as cluster analysis may help this step, first by analyzing 76 policies regarding the Portuguese hospital reform (subchapter 3.1) and then by evaluating 21 National Health Programs (subchapter 3.2). The choices, criteria and selections concerning both these subchapters will explain the area and policies focused in Chapter 4.

SubChapter 3.1 – Screening Hospital Reform Policies for Health Impact Assessment: easier decision making through cluster analysis

Abstract

Background:

Health Impact Assessment (HIA) is a combination of procedures, methods and tools by which a policy may be judged as to its potential effects and its distribution on a population's health. Screening policies to identify candidates for applying HIA is an essential first step, generally qualitative. Our aim is to show how to use exploratory multivariate statistical methods such as cluster analysis to screen through policies and pinpoint priorities for HIA quickly and reliably.

Methods:

A panel of 7 public health experts from Nova University in 2011 rated 76 policies proposed by a Technical Group planning the Portuguese hospital reform on a 10-point scale (1-Very low to 10-Very high) regarding Potential Impact, Ease of implementation and Implementation costs. Hierarchical cluster analysis is used to identify groups of similar policies and prioritize those more pertinent of being considered for HIA.

Results:

We identify 7 groups of policies and find that Ease of implementation is not as relevant to differentiate groups as Potential impact and Implementation costs: 3 groups present higher mean levels of potential impact (with respectively higher, intermediate and lower mean levels of implementation costs); 2 groups present intermediate mean levels of potential impact (with higher and lower mean costs respectively); 2 groups present lower mean levels of potential impact (with higher and lower mean costs respectively). Groups of policies are then re-ranked through different priority criteria, but Group 1 leads all possible scenarios pinpointing the most obvious candidates for HIA.

Conclusion:

Applying methods such as hierarchical cluster analysis as early as the screening step of HIA may be very helpful towards obtaining evidence based, reliable, participatory, flexible and more efficient ways of selecting policies for HIA.

Main Messages:

Although multivariate statistical methodologies may seem complex, decision-makers obtain more evidence-based knowledge and in an easy way to grasp.

This methodology may be used in other forms of assessments and in different countries.

Multivariate statistical methodologies may look complex, but decision-makers grasp easily this evidence-based knowledge.

Keywords:

Health Impact Assessment, screening policies, quantification, cluster analysis, decision-making

Acknowledgments:

We are especially obliged to Pedro Pita Barros (Faculty of Economics, University Nova of Lisbon), José Mendes Ribeiro (Fundação Francisco Manuel dos Santos), Sarah Simpson (EQUIACT), Ruy Ribeiro and Teresa Rodrigues (Laboratory of Biomathematics of the Faculty of Medicine, University of Lisbon) for their invaluable help in reviewing and giving useful suggestions to improve a draft paper to submit to international publications. We also thank the University Nova of Lisbon group of public health experts Pedro Pita Barros, Adalberto Campos Fernandes, José Fragata, Francisco Ramos, José Caldas de Almeida, Gilles Dussault and Luis Lapão for generously making available the data that made our research possible.

1. Introduction

Any project or policy (at international, national, regional or local levels), in any activity sector, generates positive and/or negative impacts on the health of human populations [1,2], and hence may be the object of HIA. Nevertheless, limited resources and good sense tell us that we should screen among possible candidates for HIA, prioritize and select the most relevant ones. The focus here will thus be the first step of HIA, the screening step [3], which is usually followed by five other steps: scoping, conducting the assessment, reporting and recommendations, monitoring and impact and outcome evaluation. The aim is to show how to use exploratory multivariate statistical methods such as cluster analysis to screen through policies and pinpoint priorities for HIA quickly and reliably.

Herbert et al identified 45 HIA guidelines for review and content analysis, from various origins and publication dates ranging from 1995 to 2011, and found a screening step in all of them [4]. In 43 of these HIA guidelines screening was described as a "selection process for identifying which projects, policies, plans or programs need to undergo a HIA based on the proposal's potential to impact people's health and add value to the decision-making process". The choice of undertaking an HIA would thus be based on criteria related to health determinants and equity and on the value of incorporating them into the decision-making process.

In reality, other non-health features already determine whether to go through with an HIA or not, even when definitions of the screening step are more health-focused. In fact, while revisiting the 45 guidelines reviewed by Herbert et al, one may see that only 12 documents focus screening essentially on health issues, determinants and impacts of the project or proposal (27% of the 45 guidelines). The majority of the guidelines (31 documents corresponding to 69% of the 45 guidelines) consider other aspects such as political and operational priorities: 10 mention such aspects to take into account without detailing much, 19 include them in the screening tools (questions to be answered and issues to rank) and 2 even propose a pre-screening step where opportunity concerns, human and financial resources are assessed and contribute to the results of the screening step [5,6]ref. Frequently yet it is not clear how these non-health concerns, eventually more subjective, are actually to be taken into consideration in the screening process. The accountability of a decision of doing HIA or not based on these non-health concerns may be assured whenever there is a clear record of how, whom and why the decision was made. However, the potential subjectivity won't necessarily be secured. Introducing these aspects clearly and in a quantitative way could thus contribute to make the screening process more transparent as far as non-health issues are concerned.

Moreover, especially in countries where HIA is insipient, and particularly in a context of economic crisis where other priorities are more pressing, a HIA expert may have a particular hard time convincing decision makers of the relevance of using these methodologies. Using a screening method essentially based on health determinants and equity issues may not be enough to persuade a decision maker of the value of investing part of his budget in HIA. Since one of the best ways to convince decision makers to undertake a HIA is really to do HIAs and show how useful and invaluable they may be to the decision-making process, it would be useful to find a way to maximize the stakes of taking decision makers on board to undertake a HIA project. Taking into account in the screening step criteria that decision makers will perhaps understand better, more in tune to their distresses and priorities, could contribute to a wider use of HIA.

In Portugal, a hospital care reform was proposed based on a report of the Technical Group planning the Portuguese hospital reform, a 417 pages document issuing 76 policy reform recommendations [7], aiming to reorganize the national hospital network through an integrated and rational view on the health system. The screening step is hence essential here to assure that the policies to be object of HIA are relevant in the health experts' point of view, but also in the policy makers' point of view.

The main aim of this research is to show how to use exploratory multivariate statistical methods such as cluster analysis to screen through policies and pinpoint priorities for HIA quickly and reliably.

Taking the results of ratings of these 76 policies by a panel of 7 public health experts from the Nova University in Lisbon, in this research, multivariate statistical methods such as cluster analysis were used at the screening stage of HIA to help filter out policies that may not require HIA, identify those more relevant, and pinpoint possible candidates to be considered for HIA.

Data and statistical methodologies used in the present research are first presented. Then, in the results section, the total sample of 76 policies is explored and a clusters partition of policies is selected. The quality of the partition is analyzed and other complementary multivariate statistical methods are used to aid the interpretation of results. In the discussion section, the clusters of policies are presented in more detail and a priority for implementing HIA is proposed, as well as different scenarios according to different possible decision-makers' criteria.

The main figures and tables are included here, but several additional ones are referred to and may be found in the appendices.

2. Materials and methods

2.1. Data

The report of the Technical Group planning the Portuguese hospital reform, a 417 pages document issuing 76 recommendations or policies to be undertaken over the following 3 years, was made available for public discussion in November 2011 [7]. The complete set of 76 policies divided by 8 areas is listed in the appendices (Table 10).

A group of public health experts from the Nova University in Lisbon responded, issuing a report in December 2011 [8]. This report included an analysis by a panel of 7 public health experts from the Nova University in Lisbon: Pedro Pita Barros, Adalberto Campos

Fernandes, José Fragata, Francisco Ramos, José Caldas de Almeida, Gilles Dussault and Luis Lapão. This panel rated each of the 76 policies proposed by the Technical Group planning the Portuguese hospital reform on a 10-point scale (1-Very low to 10-Very high) regarding 3 dimensions: Potential Impact (in terms of a "better health at lower costs" goal), Ease of implementation/likelihood to be applied over the next 3 years, and Implementation costs (including monetary, non-monetary and political costs).

In the present study, the 3 raw variables above (10-point likert scales) will be considered, but also these 3 dimensions recoded into 3 categories ordinal variables (scale values low 1-3, intermediate 4 -7, high 8-10).

2.2. Statistical Methodologies

The software used for all statistical analysis was SPSS version 19.

Univariate exploratory analysis was performed regarding the 10-point scale variables (mean, standard variation, median, percentiles 25 and 75, minimum and maximum) and the recoded variables (frequency and percentage).

Hierarchical cluster analysis (with squared Euclidean distance and Ward's aggregation criteria [9] was used to identify groups of similar policies in terms of the 3 variables considered and to prioritize those more pertinent of being considered in a HIA. A 7 clusters partition of similar policies was selected for further analysis. The number and identification of policies were accessed for each cluster. Descriptive statistics were also calculated for each cluster (mean, standard variation, median, percentiles 25 and 75, min and max), and scatter diagrams were constructed to biplot the 3 analyzed variables in terms of cluster identification.

The quality of the partition was accessed by applying non-hierarchical cluster analysis (k-means) with random seeds and also using the cluster centroids as seeds, to compare the clusters' composition [9]. Tables with counts, column percentages and adjusted residuals were built and Fisher Exact Tests with Monte Carlo significance based on 10,000 sampled tables were used. Kruskal-Wallis tests and associated multiple comparisons tests [10] were additionally used to identify statistically significant differences among clusters, that is to identify which clusters were the most distinct between them, and concerning which variables or dimensions.

Principal Component Analysis (PCA) and Multiple Correspondence Analysis (MCA) were used as complementary multivariate methods [9]. PCA was applied to the 10-point scale variables to access the more important dimensions for cluster interpretation. The 2 first components, responsible for 80% of the total variance, were selected for analysis. MCA, applied to the recoded variables and using cluster identification as supplementary variable, further complemented the analysis, by identifying the most relevant categories to differentiate among clusters.

3. Results

3.1. Exploring the 76 policies total sample

When analyzing the total sample of 76 policies, the median classification given by the panel of public health experts to Potential Impact (in terms of a "better health at lower costs" goal) tends to be slightly higher than the ones assigned to both other dimensions (median of 7 against values below 6) – Table 1. This is more evident when recoding variables into 3 categories: 34% of policies present high values of Potential Impact (against percentages below 8% for other variables) – Appendices Table 4. A considerable number of policies proposed exhibits a low classification regarding Implementation costs (including monetary, non-monetary and political costs) – a percentage of 25% of policies against percentages below 4% for the other variables. The majority of policies show intermediate classification levels for "Ease of implementation/likelihood to be applied over the next 3 years" (90% of policies against percentages below 69% for other variables). This dimension thus bears the lowest dispersion of the three, also visible when considering the interquartile range (1.4 against values above 2.2 - Table 1).

Table 1. Descriptive Analysis (N=76)

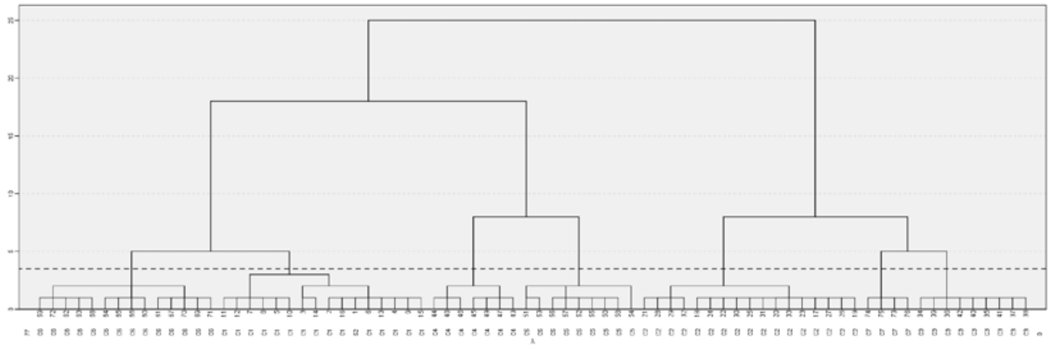
	Mean ± SD	Median (IQR)	Range
Potential Impact (in terms of a "better health at lower costs" goal)	6,79 ± 1.66	7,00 (2,26)	2,40-10,00
Ease of implementation/likelihood to be applied over the next 3 years	5,83 ± 1.11	5,90 (1,40)	2,67-8,33
Implementation costs (including monetary, non-monetary and political costs)	4,77 ± 1.68	4,59 (2,43)	1,67-9.33

SD=Standard Deviation IQR=Interquartile Range (P75-P25) Range= Minimum - Maximum

3.2. Selecting a 7 Clusters Partition

A hierarchical cluster analysis was applied with squared Euclidean distance as proximity measure and Ward linkage criterion. Partitions between 3 and 7 clusters were analyzed and the 7-clusters partition was selected for a more detailed study, considering the dendrogram (Figure 1) and the evolution of the proximity coefficients associated to each partition (Appendices Table 2).

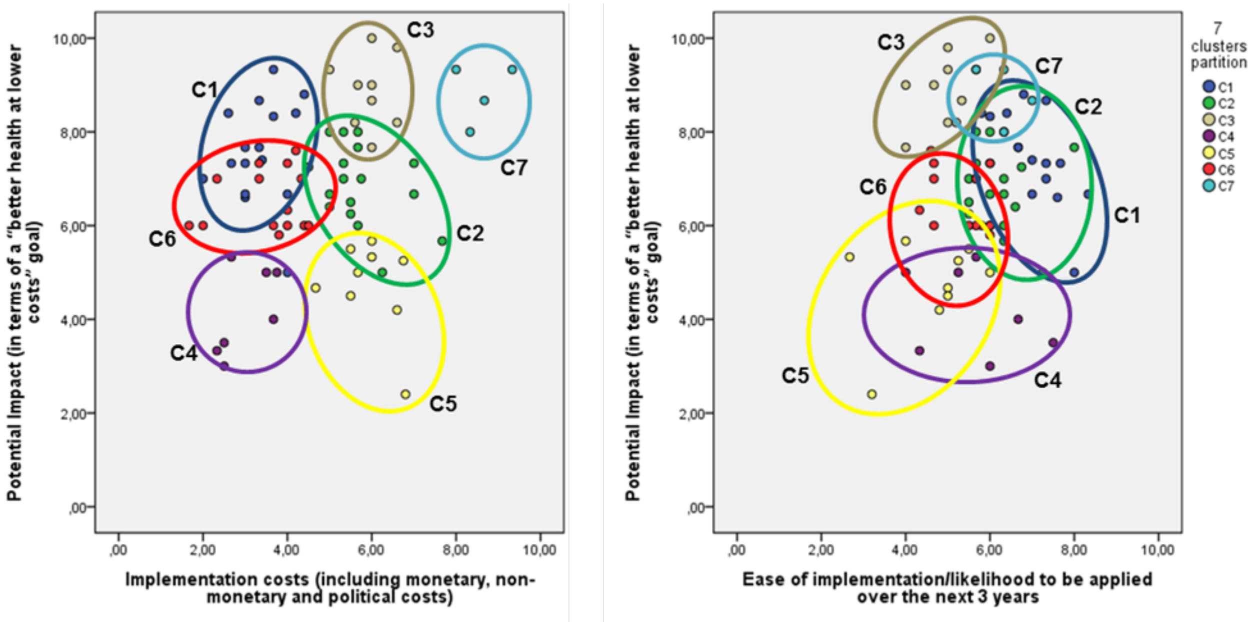
Figure 1. Hierarchical Cluster Analysis Dendrogram (Squared Euclidean Distance and Ward Linkage Criterion) with 7 clusters partition identified



The number of policies in each cluster varies between 4 and 17 policies – Appendices Figure 6 and Table 3 and Table 4. Examining the scatter diagrams of policies, biploting each pair of dimensions, it is quite clear that clusters are well differentiated when considering Potential Impact (in terms of a “better health at lower costs” goal) versus Implementation costs (including monetary, non-monetary and political costs) – Figure 2. Clusters are not so well discerned when one considers Potential Impact (in terms of a “better health at lower costs” goal) versus Ease of implementation / likelihood to be applied over the next 3 years. The analysis of the distribution for each cluster over the dimensions recoded into 3 categories (low, intermediate and high classification) is coherent with these observations - Appendices Table 4.

In Figure 2 and Appendices Table 3 and Table 4, clusters 7, 3 and 1 present higher mean levels of potential impact and respectively higher, intermediate and lower implementation costs; clusters 2 and 6 show intermediate mean levels of potential impact and respectively higher mean costs lower ones; clusters 5 and 4 display lower mean levels of potential impact and respectively, higher mean costs and with lower ones. In what concerns the ease of implementation, clusters 1, 2 and 7 are associated with a higher likelihood to be applied over the next 3 years, followed by clusters 4 and 6, and finally clusters 3 and 5. Note that in the left biplot of Figure 2, clusters 1 and 6 partially overlap, but are not superimposed in the right biplot, which means that both clusters are quite distinct taking the 3 dimensions into consideration.

Figure 2. Scatterplots of Potential Impact by Implementation Costs and by Ease of Implementation with cluster identification



3.3. Analyzing the quality of the 7 clusters partition

The quality of the partition was first accessed by applying non-hierarchical cluster analysis (k-means) to the raw data using random seeds and then by repeating the analysis using the hierarchical cluster centroids as seeds, to compare the clusters' compositions.

The first attempt to apply k-means using random seeds to generate a 7-clusters partition, produced a cluster with only one policy, that was considered an outlier (policy "Create a Medical Simulation National Centre", with the lowest scale values for the 3 variables). This analysis was thus repeated with only 75 policies.

As expected, applying a k-means algorithm using the hierarchical cluster centroids as seeds generates a 7-clusters partition much more similar to the hierarchical cluster solution, than when using a k-means with random seeds. Fisher Exact Tests with Monte Carlo significance based on 10,000 sampled tables indicate the distribution of policies throughout the 7 clusters are similar ($p<0.005<5\%$) and adjusted residuals are the highest where policies are classified in analogous clusters. There are however a few differences in the partitions (Appendices Figure 7 and Table 5), essentially related to policies that can be found in the intersections of clusters in Figure 3. Clusters 3 and 7 are the only ones identical in the three classification procedures. Cluster 4 presents a higher "misclassification" problem, featuring in both k-means clusters solutions, with several of its policies being classified into cluster 6. Still clusters 4 and 6 are better discriminated by "potential impact" in the hierarchical solution than both k-means solutions. Cluster 1 finds 2 of its policies classified into cluster 2, 1 into cluster 3 and 1 into cluster 4, when using k-means with random seeds. However, only 1 policy of cluster 1 is classified into cluster 4, when using k-means with the centroids' hierarchical clusters as seeds for the k-means algorithm.

Kruskal-Wallis tests and associated multiple comparisons tests were additionally used to identify statistically significant differences among clusters, regarding each one of the 3 original variables and each one of the 3 cluster methods applied. The tests show quite consistent results among the various methods applied, with special regard to potential impact.

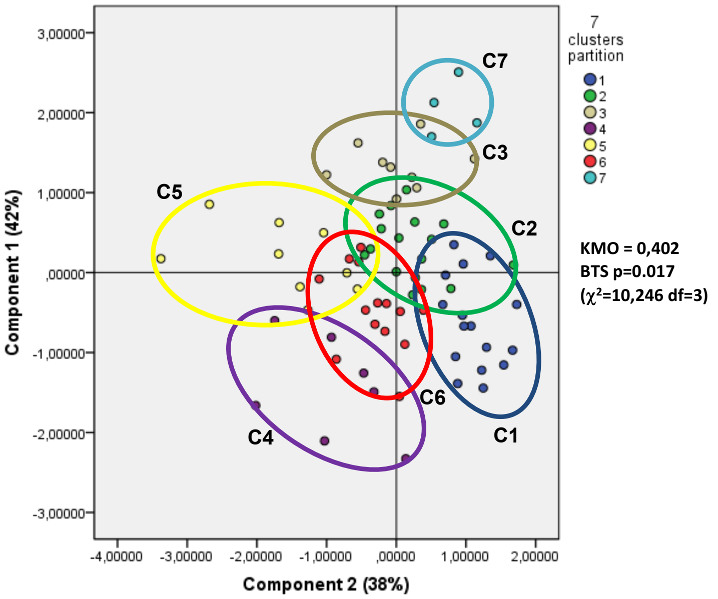
The 7 clusters hierarchical partition thus still seems the more adequate solution for analysis.

3.4. Using Complementary Methods: Principal Components Analysis and Multiple Correspondence Analysis

The Principal Components Analysis (PCA) results are coherent with the previous hierarchical cluster results. The first component which explains 42% of total variance is more related with Potential Impact (in terms of a "better health at lower costs" goal) and Implementation costs (including monetary, non-monetary and political costs) –

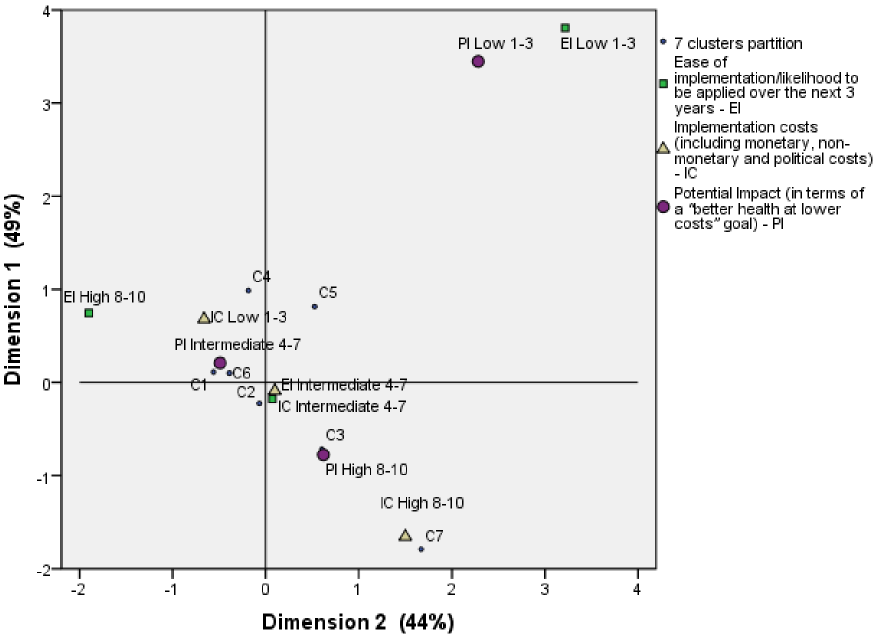
Appendices Table 8. The order followed by each cluster from the top quadrants of Figure 3 towards the bottom ones is related to the joint importance regarding these two variables. Cluster 5 is the only cluster that is not coherent with these results, which may be due to a higher dispersion in all the original variables - Appendices Table 3, and a greater importance regarding the second component, more related with the Ease of implementation/likelihood to be applied over the next 3 years - Appendices Table 8.

Figure 3. Factorial Plan on policies of a PCA 2 Components Extraction and cluster identification



The Multiple Correspondence Analysis (MCA) results help us further to explain the cluster and PCA results. The magnitude of the categories tends to decrease as one goes from the upper quadrants of the factorial plan (categories 1-3) to the lower quadrants (categories 8-10) – Figure 4. The lower the clusters are located in the figure, the higher their values will tend to be, especially regarding Potential Impact (in terms of a “better health at lower costs” goal) and Implementation costs (including monetary, non-monetary and political costs). Hence, clusters in the upper part of the figure will tend to have lower potential impact, lower implementation costs and lower ease of implementation over 3 years. Clusters near the center of the figure will tend to have intermediate values in these variables. Clusters in the lower part of the figure will be the more important ones in terms of potential impact and of implementation costs. The higher values category (8-10) of ease of implementation over 3 years is the only one to present a different behavior and is located towards the center left area of the figure. This may be due to the fact that a higher likelihood of implementation may be owed to a policy being just easy to implement or being hard to implement but so important that it is expected to be a priority.

Figure 4. Factorial Plan of a MCA 2 Components Extraction with cluster identification



4. Discussion

4.1. Ranking Clusters to Prioritize Policies

Cluster analysis and other complementary multivariate methods such as PCA and MCA were valuable to quickly identify a 7 clusters partition of policies and select the more adequate variables to characterize those clusters.

Regarding the choice of dimensions, the more relevant dimensions to be considered for the cluster description are the Potential Impact (in terms of a "better health at lower costs" goal) and the Implementation costs (including monetary, non-monetary and political costs). The Ease of implementation / likelihood to be applied over the next 3 years is less useful to differentiate among distinct clusters.

Concerning the prioritization of policies, we begin by considering that the more important clusters in terms of high levels of potential impact represent the ones with higher potential priority to become the focus of a HIA. Then we consider clusters with lower implementation costs. High potential impact is more linked with 3 clusters: cluster 1 with lower levels of costs, but also clusters 3 and 7 with intermediate and high levels of costs, respectively.

Cluster 1 groups policies connected to management issues setting a legal background and operational benchmarks regarding: the link between hospital and primary care services (drawing up the hospital referral network, referral criteria between Primary Care and Hospital networks, operational protocols between Primary Care services and Hospital services, eventually creating new healthcare units (USF)); the adjustment of hospital resources and performance to demand (create an "Heavy" Equipment Charter for the Hospital Sector, develop Multi-Year Program-Contracts, adjust appointment and surgery contracting to the respective demand, increase the Ambulatory Surgery rates, revise the legal framework for drug dispensing in hospital outpatient care, adjust hospital human resources according to healthcare demand, promote mixed contracts with pay linked to performance, create a Hospital Benchmarking and Strategic Framework for Performance Indicators); change the hospital governance framework (change the hospital governance model, assign management contracts, create intermediate management units).

Cluster 3 brings together mainly policies concerning strategic planning in health services (building the Lisbon Oriental Hospital and resizing the Great Lisbon region hospital network; creating and developing centers of excellency; strategic and operational planning of hospital units) and quality and risk control in health services units (implementing a system of evaluation and cost benefit analysis of medical devices; improving quality and patients safety; reducing the nosocomial infection rate; carrying out regular clinical audits; promoting clinical risk control).

Finally, all the policies grouped in cluster 7 regard information technology concerns such as: the need to guaranty the reliability of information; the implementation of shared software tools and applications for the complete hospital network; implementing an integrated computer network; implementing the Electronic Health Registry.

The second group of most relevant clusters includes 2 clusters with intermediate mean levels of potential impact: cluster 6 with lower mean costs and cluster 2 with higher ones.

Cluster 6 includes policies regarding hospital efficiency (share services among hospital pharmacies, standardize pre-surgery protocols, create a National Program to review adequacy of treatment in less differentiate care units following hospital admission, rationalize auxiliary diagnostic and therapeutic means requests, promote health professionals mobility, reduce the caesarean sections rate), healthcare integration to improve patients' access (promote the hospital specialties appointments in the Primary Health Centers, meet the patients screened as "Not-urgent" outside the Emergency Hospital Services, speed up patient referral to the Integrated Continuous Care Network), improving governance (select Board of Directors members with transparency, evaluate Board of Directors members performance, implement Code of Ethics in the EPE Hospitals) and improve the quality of available information at different levels (develop Clinical Trials in Portugal, make information on wait times easily available).

Cluster 2 contains policies related to improving communication and information delivery within the hospital network (hospital network architecture, promote medical appointments through new technologies in specific cases, develop therapeutic standards targeting therapeutic priorities supported by IT (information technologies), pharmaceuticals monitoring system – inpatient and outpatient hospital care, guaranty faster and safer communications, implement a virtualization program in the hospital network) and towards users and the general public (make health information available to citizens, make information on the Health System more available. raise user awareness about NHS costs of each clinical episode (proforma invoice), resume the Periodical User Satisfaction Evaluation Program, optimize the Users registered for surgery management system. It also presents management policies generally related with efficiency (convert all hospitals into Public Institution privately managed), develop an even costing and accounting system, share support services, further develop strategic partnerships with the social sector) and quality concerns (link service provider funding to quality indicators, promote the use of an uniform set of quality indicators).

The third and last group of clusters includes 2 clusters with lower mean levels of potential impact: cluster 4 with lower mean costs and cluster 5 with higher ones. These should be the policies whose health impact is less likely to be important to assess.

Cluster 4 includes policies regarding improved hospital efficiency (redesign the pharmaceutical and medical devices buying process, subject the pre-evaluation agreements to contracted programs, implement an energy efficiency program, unify hospital price tables, incorporate patients' satisfaction level in the hospital performance evaluation), improve governance (update the hospital classification regarding Board of Directors members pay) and reinforcing the citizen's role (implement effectively the Informed Consent).

Finally, cluster 5 includes mainly policies regarding reinforcing the citizen's role (monitor comfort levels in hospital units, implement effectively citizen participation in hospital life, implement the principle of freedom of choice of public healthcare providers for patients, make information on clinical benchmark available), improve hospital efficiency (adopt guidelines on the use of Medical Devices, implement a Medical Devices reuse Program, improve billing process) and quality of Health Professionals (promote Health Professionals recertification, create a Medical Simulation National Centre).

In short, considering as priority criteria to rank clusters dimensions Potential Impact (in terms of a "better health at lower costs" goal), then Implementation costs (including monetary, non-monetary and political costs) and lastly Ease of implementation / likelihood to be applied over the next 3 years, clusters would be ranked from the most to the least important to apply HIA as follows: clusters 1, 3, 7, 6, 2, 4, 5.

4.2. Clusters, Policies and Action Areas

In the initial report [7], the various proposed policies were divided into 8 strategic areas: A more consistent hospital network; A more sustainable financing policy; Healthcare integration to improve patients' access; More efficient hospitals; Quality as cornerstone of hospital reform; Information and technologies as investment and sustainability factor; Improve governance; Reinforcement of citizen's role.

When one links these areas with the 7 clusters partition (Appendices Table 10), one may acknowledge that:

- Only policies of the “Information and technologies as investment and sustainability factor” area have a high potential impact/high implementation costs profile. Policies from this area are always connected with high implementation costs profiles, whether with high or intermediate potential impacts.
- Policies from the “More consistent hospital network” area mainly have a high potential impact/low implementation costs profile and are never connected with low potential impacts.
- Policies from the “More sustainable financing policy” area do not seem to have a specific profile and distribute quite evenly among different clusters.
- Policies from the “Healthcare integration to improve patients’ access” area are associated with low implementation costs profiles, whether with high or intermediate potential impacts, but never connected with low potential impacts.
- Policies from the “More efficient hospitals” area don’t seem to have a specific profile and are distributed quite evenly among different clusters, although less frequently connected with low potential impacts.
- Policies from the “Quality as cornerstone of hospital reform” area are mainly connected with high potential impacts/intermediate implementation costs profiles and intermediate potential impacts profiles.
- Policies from the “Improve governance” area are always associated with low implementations costs profiles, no matter what the potential impact profile.
- Policies from the “Reinforcement of citizen’s role” are almost always connected with high costs profiles, whether regarding intermediate or low potential impact profiles, but never with high potential impact profiles.

If a priority rank for areas exists, selecting more important clusters according to a set of priority criteria may be easier. For instance, if decision-makers would regard the “Information and technologies as investment and sustainability factor” area as the strategic priority and “Potential Impact” followed by “Implementation costs” the priority criteria, clusters 7, mainly, and 2 would be the obvious candidates for HIA.

Analyzing clusters in the context of strategic action health areas may thus also help decision-makers screen through clusters as potential candidates to HIA.

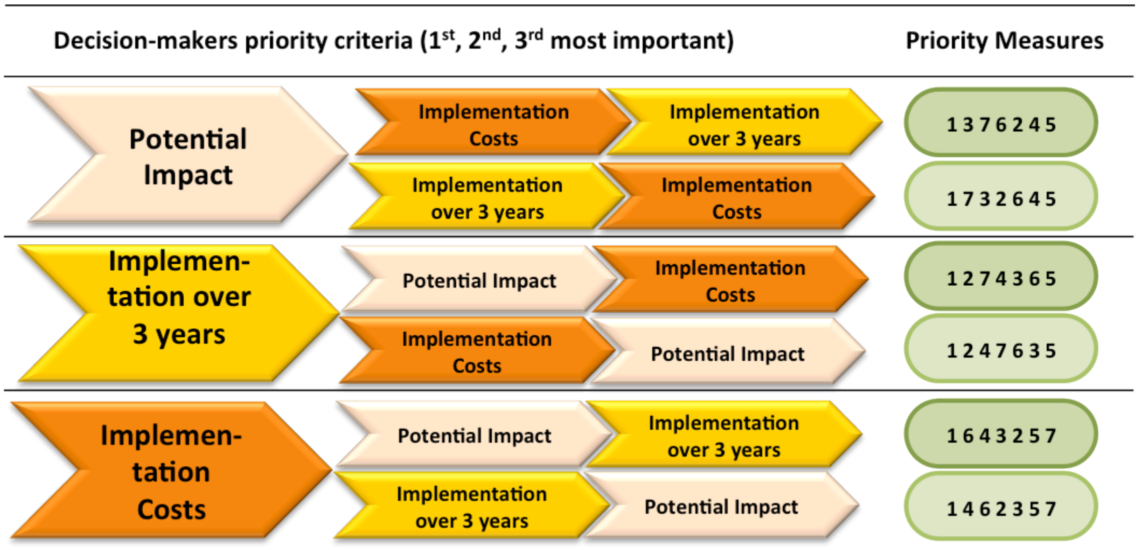
4.3. Swift Response to changes in priority criteria

As seen previously, using multivariate statistical methods such as cluster analysis in the screening step allows us to select as first candidates for HIA policies from cluster 1. But this ranking of clusters is obtained considering as priority criteria, first to maximize the Potential Impact (in terms of a “better health at lower costs” goal), then to minimize the Implementation costs (including monetary, non-monetary and political costs) and at last to maximize the Ease of implementation / likelihood.

However, the decision-makers’ priority criteria may be different, especially considering a country such as Portugal, amid a structural economic crisis, monitored at the time by the International Monetary Fund, the European Commission and the European Central Bank, with an adjustment program with detailed target policies to be achieved at specific times and precise associated indicators and quarterly reviews of its progress. With time and costs constraints related to the situation at the time, the potential impact of policies may not be the priority at all, but costs or even feasibility in 3 years. Figure 5 illustrates every possible different scenario when priorities change, helping decision-makers to view what solution is best according to their limitations and wishes. It is very interesting to see that, no matter what priority criteria one may have, the first cluster in every solution is cluster 1, identifying it as the group of policies most likely to be targets for HIA.

The decision-making process may thus be helped and speeded up not only to find one final more adequate solution, but also to allow choosing in an easy way among all possible combinations of solutions. Although multivariate statistical methodologies may be complex, its results are not very difficult to understand and thus decision-makers have more information, reliably, and not necessarily in a more difficult way to grasp.

Figure 5. Clusters prioritized according to different decision-makers priority criteria



4.4. Limitations and future paths of research

The present study is an essay to show how the use of multivariate statistical methods, such as cluster analysis, may be useful at the screening step of a HIA. Its limitations also set us a few potential future paths for research.

A larger sample of experts may be asked to classify policies described by more than 3 dimensions. A larger sample may also include experts and/or representatives of potential stakeholders of futures HIA to be undertaken, making the process more participative. This may be especially interesting if we consider one of the strong points of HIA to be the capacity and opportunity of involvement for all stakeholders related to a particular policy.

A larger set of dimensions may be taken into account, as one of the advantages of multivariate statistical methods is precisely working at a multidimensional level. Hierarchical cluster analysis based on the affinity coefficient as proximity measure, for example, may be used with a heterogeneous dataset (variables of different types, such as nominal, discrete or interval), in a two or three-way context [11,12]. Using different dimensions can also allow for the use of these methods, with more health-related features, becoming part of a broader all-purpose screening tool.

Using statistics at this stage of HIA means one needs quantified information, which enriches the decision-making process making it more evidence-based, but also may make it more efficient, in terms of lowering time related with the choice of undertaking HIA and, in the future, even taking into account costs. This is increasingly relevant with the rising importance of the HIA methodologies in the present and in the future, following international documents such as Health 2020 [13].

5. Conclusions

It is important that each step of HIA methodologies in the context of policies becomes increasingly quantified and multivariate, but in a way clear for decision makers to understand, and truly help the decision-making process.

This research helps to screen and prioritize policies quickly and reliably, using multivariate statistical methods to depict a multivariate reality and enabling scenario analysis by easily re-ranking clusters to distinct priority criteria and potential action areas. It may also contribute to make the screening process more transparent regarding non-health features. However, this methodology may easily be used for a more “traditional” screening step, just by using different variables.

This methodology may be applied to other forms of impact assessments and in other countries and may integrate stakeholders’ and the public’ opinions in the decision-making process.

Applying multivariate statistical methods such as hierarchical cluster analysis as early as the screening step in HIA may be very helpful towards obtaining evidence based, reliable, participatory, flexible and more efficient ways of selecting policies that should be the object of HIA.

References

1. WHO Regional Office for Europe. Health 21: The health for all policies framework for the WHO European Region: World Health Organization; 1999.
2. Stahl T, Wismar M, Ollila E, Lahtinen E, Leppo K, editors. Health in All Policies - Prospects and Potentials: Ministry of Social Affairs, Finland ; European Observatory on Health Systems and Policies; 2006.
3. Scott-Samuel A, Birley M, Ardern K. The Merseyside Guidelines for Health Impact Assessment. 2nd ed: International Health Impact Assessment Consortium; 2001.
4. Hebert KA, Wendel AM, Kennedy SK, Dannenberg AL. Health impact assessment: A comparison of 45 local, national, and international guidelines. *Environmental Impact Assessment Review* 2012; **34**: 74-82.
5. Diallo T, editor. Guide d'introduction à l'Évaluation d'Impact sur la Santé en Suisse: Plateforme Suisse sur l'Évaluation d'Impact sur la Santé (Plateforme EIS); 2010.
6. Harris P, Harris-Roxas B, Harris E, Kemp L. Health Impact Assessment: A Practical Guide. Sydney: Centre for Health Equity Training, Research and Evaluation (CHETRE). Part of the UNSW Research Centre for Primary Health Care and Equity, UNSW.; 2007.
7. Mendes Ribeiro J, Barreto AXD, Varanda JAV, Penedo JMV, Caiado JCF, Nunes JM, Santos NS, Boto PAF, Ivo RS, Santos TAC. Relatório Final do Grupo Técnico para a Reforma Hospitalar - Os Cidadãos no centro do Sistema, os Profissionais no centro da mudança, 2011.
8. Pita-Barros P, Campos-Fernandes A, Ramos F, Dussault G, Caldas-Almeida J, Fragata J, Lapão L. "Os Cidadãos no centro do Sistema, os Profissionais no centro da mudança": Contributo para a discussão. Lisboa, Portugal, 2011.
9. Hair JF, Black B, Babin B, Anderson RE, Tatham RL. Multivariate Data Analysis. 6th ed: Prentice Hall; 2006.
10. Daniel WW. Biostatistics – A Foundation for Analysis in the Health Sciences. 9th ed: John Wiley&Sons; 2009.
11. Bacelar-Nicolau L. Caracterização dos Sistemas de Informação das Organizações com base no modelo de Nolan. Aplicação de modelos de classificação hierárquica aos organismos da Administração Pública: NOVA IMS Information Management School (formerly Institute of Statistics and Information Management ISEGI - Universidade Nova de Lisboa); 2002.
12. Bacelar-Nicolau H, Nicolau F, Sousa A, Bacelar-Nicolau L. Measuring Similarity of Complex and Heterogeneous Data in Clustering of Large Data Sets. *Biocybernetics and Biomedical Engineering* 2009; **29**(2): 9-18.
13. WHO Regional Office for Europe. Health 2020: A European Policy Framework and Strategy for the 21st Century: World Health Organization; 2013.

Chapter 3 – Contribution of Hierarchical Cluster Analysis to the Health Impact Assessment Screening Step

SubChapter 3.2 – Screening National Health Programs for Health Impact Assessment: targeting policies with cluster analysis

CONTENTS

SubChapter 3.2 – Screening National Health Programs for Health Impact Assessment: targeting policies with cluster analysis

Abstract

Background: Health Impact Assessment (HIA) is a combination of procedures, methods and tools by which a policy may be judged as to its potential effects and its distribution on a population's health. Screening policies to identify candidates for applying HIA is an essential first step, generally qualitative. Our aim is to show how to use exploratory multivariate statistical methods such as cluster analysis to screen through National Health Programs (NPs) and pinpoint candidates for HIA.

Methods: Data consists on results of a two-part evaluation survey in 2012 regarding 31 NPs from the National Health Plan 2004-2010 (67 variables) - a characterization of NPs by their coordinator regarding 8 different areas and information on regional dissemination by Health Regions Administrations. Hierarchical cluster analysis was used for each area separately, complemented by principal component or multiple correspondence analyses, k-means cluster analyses and Kruskal-Wallis tests.

Results: Hierarchical Clusters Methods enable ranking clusters within each area and then rank each NP, according to a previously set of criteria for being a potential priority for HIA, from the highest to the lowest priority potential for HIA. The Cerebro-cardiocardiovascular Diseases National Program (*Programa Nacional de Doenças Cerebro-cardiovasculares* -PNDCV) is thus selected as the most adequate candidate for HIA.

Conclusion: Using multivariate statistical methods, such as cluster analysis, may be useful at the screening step of a HIA to pinpoint candidates for assessment. The Cerebro-cardiocardiovascular Diseases National Program best fulfills the established set of priority criteria, being thus the most obvious candidate for HIA.

Keywords: Health Impact Assessment, screening policies, quantification, cluster analysis, decision-making, national health programs, cardiovascular program.

1. Introduction

National Health Programs are an instrument to address public health issues, examining and mobilizing health system resources. In Portugal, National Health Programs are part of the National Health Plan, created within the health sector to help to establish indicators, goals, guidelines or notices of compliance in certain health-related areas [1,2]. The evaluation of health programs is essential to understand their impact and to strengthen their effectiveness[3]. Health Impact Assessment (HIA) is a systematic approach which allows examining and understanding the effect of a health program on health gains [4]. HIA is classically organized in sequential steps, the first of which is the screening step to identify whether a specific health program, intervention or public policy is suitable for HIA evaluation. Screening is generally a qualitative step and requires a clear enough definition of significant health impact, a perspective of added value in the HIA process, the ability to have or to create evidence to support the analysis and assessment feasibility [5-7].

The main aim of the present research is to show how to use exploratory multivariate statistical methods such as cluster analysis to screen through National Health Programs (NP) and pinpoint which NP or NPs are more suitable as priorities for HIA.

Classically, the screening of programs for HIA is conducted as a “selection process for identifying which projects, policies, plans or programs need to undergo a HIA based on the proposal's potential to impact people's health and add value to the decision-making process” [6]. Although HIA guides state screening is primarily based on criteria related to health determinants and equity, most consider other aspects such as political and operational priorities, especially when proposing screening tools [4]. In HIA guides there is a strong concern regarding assuring the accountability of a decision of doing HIA or not, but frequently it is not so evident how these non-health aspects, eventually more subjective, are actually to be taken into consideration in the screening process (chapter 2).

In the present research, authors propose a systematic and objective approach, based on cross-sectional criteria and a two steps statistical procedure with hierarchical cluster analysis.

Data, priority criteria and statistical methodologies used are presented in the next section. In the results section, a two-steps statistical procedure is proposed, where 30 NPs are systematically and separately clustered through 7 distinct groups of variables (corresponding to the 7 priority criteria features described in the materials and methods section) and clusters and NPs candidates for HIA are ranked. The discussion section reflects upon the usefulness of using these multivariate methodologies, the latent limitations of the research and possible future paths to be undertaken.

Main figures and tables are included in this paper, but several additional ones are referred to and may be found in the appendices.

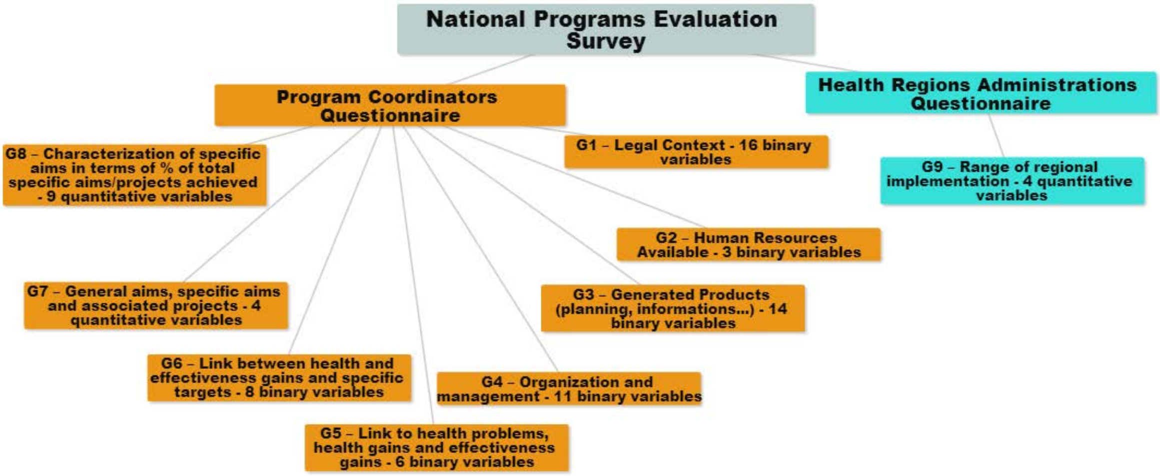
2. Materials and methods

2.1. Data

Data used in this research consists on results of a two-part evaluation process regarding 31 National Health Programs (NPs) from the Portuguese National Health Plan 2004-2010 [1-3]. In the first part, program coordinators were asked to answer a questionnaire characterizing the national program they were responsible for including: legal context; financing; products such as planning documents, progress reports, published information for the general population or health professionals, websites, among others; general and specific aims, as well as related projects; monitoring process of indicators on health gains, effectiveness, self-evaluation, etc. In the second part of the evaluation process, Health Regions Administrations answered a questionnaire concerning the dissemination and implementation of National Health Programs at a regional level, regarding: the existence of a regional coordinator; active or implemented projects in 2011, annual progress reports between 2009 and 2010; the existence of a regional evaluation program.

A total of 75 variables were first considered, organized into 9 areas ensuing from the format of the questionnaire applied in the survey (Figure 1).

Figure 1. Areas and associated number and types of variables in the National Program Evaluation Survey



The complete list of variables may be found in the Appendices Table 8. Group G2 was not considered for analysis as apparently the questions were not understood the same way throughout the sample, namely regarding the number of what was considered partial time and full time human resources assigned to the NPs. Group G6 was also not taken into account since it presented a high number of missing values and the health and effectiveness gains issues were already broadly being considered in group G5. The analysis was performed, therefore, using 64 variables (47 binary variables in 4 groups and 17 quantitative variables in 3 groups).

A total of 31 National Health Programs (NPs) was identified as active programs, but only 30 NPs were considered for analysis (Table 1), since the Oral Health NP (code 22) presented a very high number of missing values.

Table 1. 30 National Health Programs (NPs) analyzed

		Programa Nacional (PN)	National Program (NP)
1	ASCJR	*Ação de Saúde para Crianças e Jovens em Risco*	Health Action for at Risk Children and Youth
2	PNDCV	*PN para as Doenças Cérebro-Cardiovasculares (Coordenação Nacional de Doenças Cardiovasculares)*	NP for Cerebro-Cardiovascular Disease
3	PNIVIH/SIDA	*PN de Prevenção e Controlo da Infeção VIH/SIDA (Coordenação Nacional para a Infeção VIH/SIDA)*	NP for HIV/AIDS Infection
4	PNSM	*PN de Saúde Mental (Coordenação Nacional para a Saúde Mental)*	NP for Mental Health
5	PNPCDO	*PN de Prevenção e Controlo das Doenças Oncológicas (Coordenação Nacional para as Doenças Oncológicas)*	NP for Oncological Disease Prevention and Control
6	PNCDT	*PN contra as Drogas e as Toxicodependências*	NP against Drugs and Addictions
7	PNRPLA	*PN para a Redução dos Problemas Ligados ao Álcool*	NP for Reducing Alcohol Related Problems
8	PCO	*Plataforma Contra a Obesidade (PN para a Promoção da Alimentação Saudável)*	NP for Promoting Healthy Eating
9	PNCDR	*PN Contra as Doenças Reumáticas*	NP against Rheumatic Diseases
10	PNAS	*PN de Acreditação em Saúde*	NP for Certification in Health
11	PNCA	*PN de Controlo da Asma*	NP for Asthma Control
12	PNCD	*PN de Controlo da Dor*	NP for Pain Control
13	PNCP	*PN de Cuidados Paliativos*	NP for Palliative Care
14	PNEP	*PN de Erradicação da Poliomielite*	NP for Polio Eradication
15	PNIIDSEV	*PN de Intervenção Integrada sobre Determinantes da Saúde Relacionados com os Estilos de Vida*	NP for Integrated Intervention on Health Determinants related to Life Styles
16	PNLCT	*PN de Luta Contra a Tuberculose*	NP against Tuberculosis
17	PNPRA	*PN de Prevenção das Resistências aos Antimicrobianos*	NP for Resistances to Antimicrobials Prevention
18	PNPA	*PN de Prevenção de Acidentes*	NP for Accidents Prevention
19	PNPCD	*PN de Prevenção e Controlo da Diabetes (PN para a Diabetes)*	NP for Diabetes
20	PNPCDPOC	*PN de Prevenção e Controlo da Doença Pulmonar Obstrutiva Crónica*	NP for Chronic Obstructive Pulmonary Disease Prevention
21	PNCI	*PN de Prevenção e Controlo das Infeções Associadas aos Cuidados de Saúde*	NP for Healthcare associated Infections Prevention and Control
23	PNSA	*PN de Saúde Ambiental*	NP for Environmental Health
24	PNSE	*PN de Saúde Escolar*	NP for School Health
25	PNSO	*PN de Saúde Ocupacional*	NP for Occupational Health
26	PNSR	*PN de Saúde Reprodutiva*	NP for Reproductive Health
27	PNV	*PN de Vacinação*	NP for Vaccination
28	PNIVCLG	*PN Integrado da Vigilância Clínica e Laboratorial da Gripe*	National Integrated Program of Clinical and Laboratory Surveillance of Influenza
29	PNSV	*PN para a Saúde da Visão*	NP for Eyesight Health
30	PNSPI	*PN para a Saúde das Pessoas Idosas*	NP for Elderly Health
31	PNDR	*PN para Doenças Raras*	NP for Rare Diseases

2.2. Relevance Criteria

A set of priority criteria was considered to determine how important each cluster could be considered. These criteria were subjectively chosen by authors to illustrate how one can introduce criteria into this methodological approach. Nevertheless, an alternative set of criteria could easily be used.

Here, a NP is considered more relevant for analysis the more often it presents the following features, by order of importance (from the more to the less important):

a) Having a regional span as extended and in depth as possible;
b) Showing a concern of monitoring health gains, health systems needs and effectiveness gains;
c) Being a high-priority NP according to the National Health Plans 2004-2010 and 2012-2016;
d) Having been generating a variety of different products for health professionals, specific population groups and general population (guidelines, published information, online presence, events, etc);
e) Listing its planning documents, general aims and linking them to specific aims and/or projects' aims;
f) Presenting an adequate number of aims (being ambitious but realistic in its ambitions), coherent with the number of specific aims for each general aim and the number of projects for each aim;
g) Considering monitoring and evaluating the way aims are being achieved, including resources allocation.

Each of these criteria is linked to one of the 7 groups of variables considered (table 2) and is used to rank clusters and respective NPs (section 3.4).

Table 2. Link between each variable group and respective priority criterion, as well as importance rank

Features for being a potential priority for HIA	Group of Variables	Rank
a) Having a regional span as extended and in depth as possible	G9 – Range of regional implementation	1
b) Showing a concern to monitor health gains, health systems needs and effectiveness gains	G5 – Link to health problems, health gains and effectiveness gains	2
c) Being a high-priority NP according to the National Health Plans 2004-2010 and 2012-2016	G1 – Legal Context	3
d) Having a practice of generating a variety of different products to the health professionals, specific groups of the population and the population in general (guidelines, published information, online presence, events, etc)	G3 – Generated Products (planning, informations, etc.)	4
e) Considering the monitorization and evaluation of the way the aims are being achieved, including resources allocation	G8 – Characterization of specific aims in terms of % of total specific aims/projects achieved	5
f) Listing its planning documents, general aims and linking them to specific aims and/or projects' aims	G4 – Organization and management	6
g) Presenting an adequate number of aims and projects	G7 – General aims, specific aims and associated projects	7

2.3. Statistical Methodologies

Univariate descriptive analysis was performed to generally characterize the set of NPs and also with a data validation concern. These results will not be presented here, since the multivariate proposed approach may summarize the main univariate findings and is also the main focus of this research.

In this two-steps approach, hierarchical cluster analysis was applied to each group of variables to classify NPs, using as proximity measure the Ochiai coefficient for groups of binary variables and the squared Euclidean distance for groups of quantitative variables, as well as the average linkage aggregation criterion for all variables.

For groups of quantitative variables k-means non-hierarchical clusters were used (based on centroids from the hierarchical cluster analysis' partition) to validate hierarchical cluster analysis' selected partitions [8,9].

Multiple correspondence analysis (MCA) and principal components analysis (PCA) were applied respectively to binary and quantitative variables, as an aid in profiling the various clusters of selected partitions. Crosstabs with column percentages and adjusted residuals, as well as Fisher Exact Tests (with a significance level of 5%), were used to identify more significant binary variables and relevant clusters. For quantitative variables, descriptive statistics by cluster (mean, median, standard deviation, quartiles) and Kruskal-Wallis tests and associated multiple comparisons tests [10] were additionally employed to identify more relevant differences among clusters, that is to identify which clusters were the most distinct between them, and concerning which variables.

Since each group of variables corresponds to a priority criterion, for each group of variables, the partition or clusters of NPs obtained may be ranked as to being more or less evolved regarding to the associated criterion. The clusters of each partition are given a color-coded priority level and each NP is then evaluated according to this color-coded priority scheme. For each group of variables, color green is associated with the clusters more evolved regarding the criterion linked to that group of variables, color yellow to an intermediate level of evolvement and color red to a low level of evolvement. Clusters with only one NP associated are identified in light grey and are analyzed individually. The top NPs candidates for HIA are consequently easily identifiable, by being the ones integrated more often in clusters linked to the color green.

The statistical analyses were performed with IBM-SPSS version 21 software. Whenever necessary, a significance level of 5% was used, unless otherwise specified.

3. Results

In this section, results from our two-steps hierarchical cluster analysis approach are presented, first introducing the rationale on which the approach is based, then following the sequence of steps that culminate in the choice of the most adequate NP for HIA.

3.1. Rationale

The first of the two steps here proposed regards taking each one of the 7 groups of variables under study and applying hierarchical cluster analysis to obtain a partition for each group of variables. For each group of variables, a set of NPs clusters is obtained. The partition of each group of variables will probably be different, which means that for each group of variables a different number of clusters may be obtained, as well as in each cluster a different set of NPs (subsection 3.2).

Taking each group of variables separately, and as each of these groups is associated with a different priority criterion (subsection 2.2 and table 2), one may rank the clusters of NPs according to their relevance for each priority criterion (subsection 3.3). NPs may thus be color-coded regarding their ranking for each priority criterion.

The second step of this approach therefore consists on ranking the NPs within each group by their relevance for each criterion and then ranking them by the importance of the criteria used. A set of NPs candidates for HIA is thus quite easily obtained (subsection 3.4).

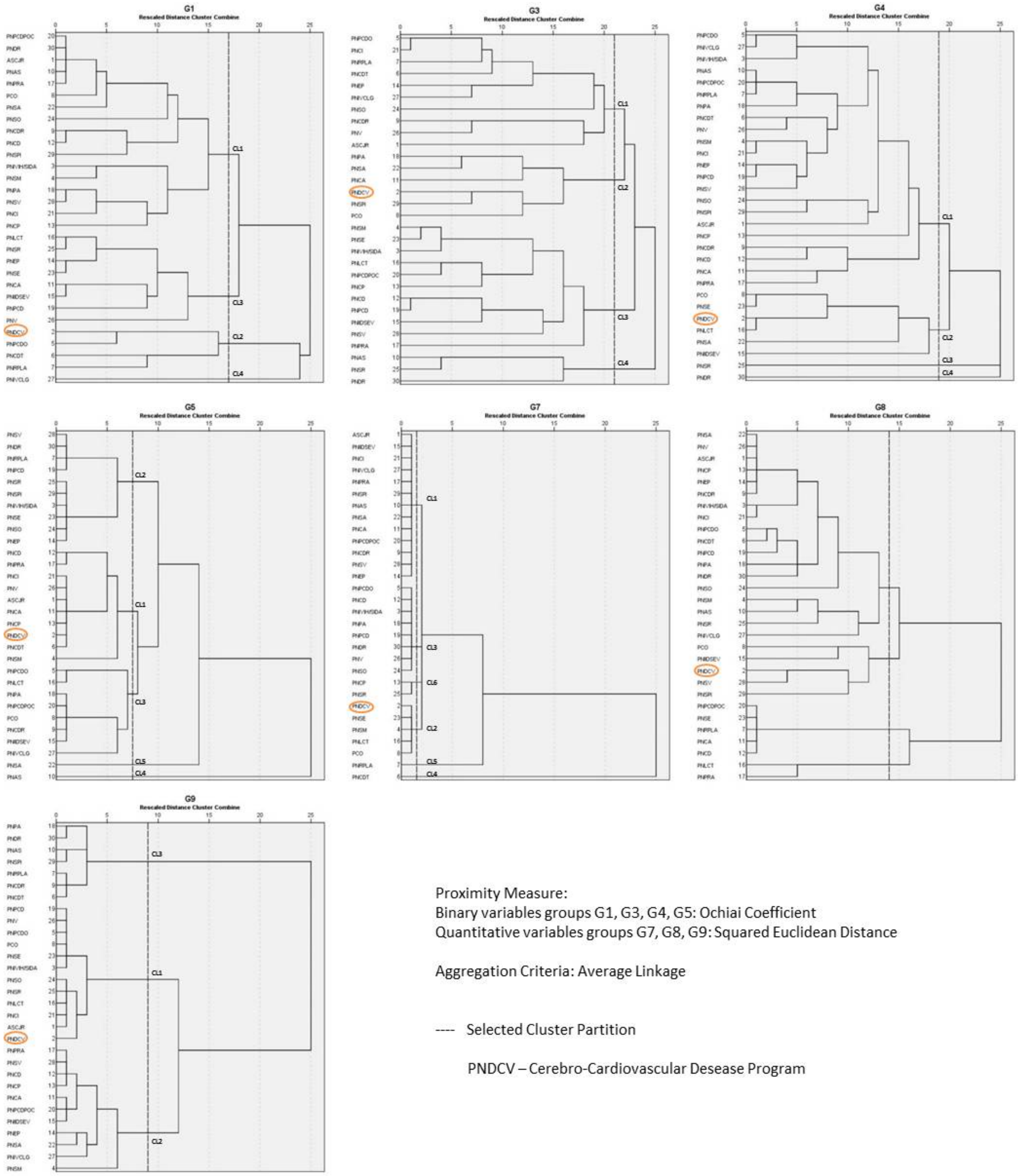
The following subsections give a more detailed description of the methodology implemented.

3.2. Choosing the adequate partition of clusters for each group of variables

Hierarchical trees or dendrograms (Figure 2 and, for easier viewing, Appendices Figures 5 to 11), complemented with the study of agglomeration schedules, led us to select a cluster partition of NPs for each group of variables. The number of clusters in each chosen partition may be seen in the dendrograms, but likewise in table 5. Hence, a 3 clusters partition was selected for analysis for group G9, 4 clusters' partitions were chosen for groups G1, G3, G4 and G8, a 5 and a 6 clusters' partitions were taken respectively for groups G5 and G7.

The dendrograms give us furthermore which NPs belong to which cluster. For instance, for area G1 - Legal Context a partition of 4 clusters was selected, in which cluster 2 (CL2) includes the following National Programs (NPs): NP for Cerebro-cardiovascular Diseases (PNDCV), NP for Oncological Disease Prevention and Control (PNPCDO), NP against Drugs and Addictions (PNCDT) and NP for Reducing Alcohol Related Problems (PNRPLA). The alignment of NPs for each cluster may be consulted in table 6.

Figure 2. Dendrograms of hierarchical cluster analysis for each variable group with selected partition and PNDCV identification



Proximity Measure:
Binary variables groups G1, G3, G4, G5: Ochiai Coefficient
Quantitative variables groups G7, G8, G9: Squared Euclidean Distance

Aggregation Criteria: Average Linkage

---- Selected Cluster Partition

PNDCV – Cerebro-Cardiovascular Desease Program

3.3. Profiling clusters for each group of variables

Once the number of clusters and respective alignment of NPs are determined, the profile for each cluster of NPs was outlined. Multiple correspondence analysis (MCA) and principal components analysis (PCA) were applied respectively to binary and quantitative variables (Figures 3 and 4, as well as Appendices Figures 12 to 18, for easier viewing). Additionally, we also used crosstabs with column percentages and adjusted residuals (binary variables) or descriptive statistics (quantitative variables) by cluster, as well as hypothesis testing (Fisher Exact and Kruskall-Wallis Tests, depending on variable types) for each variable of each group of variables. Tables 3 and 4 present significant tests results ($p<0.05$) for each variable and summary interpretation. More complete descriptive and inferential results may be found in the appendices (Appendices Tables 9 to 17, 19 and 21).

Thus, regarding area G1 – Legal Context, cluster 2 NPs' seem to differentiate themselves from other programs, being relatively isolated in the right quadrants of the MCA and more related to categories in the right quadrants of the joint plot of category points such as: having been created through Law, Decree, Government or Republic's Assembly Act (category V8_L_DL_Resol_Y), before the National Health Plan 2014-2010 (V13_BeforePN_Y), being more often IDT's responsibility (V7_IDT_Y) then DGS's (V3_DGS_N) and having received Social Games financing (V17_FinSocialGames_Y). These categories, more important according to MCA, are precisely the more relevant found also through descriptive analysis and hypothesis testing (Table 3). All the NPs from cluster 3 are the DGS' responsibility and created before the National Health Plan 2004-2010.

In what concerns group G3, cluster 1 is unlike the other clusters by being the only one with NPs that submit Evaluation Reports, where most NP's present Project Reports and have a website. All NPs from cluster 2 present Implementation Plans, most of them include Training Documents and other information materials, but none has Activities Reports and most do not present Project Reports. Cluster 3's NPs have Activities Plans, but most do not present Implementation Plans. Most NPs from cluster 4 don't submit Activities Plans, neither Project Reports. When analyzing the MCA factorial plans, there seems to be a clockwise "evolution" of clusters beginning with cluster 1 in the lower left side quadrants, followed by clusters 2, 3 and 4, this one in the most right and lower quadrants.

As regards to group G4, most NP's from cluster 1 link its general aims directly to its specific aims and describe the provided accountability process, while none of the NPs from cluster 2 does either of these. The MCA factorial plan shows us the NPs from cluster 2 concentrated in the lower right quadrant, with the NPs from cluster 1 stretching towards the upper left quadrant.

Concerning group G5, all NPs from cluster 1 use organizational and health systems response aspects as justification for creating the NP and identify effectiveness gains when defining its general aims. NPs from cluster 3 use organizational and health systems response aspects as justification for creating the NP, but do not identify effectiveness gains when defining its general aims. None of the NPs from cluster 2 use organizational and health systems response aspects as justification for creating the NP and many do not identify effectiveness gains when defining its general aims. The MCA factorial plan shows us the NPs from cluster 1 concentrated in the upper quadrants, with the NPs from other clusters occupying the lower quadrants.

In what regards group G7, cluster 3's NPs present a higher median number of specific goals and of projects associated to specific goals (initially expected as well as actually implemented). Cluster 1 have the lowest median value of general and of specific goals and Cluster 6 the lowest median value of projects associated to specific goals (initially expected as well as actually implemented). The PCA factorial plan shows us an overall concentration of NPs near the center of the plan, which means NPs aren't very different from each other in what relates to the variables of this group. There is however a tendency for NPs of the same clusters to near each other. NPs from cluster 3 occupy the right and lower quadrants, but NPs from cluster 1 concentrate in the left and lower quadrant, with NPs from clusters 2 and 6 occupying the upper quadrants.

About group G8, cluster 1 presents the best performance with a median of 100% in 8 issues and of more than 80% in the 2 remaining aspects. Cluster 2 presents a median value of 100% in 3 of the issues and 0% in only 2 aspects. It is followed by cluster 4 (median of 0% in 4 of the 9 issues analyzed as well as of 50% or less in 2 other issues). Cluster 3 includes the NPs with the worst performance associated with all aspects of total specific aims/projects achieved (median of 0% for all issues). The PCA factorial plan shows us the NPs from cluster 1 occupying the right-side quadrants, NPs from cluster 3 concentrated in the far-left side and NPs from cluster 4 towards the upper left quadrant. Component 1 thus tends to embody an axis of success in reaching distinct expectations for specific objectives.

Finally concerning group G9, cluster 1 is different from other clusters presenting the highest number of NPs present in all or almost all regions with a regional coordinator, active projects in 2011, annual progress reports during 2009-2010 and a regional evaluation of the NPs being done or scheduled. Cluster 3 includes NPs with the worst regional implementation at all levels. The PCA factorial plan shows a progression from right to left of NPs from cluster 1 (more to the right), to NPs from cluster 2 (center of the factorial plan) and then to NPs from cluster 3 (to the left). Component 1 thus represents an axis of regional dissemination of the NPs.

Figure 3. Multiple correspondence analysis (MCA) Factorial Plans for each group of binary variable categories and for cases identified by National Program short name and by associated cluster

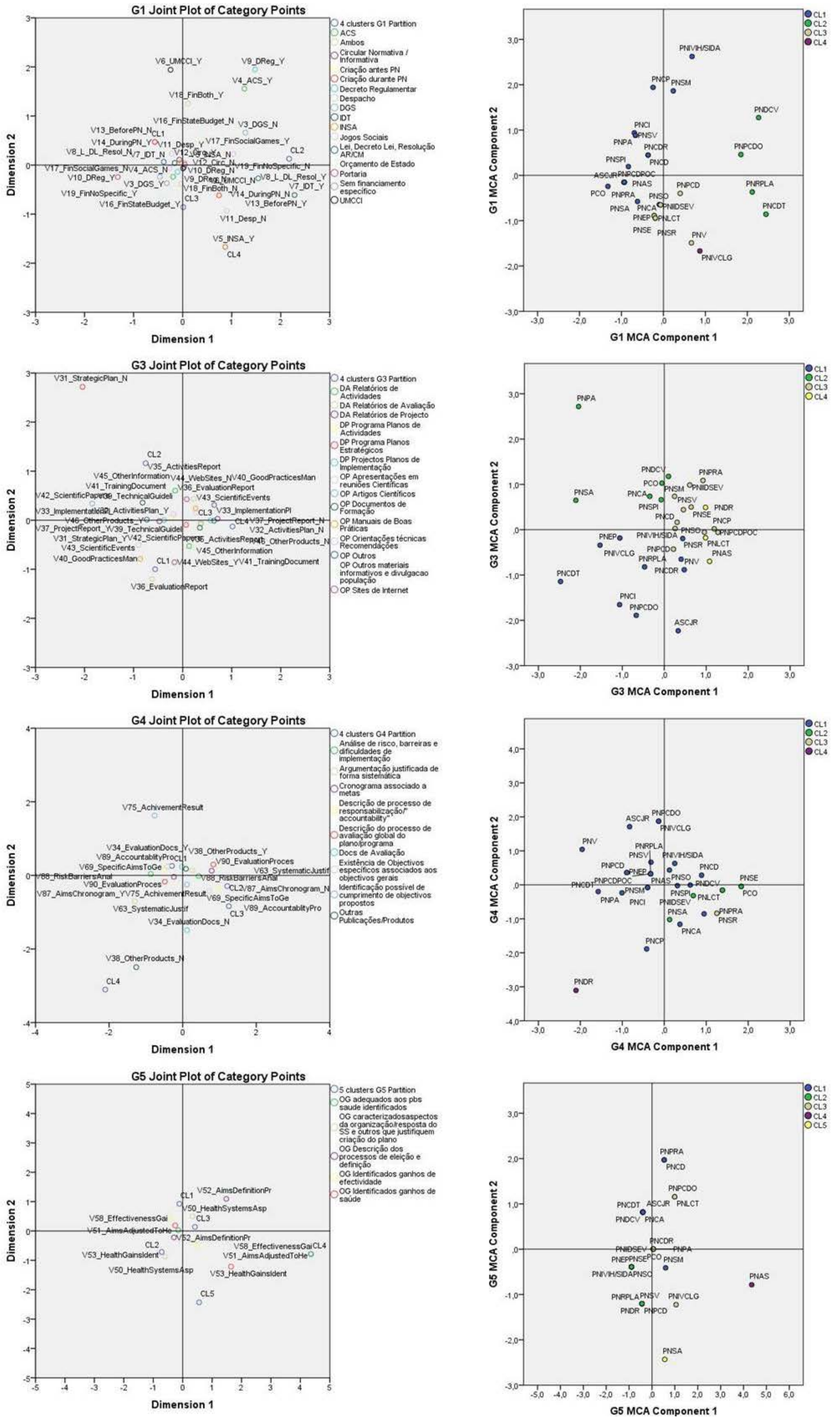


Figure 4. Principal components analysis (PCA) Factorial Plans for each group of quantitative variables and for cases identified by National Program short name and by associated cluster

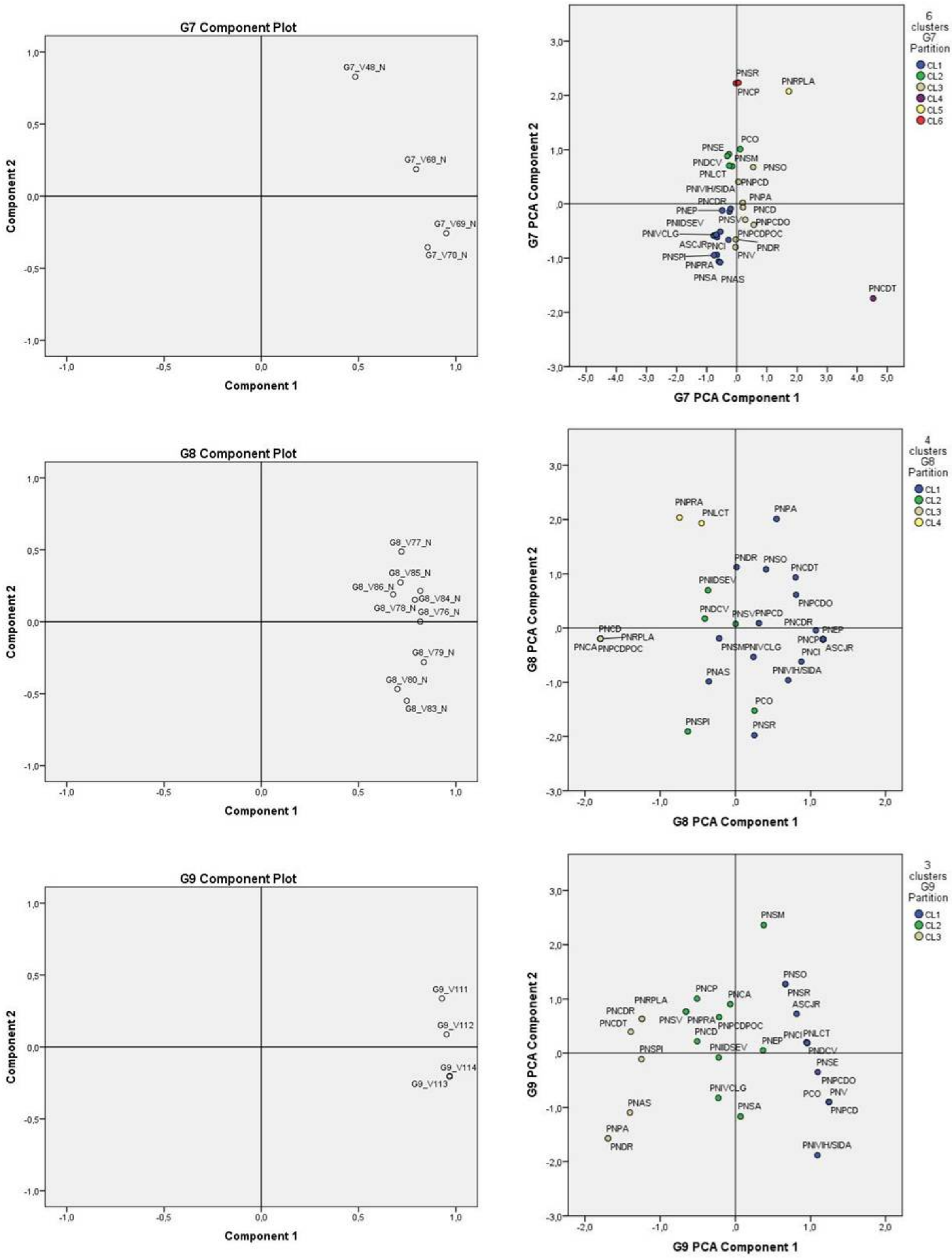


Table 3. Fisher Exact Tests results with p<0.05 (2-sided), for binary variables of G1, G3, G4, G5 by selected cluster partitions and results summary of crosstabs analysis

Variables	Test Statistic	Exact Sig. (2-sided)	Main results complemented with crosstabs analysis (column % and adjusted residuals)
G1 - Legal Context			
General Health Directorate (DGS)'s responsibility	14,605	0.001	None of cluster 2's NPs are DGS's responsibility and all of cluster 3's NPs are DGS's responsibility.
Instituto de Drogas e Toxicodependência (IDT)'s responsibility	8,487	0.023	Cluster 2 is the only one that includes NPs of IDT responsibility.
Creation through Law, Decree, Government or Republic's Assembly Act	13,850	0.001	All NPs from cluster 2 but only one NP from cluster 1 have been legally created this way.
Creation prior to National Health Plan 2004-2010	33,003	p<=0.001	Only NPs from cluster 1 didn't exist prior to the National Health Plan 2004-2010.
Creation during National Health Plan 2004-2010	33,003	p<=0.001	Only NPs from cluster 1 have been created during the National Health Plan 2004-2010 period.
Financing through Social Games (Lottery, etc)	6,918	0.042	Most NPs from cluster 2 received Social Games financing.
G3 - Products			
Activities Plans	14,199	0.001	All NPs from cluster 3 have Activities Plans, but most NPs from cluster 4 don't.
Implementation Plans	13,540	0.001	All NPs from cluster 2 have Implementation Plans, but most NPs from cluster 3 don't.
Activities Reports	10,075	0.011	Cluster 2 is the only cluster where none of the NPs has Activities Reports.
Evaluation Reports	18,744	p<=0.001	Cluster 1 is the only cluster with NPs that present Evaluation Reports
Project Reports	11,342	0.006	Only one NP from cluster 1 doesn't present Project Reports, but most of cluster 2's NPs and all of cluster 4's NPs don't.
Training Documents	9,977	0.009	Cluster 2 is the only cluster where most NPs include Training Documents.
Websites	7,975	0.034	Most NPs from cluster 1 have a website.
Other information materials	15,856	p<=0.001	All NPs from cluster 2 present other information materials, while only one NP from cluster 1 does.
G4 - Management			
Objectivos específicos associados aos objectivos gerais	15,222	p<=0.001	Most NPs from cluster 1 link its general aims directly to its specific aims, while none of cluster 2's NPs does.
Descrição de processo de responsabilização / "accountability"	14,158	p<=0.001	Most NPs from cluster 1 describe the provided accountability process, while none of cluster 2's NPs does.
G5 - Link to health problems and gains			
OG caracterizados aspectos da organização/Sistema Saúde e outros	30,837	p<=0.001	All NPs from clusters 1 and 3, but none from cluster 2, use organizational and health systems response aspects as justification for creating the NP.
OG Identificados ganhos de efectividade	21,824	p<=0.001	All NPs from cluster 1, but none from cluster 2, identify effectiveness gains when defining its general aims.

Table 4. Kruskal-Wallis tests and associated multiple comparisons tests results with p<0.05 (2-sided), for quantitative variables of G7, G8, G9 by selected cluster partitions

Variables	Test Statistic	Exact Sig. (2-sided)	Significant Multiple Comparisons Tests (5%)
G7 - General aims, specific aims and associated projects			
Objetivos Gerais Nº	21,869	0.001	CL1-CL2 (p<0.012) CL1-CL6 (p<0.024)
Objetivos Específicos Nº	20.379	0.001	CL1-CL3 (p<0.002)
OE Projetos próprios a cada objetivo específico Nº total previsto inicialmente	22.657	p<=0.001	CL2-CL3 (p<0.004)
G8 - Characterization % of total specific aims/projects achieved			
OE Definidas necessidades saúde/população alvo/determinantes	19.171	p<=0.001	CL3-CL1 (p<0.000) CL3-CL2 (p<0.002)
OE Definidos ganhos esperados	11.536	0.009	CL3-CL1 (p<0.010)
OE Análise de ações propostas prevista	15.277	0.002	CL3-CL2 (p<0.006)
OE Parcerias com instituições regionais/locais	19.340	p<=0.001	CL3-CL1 (p<0.001) CL3-CL2 (p<0.014)
OE Atribuição de recursos materiais	10.987	0.012	CL3-CL1 (p<0.022)
OE Orçamentos e Relatórios de Execução	14.218	0.003	CL3-CL1 (p<0.005)
OE Indicadores de operacionalização e concretização	16.222	0.001	CL3-CL1 (p<0.001) CL3-CL4 (p<0.029)
OE Avaliação através de metas	23.724	p<=0.001	CL3-CL1 (p<0.001) CL2-CL1 (p<0.002)
OE Análise de integração nos sistemas/serviços existentes	11.547	0.009	CL3-CL1 (p<0.010)
G9 - Range of regional implementation			
Tem Coordenador Regional? (nº regiões)	24.667	p<=0.001	CL3-CL1 (p<0.000) CL2-CL1 (p<0.011)
Está a ser implementado e tem projetos ativos em 2011? (nº regiões)	25.050	p<=0.001	CL3-CL1 (p<0.000) CL2-CL1 (p<0.006)
Tem Relatórios de Progresso Anual nos anos 2009-2010? (nº regiões)	25.321	p<=0.001	CL3-CL1 (p<0.000) CL2-CL1 (p<0.007)
Foi realizada ou está prevista uma Avaliação do Programa a nível regional? (nº regiões)	25.426	p<=0.001	CL3-CL1 (p<0.000) CL2-CL1 (p<0.007)

3.4. Choosing the most adequate NP

The cluster’ profiles analyzed enable us to rank each cluster in each partition regarding what is considered the essential criteria for being a potential priority for HIA (table 2). Each criterion is associated to a different group of variables and the groups are ranked according to the importance attributed to the different criteria (from the most important corresponding to group G9 to be least important associated to group G7). Taking the partition chosen for each group and the clusters’ profiles, it is possible then to rank these clusters from the highest priority potential for HIA (color green) to the lowest (color red) – table 5. For example, for group G9 corresponding to our main priority criterion for applying HIA regarding regional implementation, cluster 1 is credited with the highest priority potential for HIA (color green), cluster 2 with medium priority (color yellow) and cluster 3 with low priority (color red).

Furthermore, it is then possible to identify the NPs included in each cluster and granting each NP the color of the cluster it belongs to (table 6). Additionally, NPs may then be ranked by the 9 priority criteria (columns of table 6). Hence, assigning a color code to this ranking scheme in tables 5 and 6 helps us to easily identify the more and least advanced clusters and subsequently NPs.

One of the most essential features to be a NP candidate for HIA in our research is having a broad regional range, because of our equity concerns. That immediately limits our HIA candidates to a list of 12 NPs (listed at top of table 6), all green coded in group G9. Since a NP with a red code (low priority) in any of the areas is instantly rejected as a contender, a shortlist of 5 NPs is obtained (orange highlight). The NP for Cerebro-Cardiovascular Disease (PNDCV) is the only NP with a green code both in G1 Legal Context and G5 Link to health problems and gains (associated to the second and third more important criteria) and is thus indeed the adequate program to consider for an HIA with an equity focus and health systems impact concern.

In Table 7 we summarize the analysis of profiles of clusters that include the PNDCV throughout the groups of variables in our study. Groups of variables are ranked according to the priority criteria stated in the introduction of this chapter and recapped in the “Features for being a potential priority for HIA” column. The clusters that include PNDV seem to agree well with the stated criteria, especially in what concerns the first two priorities embodied in groups G9 and G5. Hence, clusters with the PNDV seem to be better placed for selection that other clusters and within these groups the PNDV seems indeed to be the more adequate for HIA selection than other NPs.

Table 5. Color ranking priorities for HIA of clusters for each variable group and respective priority criterion

Groups of Variables ranked by importance for our research	Features for being a potential priority for HIA	Chosen partition (number of clusters)	Cluster					
			1	2	3	4	5	6
G9 Range of regional implementation	Having a regional span as extended and in depth as possible	3	**+**	+-	-			
G5 Link to health problems and gains	Showing a concern to monitor health gains, health systems needs and effectiveness gains	5	**+**	+-	+-			
G1 Legal Context	Being a high-priority NP according to the National Health Plans 2004-2010 and 2012-2016	4	+-	**+**	+-			
G3 Products	Having a practice of generating a variety of different products to the health professionals, specific groups of the population and the population in general (guidelines, published information, online presence, events, etc)	4	+	**+-**	-	-		
G8 Characterization % of total specific aims/projects achieved	Considering the monitorization and evaluation of the way the aims are being achieved, including resources allocation	4	+	**+-**	-	-		
G4 Management	Listing its planning documents, general aims and linking them to specific aims and/or projects' aims	4	+	**+-**				
G7 General aims, specific aims and associated projects	Presenting an adequate number of aims and projects	6	-	**+-**	+			-

bold	Cluster including PNDCV
+	High priority
+ -	Medium priority
-	Low priority
	Not adequate for comparison: one National Health Program cluster
	Non-existent: the chosen partition includes a lower number of clusters

Table 6. National Programs ranked by priority criterion according to color ranking priorities for HIA of clusters for each variable group of previous table

National Program	G9 Range of regional implementation	G5 Link to health problems and gains	G1 Legal Context	G3 Products	G8 Characterization on % of total specific aims/projects achieved	G4 Management	G7 General aims, specific aims and associated projects
PNDCV	**CL1**	**CL1**	**CL2**	**CL2**	**CL2**	**CL2**	**CL2**
PNV	CL1	CL1	CL3	CL1	CL1	CL1	CL3
PNPCDO	CL1	CL3	CL2	CL1	CL1	CL1	CL3
PNSO	CL1	CL2	CL1	CL1	CL1	CL1	CL3
PCO	CL1	CL3	CL1	CL2	CL2	CL2	CL2
ASCJR	CL1	CL1	CL1	CL1	CL1	CL1	CL1
PNCI	CL1	CL1	CL1	CL1	CL1	CL1	CL1
PNIVIH/SIDA	CL1	CL2	CL1	CL3	CL1	CL1	CL3
PNPCD	CL1	CL2	CL3	CL3	CL1	CL1	CL3
PNSR	CL1	CL2	CL3	CL4	CL1	CL3	CL6
PNSE	CL1	CL2	CL3	CL3	CL3	CL2	CL2
PNLCT	CL1	CL3	CL3	CL3	CL4	CL2	CL2
PNSM	CL2	CL1	CL1	CL3	CL1	CL1	CL2
PNCA	CL2	CL1	CL3	CL2	CL3	CL1	CL1
PNCP	CL2	CL1	CL1	CL3	CL1	CL1	CL6
PNCD	CL2	CL1	CL1	CL3	CL3	CL1	CL3
PNPRA	CL2	CL1	CL1	CL3	CL4	CL1	CL1
PNEP	CL2	CL2	CL3	CL1	CL1	CL1	CL1
PNPCDPOC	CL2	CL3	CL1	CL3	CL3	CL1	CL1
PNSV	CL2	CL2	CL1	CL3	CL2	CL1	CL1
PNIIDSEV	CL2	CL3	CL3	CL3	CL2	CL2	CL1
PNIVCLG	CL2	CL3	CL4	CL1	CL1	CL1	CL1
PNSA	CL2	CL5	CL1	CL2	CL1	CL2	CL1
PNCDT	CL3	CL1	CL2	CL1	CL1	CL1	CL4
PNRPLA	CL3	CL2	CL2	CL1	CL3	CL1	CL5
PNCDR	CL3	CL3	CL1	CL1	CL1	CL1	CL1
PNPA	CL3	CL3	CL1	CL2	CL1	CL1	CL3
PNSPI	CL3	CL2	CL1	CL2	CL2	CL1	CL1
PNAS	CL3	CL4	CL1	CL4	CL1	CL1	CL1
PNDR	CL3	CL2	CL1	CL4	CL1	CL4	CL3

bold	PNDCV
	Potential National Programs for HIA
+	High priority
+ -	Medium priority
-	Low priority
	Not adequate for comparison: one National Program cluster

Table 7. Summary profile of the cluster including the PNDCV for each variable group and to the respective priority criterion

Group of Variables	Features for being a potential priority for HIA	Cluster including PNDCV	
		NPs	**Profile's essential features**
G9	Having a regional span as extended and in depth as possible	ASCJR, PNDCV, PNIVIH/SIDA, PNPCDO, PCO, PNLCT, PNPCD, PNCI, PNSE, PNSO, PNSR, PNV	PNs with the highest national coverage in all the 4 aspects analyzed.
G5	Showing a concern to monitor health gains, health systems needs and effectiveness gains	PNDCV, PNCI Infecções Associadas aos Cuidados de Saúde, PNVacinação, ASCJR jovens em risco, PNCAsma, PNCPaliativos, PNCDToxicodependências, PNSMental	PN's where general aims include concerns of effectiveness gains and organization/response from health systems.
G1	Being a high-priority NP according to the National Health Plans 2004-2010 and 2012-2016	PNDCV, PNPCDOncologicas, PNCDToxicodependentes, PNRPLAlcóol	PNs mainly created before the National Health Plan 2004-10, from IDT and ACS, mainly financed by Social Games, considered high-priority in the National Health Plans 2004-10 and 2012-16.
G3	Having a practice of generating a variety of different products to the health professionals, specific groups of the population and the population in general (guidelines, published information, online presence, events, etc)	PNDCV, PNPAcidentes, PNSAmbiental, PNSAsma, PNSPIdosas, PCObesidade	PNs always with an Implementation Plan, that frequently have "alternative" products such as Training documents, Other information materials and Other products. PNs that might look for ways of informing the public and health professionals different from the "traditional" ones and perhaps more effective.
G8	Considering the monitorization and evaluation of the way the aims are being achieved, including resources allocation	PNDCV, PCObesidade, PNIIDSEV Determinantes Saúde Estilos de Vida, PNSVisão, PNSPIdosos	PNs that register more frequently than those in other an Analysis of proposed actions, but less frequently an assignment of resources, budgets and execution reports, operationalization and delivering indicators, evaluation through goals and an integration analysis with existent systems.
G4	Listing its planning documents, general aims and linking them to specific aims and/or projects' aims	PNDCV, PCObesidade, PNIIDSEV Determinantes Saúde Estilos de Vida, PNLCTuberculose, PNSAmbiental, PNSEscolar	PNs that tend not to have specific aims directly linked with general aims.
G7	Presenting an adequate number of aims and projects	PNDCV, PNSMental, PNSEscolar, PNLCTuberculose, PCObesidade	PNs with higher median number of general aims, intermediate median number of specific aims, lower median number of projects by specific aim, higher median number of projects by specific aim. These PNs may thus be more realistic when setting their aims and consequently present a higher success rate in achieving the proposed aims.

4. Discussion

4.1. Two-steps hierarchical cluster analysis approaches: usefulness

The use of multivariate statistical methods, such as cluster analysis, at the first stage of a HIA helps filter out NPs that may not be suitable for HIA, identify those more relevant, and pinpoint possible candidates to be considered for HIA. We propose here to apply mainly hierarchical cluster analysis to generate swift and reliable results and help the decision-making process during the screening step of HIA in selecting NPs whose health impact should be assessed. PCA and MCA methodologies are used complementary to characterize clusters obtained through hierarchical cluster analysis and ranked them according to given priorities.

One advantage of these methodologies is to allow for the use of different types of variables, both quantitative and qualitative, in the search for a single final solution.

This approach has also an advantage of being very visual, using helpful graphic displays such as dendrograms and PCA and MCA factorial plans, but also facilitating the use of a color coding scheme that enables an easier choice of NPs candidates for HIA. This may especially valuable in a HIA context where assessments are made for a decision-making process ultimately by non-statisticians.

4.2. The importance of the Cerebro-cardiocardiovascular Diseases National Program

Our general aim to screen NPs to pin point the more relevant ones for HIA indicated as a primary target for HIA the Cerebro-cardiocardiovascular Diseases National Program (Programa Nacional de Doenças Cerebro-cardiovasculares –PNDCV).

According to WHO Europe, Cardiovascular disease (CVD) causes more than half of all deaths across the European Region, but 80% of premature heart disease and stroke is preventable [11].

Eurostat cardiovascular diseases statistics from data extracted in October 2015 show that cardiovascular diseases are the leading cause of death in the EU [12]. In Portugal diseases of the circulatory system in 2012 account for 30.4% of all deaths, a little below the 34.7% share for the average EU-28, near rates from Spain (30.2%), below countries such as Greece, Germany or Italy (respectively 42.6%, 40.2% and 37.5%), but higher than countries such as UK, Netherlands or France (respectively 28.4%, 27.6% and 25.2%).

A reduction in the number of deaths associated with diseases of the circulatory system across many EU Member States has been observed. The possible causes for these changes include increased screening and new surgical procedures, new forms of medication available (such as statins), as well as lifestyle changes (such as a reduction in the number of smokers). This indicates that further improvement is still possible, especially in a context of prevention and health promotion [13]. Through HIA health impacts of various policies and projects, especially in the context of the Cerebro-cardiocardiovascular Diseases National Program, may help to select those with a higher impact on health, but also more cost-effective, with a higher return in terms of health value.

HIA thus may benefit from certain complementary features of Health Technologies Assessment [14], for example, to quantify health benefits and improve cost effectiveness of policies and projects. Being able to measure the return on health investment of public policies and projects is increasingly becoming an important aspect for decision makers. For instance, in 2013 a total of 11.1 million in-patients with diseases of the circulatory system were discharged from hospitals across the EU. Diseases of the circulatory system thus represent a substantial burden on healthcare systems and government budgets, which is crucial especially in countries with public financed national health services.

Moreover, age, gender, regional and socio-economic differences, among other health determinants that characterize those who suffer from these diseases, also emphasizes important equity issues that concern so much HIA.

All these aspects thus make a case for the use of HIA regarding actions, projects and policies concerning the Cerebro-cardiocardiovascular Diseases National Program. The selection of this NP, through our multivariate statistical methodologies, in the screening step of HIA, is hence backed up by evidence. Furthermore, this reality is patent both in

Portugal and in other European countries where the burden of these chronicle diseases is also high. This means these methodologies may also be used in other countries and regions.

4.3. Limitations and future paths of research

Our study shows how the use of multivariate statistical methods, such as cluster analysis, may be useful at the screening step of a HIA. Its limitations also set us a few potential future paths for research.

In reality, the color-code scheme which was the basis of ranking clusters is obtained considering a particular set of priority criteria within each variable group. However, if a different priority rank for features to be a NP candidate for HIA exists, the color code may easily be adapted.

Similarly, the ranking of NP's according to the proposed color scheme is also based on a particular set of priorities given to the variable groups. Nevertheless, for another decision-makers' priority criteria, it is easy to simulate a different scenario.

The decision-making process may thus be helped not only by finding one final, more adequate solution, but also to allow for choosing among several possible solutions. Although multivariate statistical methodologies may be complex, decision-makers may thus have more information, reliably, and not necessarily in a more difficult way to grasp.

The inclusion of other variable groups, representing other areas of characteristics of NPs, such as more refined health and effectiveness gains information for example, is also very simple. One has only to apply hierarchical cluster analysis to the new set of variables and give the new area a priority relatively to the already available featured groups. This means there is no real technical limit as to the number of variables one may work with.

Still, one may wish to cluster NPs according to a single set of variables and not various groups of variables like it was done here, or even using complex variables (distributions of values associated to a variable and not a single value, for instance). Hierarchical cluster analysis based on the affinity coefficient as proximity measure, for example, may be used with a heterogeneous dataset (variables of different types, such as nominal, discrete or interval), in a two or three-way context [15,16]. This will also be a future path for our research.

5. Conclusions

This research helped us screen and prioritize national programs, electing the Cerebro-Cardiovascular Disease National Program as the foremost candidate for HIA.

It is important that each step of HIA methodologies in the context of policies becomes increasingly quantified and multivariate, but in a way clear for decision makers to understand. Generating graphic outputs that help even non-statisticians to grasp results may truly help the decision-making process in becoming more evidence-based.

This research aids screening and prioritizing policies quickly and reliably, using multivariate statistical methods to depict a multivariate reality, but enabling scenario analysis by easily re-ranking clusters to distinct priority criteria and potential action areas.

These methodologies may also be applied to other forms of impact assessments and in other countries.

Applying multivariate statistical methods such as hierarchical cluster analysis as early as the screening step in HIA may be very helpful towards obtaining evidence based, reliable, participatory, flexible and more efficient ways of selecting policies that should be the object of HIA.

References

1. Ministério da Saúde. National Health Plan 2012-2016, 2013.
2. Ministério da Saúde de Portugal. Plano Nacional de Saúde: Orientações Estratégicas para 2004-2010, 2004.
3. World Health Organization. WHO Evaluation of the National Health Plan of Portugal (2004-2010), 2010.
4. Kemm J, editor. Health Impact Assessment: Past Achievements, Current Understanding and Future Progress: Oxford University Press; 2013.
5. Metcalfe O, Higgins C, Lavin T. Health Impact Assessment Guidance: Institute of Public Health in Ireland; 2009.
6. Hebert KA, Wendel AM, Kennedy SK, Dannenberg AL. Health impact assessment: A comparison of 45 local, national, and international guidelines. *Environmental Impact Assessment Review* 2012; **34**: 74-82.
7. UCLA Health Impact Assessment Project. HIA-CLIC website - Phases of HIA 1.Screening. http://www.hiaguide.org/methods-resources/methods/phases-hia-1-screening (accessed 4/27/2016).
8. Saporta G. Probabilités, Analyse des Données et Statistique. 3e édition ed: Éditions Technip; 2011.
9. Hair JF, Black B, Babin B, Anderson RE, Tatham RL. Multivariate Data Analysis. 6th ed: Prentice Hall; 2006.
10. Daniel WW. Biostatistics – A Foundation for Analysis in the Health Sciences. 9th ed: John Wiley&Sons; 2009.
11. WHO Regional Office for Europe. Cardiovascular diseases: Data and statistics. 2016. http://www.euro.who.int/en/health-topics/noncommunicable-diseases/cardiovascular-diseases/data-and-statistics (accessed 5/26/2016).
12. Eurostat. Cardiovascular diseases statistics. 10/1/2016. http://ec.europa.eu/eurostat/statistics-explained/index.php/Cardiovascular_diseases_statistics (accessed 6/25/2016).
13. Piepoli MF, Hoes AW, Agewall S, Albus C, Brotons C, Catapano AL, Cooney MT, Corra U, Cosyns B, Deaton C, Graham I, Hall MS, Hobbs FD, Lochen ML, Lollgen H, Marques-Vidal P, Perk J, Prescott E, Redon J, Richter DJ, Sattar N, Smulders Y, Tiberi M, van der Worp HB, van Dis I, Verschuren WM, Authors/Task Force M. 2016 European Guidelines on cardiovascular disease prevention in clinical practice: The Sixth Joint Task Force of the European Society of Cardiology and Other Societies on Cardiovascular Disease Prevention in Clinical Practice (constituted by representatives of 10 societies and by invited experts)Developed with the special contribution of the European Association for Cardiovascular Prevention & Rehabilitation (EACPR). *Eur Heart J* 2016; **37**(29): 2315-81.
14. Lobo M, Fernandes E, Nisa C, Bacelar-Nicolau L. Main results and lessons to be learned from the CUTEheart project. 2nd CUTEheart Workshop on Health Technology Assessment in Cardiovascular Disease, in Congresso Português de Cardiologia; 4/23/2016; Vilamoura, Portugal; 2016.
15. Bacelar-Nicolau H, Nicolau F, Sousa A, Bacelar-Nicolau L. Measuring Similarity of Complex and Heterogeneous Data in Clustering of Large Data Sets. *Biocybernetics and Biomedical Engineering* 2009; **29**(2): 9-18.
16. Bacelar-Nicolau L. Caracterização dos Sistemas de Informação das Organizações com base no modelo de Nolan. Aplicação de modelos de classificação hierárquica aos organismos da Administração Pública: NOVA IMS Information Management School (formerly Institute of Statistics and Information Management ISEGI - Universidade Nova de Lisboa); 2002.

Chapter 4 – Picturing Inequities for Health Impact Assessment: Linked Electronic Records, Mortality and Regional Disparities in Portugal *

CONTENTS

*** This chapter has been accepted for publication as: Bacelar-Nicolau L, Rodrigues T, Fernandes E, et al. Picturing Inequities for Health Impact Assessment: Linked Electronic Records, Mortality and Regional Disparities in Portugal. Impact Assessment and Project Appraisal 2017.**
[http://www.tandfonline.com/toc/tiap20/current]
This chapter has thus different titles and references formats than other thesis chapters.

GENERAL INFORMATION ON THE PAPER

TITLE:

Picturing Inequities for Health Impact Assessment: Linked Electronic Records, Mortality and Regional Disparities in Portugal

Keywords:
Equity
Quantification
Decision-making
Big Data
Data Science
Acute Myocardial Infarction

Authors:
First Author: Leonor Bacelar-Nicolau
Co-Authors:
Teresa Rodrigues, Faculty of Medicine, University of Lisbon, Portugal
Elisabete Fernandes, Institute of Preventive Medicine and Public Health, Faculty of Medicine, University of Lisbon, Portugal
Mariana Lobo, Center for Health Technology and Services Research (CINTESIS) & Faculty of Medicine, University of Porto, Portugal
Cláudia Fernandes Nisa, Center for Health Technology and Services Research (CINTESIS) & Faculty of Medicine, University of Porto, Portugal
Vanessa Azzone, Department of Health Care Policy, Harvard Medical School, USA
Armando Teixeira-Pinto, School of Public Health, The University of Sydney, Australia;
Altamiro Costa-Pereira, Center for Health Technology and Services Research (CINTESIS) & Faculty of Medicine, University of Porto, Portugal
Sharon-Lise Teresa Normand, Department of Health Care Policy, Harvard Medical School, USA
José Pereira Miguel, Institute of Preventive Medicine and Public Health & ISAMB – Institute of Environmental Health, Faculty of Medicine, University of Lisbon, Portugal

Acknowledgements:
Authors thank SPMS (Serviços Partilhados do Ministério da Saúde) and ACSS (Administração Central do Sistema de Saúde) for having made available the data used in our research and especially SPMS' President Henrique Martins for his invaluable support.
This work was partially supported by the CUTEHeart Project – Comparative Use of Technologies for Coronary Heart Disease, funded by FCT, QREN, COMPETE under Grant HMSP-ICT/0013/2011 (http://cuteheart.med.up.pt).

ABSTRACT:

Health Impact Assessment (HIA) focuses on minimizing inequities when studying the effects of a policy on the population's health. Nevertheless, it is seldom simultaneously quantified, multivariate and visually graphically comprehensible for non-statisticians.

This paper aims to address that gap, assessing a policy promoting the quality of Electronic Health Records, linking hospital and primary healthcare data (Blood Pressure, Cholesterol, Triglycerides, Waist Circumference, Body Mass Index) to mortality outcomes and regional inequities. Acute Myocardial Infarction patients admitted in the hospital are then followed regularly in Portuguese NHS Primary Care.

Regional disparities regarding recorded information are observed and different association patterns with mortality identified, ranked and visualized through adjusted ORs for sex, age and indicators of severity of hospital admission, complemented with multivariate correspondence analysis.

A pathway to handling equity within quantitative HIA shows that complexity in data and methods may generate simplicity and clarity through visual graphical aids. Tackling Big Data with Data Science in HIA may even be at the center of future health reforms, assessing impacts of health promotion and chronic disease policies.

Introduction

Context

Health Impact Assessment (HIA) was earlier defined as a “combination of procedures, methods and tools by which a policy, program or project may be judged as to its potential effects on the health of a population and the distribution of effects within the population” (European Centre for Health Policy, 1999). The International Association for Impact Assessment (IAIA) added that “HIA identifies appropriate action to manage those effects’ (i.e. the effects on health and distribution of health)” (Quigley et al. 2006).

HIA thus identifies paths between a policy, program or project and positive and negative externalities induced on health determinants (individual, social and environmental factors, including institutional factors), estimating its unintended, often unexpected, health outcomes. It is at its core a decision support tool, to inform and influence decision makers into improving a proposal for health and equity, maximizing positive health impacts and minimizing negative ones throughout a population (Kemm 2013; Quigley et al. 2006).

HIA is regularly being used in many countries such as the UK, the Netherlands, Australia, New Zealand, Thailand, the USA and others, more often with a qualitative emphasis (Kemm 2013; World Health Organization 2015). Quantifying health estimations within HIA was however very early in HIA history identified as potentially more informative and influential with decision-makers (Kemm 2013; Mindell et al. 2001), complementing qualitative analyses to achieve more robust, evidence-based and whole estimations of health impacts that would include the nature of these impacts, as well as their direction, magnitude and distribution.

Nevertheless, it has been recognized that quantification within HIA is rarely done, since it “is often hard or impossible” because of a lack of information regarding initial conditions, effects of the proposal, and the theoretical framework linking conditions to health outcomes (Kemm 2013).

Generally, two different approaches to HIA quantification have been followed, one based on health economic evaluation and another on risk assessment (Fehr et al. 2012).

Quantified HIA based on health economic evaluation relies on health technology assessment methods, estimating indirect costs and health-related quality of life indicators (Brodin and Hodge 2008) and dealing with equity for instance by applying weights to account for inequalities when calculating health gains or by estimating health benefits separately by relevant population sub-groups (Glover and Henderson 2010). The HIA quantification based on risk assessment is grounded in environmental and public health research experience of estimating risk exposure, frequently relying on epidemiology modelling (Fehr et al. 2012; Kemm 2013). Other HIA related quantification experiences include profiling individuals, screening policies (Bacelar-Nicolau, Pereira Miguel, and Saporta 2008; Bacelar-Nicolau, Pereira Miguel, and Saporta 2015a; Bacelar-Nicolau, Pereira Miguel, and Saporta 2015b) and evaluating HIA effectiveness (Haigh et al. 2015; Harris-Roxas et al. 2012; Harris-Roxas et al. 2014).

An assortment of computational tools for HIA quantification has been made available: some more generic, others more specific to certain determinants or diseases; some more related to environmental health risk assessments, others more in tune with public health risk factor-outcome modelling; most not very user-friendly without support from the original developers. Further tool development is no longer considered a priority, but improvements are needed regarding two aspects: its application in various real-life contexts and especially in “whether and how they estimate impacts on health inequalities” (Fehr et al. 2012; Fehr et al. 2016).

The fact is that HIA still quite seldom uses multivariate statistical methods to estimate health impacts while taking equity into account and providing easy to understand visual outputs (Veerman, Barendregt, and Mackenbach 2005).

Among the difficulties, a major one is to find available and reliable data to model interrelations, explicitly between health determinants, health impacts, policies and related costs (Fehr et al. 2012; Fehr et al. 2016; Harris-Roxas et al. 2012). Another barrier is that complex statistical methodologies used frequently generate results difficult to understand by non-statisticians, including decision-makers (Fehr et al. 2012).

Our approach focuses precisely on how to overcome these difficulties and improve quantified HIA by showing how one may take into account equity while applying multivariate methodologies usually used in a data mining, big data context: complex but with clear graphical representations of results.

We were given access to a database linking several data origins – data source SPMS/ACSS (Serviços Partilhados do Ministério da Saúde/Administração Central do Sistema de Saúde) – as a pilot project to investigate how enriching it could be to have information on individual patients linking data from the Portuguese National Health Service regarding hospital admissions data, primary care data, pharmaceutical drugs consumption and prescription, as well as the mortality registry. As far as we know, it was the first time researchers in Portugal were able to get this kind of data and various procedures had to be taken to safeguard the anonymity of patients and their rights.

Aims

Our aims in this paper are:

1. To show how to identify and visualize regional disparities in a quantified way when applying an Electronic Health Records policy targeted for HIA;
2. To study associations between mortality of Acute Myocardial Infarction patients and an Electronic Health Records policy targeted for HIA, while identifying potential regional inequities, in a multivariate yet simple way to visualize;
3. To propose a conceptual quantitative path of analysis for HIA to study associations between equity, health impacts and policies, based on Data Science and Data Mining methods applied in a Big Data context.

Strategy

To put our strategy into practice, we take:

- As sample, all adults admitted to hospitals for acute myocardial infarction (AMI) during the second semester of 2012, followed regularly in primary care (PC) during 2013, always within the National Health Service (NHS) in Portugal;
- As a policy targeted for HIA, an Electronic Health Records (EHR) program to promote registration of information at PC level regarding the indicators Blood

Pressure, Cholesterol, Triglycerides, Waist Circumference and Body Mass Index (BMI);

- As health impact of interest, the mortality status at the end of the period of study, running from after hospital admission during the 2nd semester of 2012 until December 31 2013;
- As equity aspect under scrutiny, regional disparities in Portugal, since not assuring an adequate application of the policy throughout all 5 health regions of residence (Norte, Centro, LVT-Lisboa e Vale do Tejo, Alentejo and Algarve) may contribute to regional health inequities.

To reach our first aim, we start by identifying associations between the EHR policy and regions: regions are ranked according to the strength of their association with information registered and then these associations are visualized graphically to ease interpretation.

To attain our second aim, associations between information registration and mortality are assessed within each region; regions are then ordered by the strength of these associations, and these connections are finally visualized graphically to simplify interpretation.

Lastly, to reach our third aim, inspired on the path followed in our case study regarding goals above, a conceptual framework is proposed to analyze associations between policies and health impacts while considering equity, in a quantified multivariate way, when undertaking HIA.

Materials and methods

Data

Data consists of information on all adults (≥20 years old) admitted in Portuguese NHS Hospitals with AMI diagnosis during the second semester of 2012 and followed in the NHS PC network regularly during 2013 (over 2 quarters with appointments with a general practitioner) – data source SPMS/ACSS (Serviços Partilhados do Ministério da Saúde/Administração Central do Sistema de Saúde). Patients with no resuscitation or with only comfort measures information or who were discharged against medical opinion were excluded. A total of 3,776 cases were considered for analysis.

Variables for analysis included:

- Mortality outcome under study: being deceased or not at December 31 2013;
- Four indicators regarding having information registered or not: Blood Pressure, Cholesterol, Triglycerides, Waist Circumference, Body Mass Index (BMI). BMI was either existent in the database or was calculated whenever values for weight and height were both available;
- Five health regions of residence: Norte, Centro, LVT, Alentejo and Algarve;
- Demographic variables: sex and age;
- Four hospital admission severity variables: having one or more hospital readmissions during the second semester of 2012 also for AMI diagnosis, having undertaken surgery during hospital admission, having mean admission duration over 6 days, having 6 or more diagnosis associated with hospital admission.

Note that the inclusion criterion of being followed in the NHS PC network regularly during 2013, guarantying that each patient has at least 3 quarters with appointments with a general practitioner, means assuring that each patient has had the same opportunity of having information registered about their condition. Any patient within the study has accordingly had appointments with a general practitioner, even if he or she has died during the follow-up period of 2013.

Statistical Methodologies

Statistical methodologies differ depending on the stage of the study undertaken. In the first stage, associations between registering or not registering indicators (Blood Pressure, Cholesterol, Triglycerides, Waist Circumference, BMI) and regions (Norte, Centro, LVT, Alentejo and Algarve) were regarded, and in the second stage associations between mortality and registering or not registering indicators stratified by region were considered.

At each stage, a bivariate approach was first undertaken with contingency tables, independence Chi-Square or Fisher exact tests (Daniel 2009), followed by a multivariate approach based on logistic regression with Odds Ratios (Kleinbaum and Klein 2010), crude and adjusted after controlling for sex, age and sex and age interaction. In the first stage overall and adjusted OR were also calculated controlling for region. Results presented in this paper mainly focus on models with Algarve as reference region, although models with other regions as references were estimated to identify significant differences between regions. In the second stage, logistic models were additionally adjusted for hospital admission severity indicators and stratified by region.

Finally, multivariate exploratory data analysis methods were used, specifically principal components analysis over the OR table (indicators versus regions – SOM Table 4) in the first stage and multivariate correspondence analysis over the initial database (Hair et al. 2006; Saporta 2011).

Statistical analyses were generally conducted with IBM-SPSS version 22 software. A significance level of 5% was used whenever statistical tests were applied.

Further detailed information on statistical analyses undertaken and results obtained may be found in Supplemental Online Material (SOM).

Results

Associating regions to health indicator registration

In this first stage, with our first aim in mind, we start by studying associations between regions and the registration or not of certain health indicators.

Bivariate analyses show that registering information on each indicator at PC level is not uniform throughout all health regions of residence of patients under study (SOM Table 1 and Figure 6). Algarve, closely followed by LVT, is the region with the highest percentage of no-registration for every indicator in the study. Norte, usually followed by Algarve, is the region with the lowest percentage of no-registration for every indicator. Centro usually appears between values of these 2 subgroups. Blood Pressure presents the highest registration rates, and inversely Waist Circumference displays the highest no-registration rates.

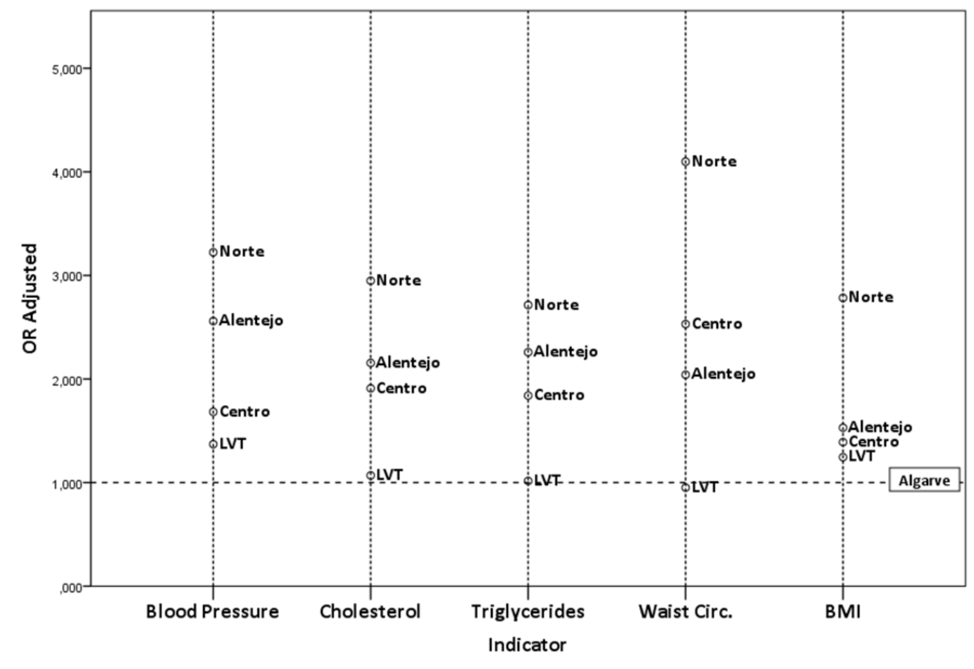
Adjusted logistic regression models show Norte with the strongest association with registration for all health indicators and significantly different from all other regions, excepting Alentejo for Blood Pressure and Triglycerides (Figure 1 and SOM Tables 2 and 3). Norte displays adjusted OR always above 2, being thus more than twice as likely to have values registered than Algarve (the reference region, usually with worse registration rates regarding the indicators under study). The minimum Norte OR of 2.7 for Triglycerides is always higher to the maximum OR of all other regions for all other indicators. Norte mostly differs from other regions regarding Waist Circumference registration.

Alentejo and Centro usually follow Norte as the most associated with registration and are only significantly different from each other for Blood Pressure, for which Alentejo draws up to Norte. Alentejo is usually always a little more associated with registration than Centro and is only overcome by Centro for Waist Circumference, although not enough to be statistically significant. Alentejo records OR over 2 for all indicators but BMI, which displays a lower value, whereas Centro only presents an OR over 2 for Waist Circumference.

LVT and Algarve are the regions less associated with registration, LVT presenting OR always below 2 for all indicators. LVT is only significantly different from Algarve for Blood Pressure, although with a small OR of 1.370 (Figure 1 and SOM Tables 2 and 3).

When comparing indicators over the various regions (Figure 1 and SOM Table 2), Waist Circumference performs better in Norte and Centro, while other indicators do not perform very differently over various regions. Nevertheless, Blood Pressure still tends to present higher OR and BMI often appears with worse performance than other indicators, namely in Centro and Alentejo.

Figure 1. Association between registration of each health indicator and health regions of residence - adjusted OR [1,2]



(1) After controlling for Sex, Age, Sex*Age (2) Algarve as Reference Category

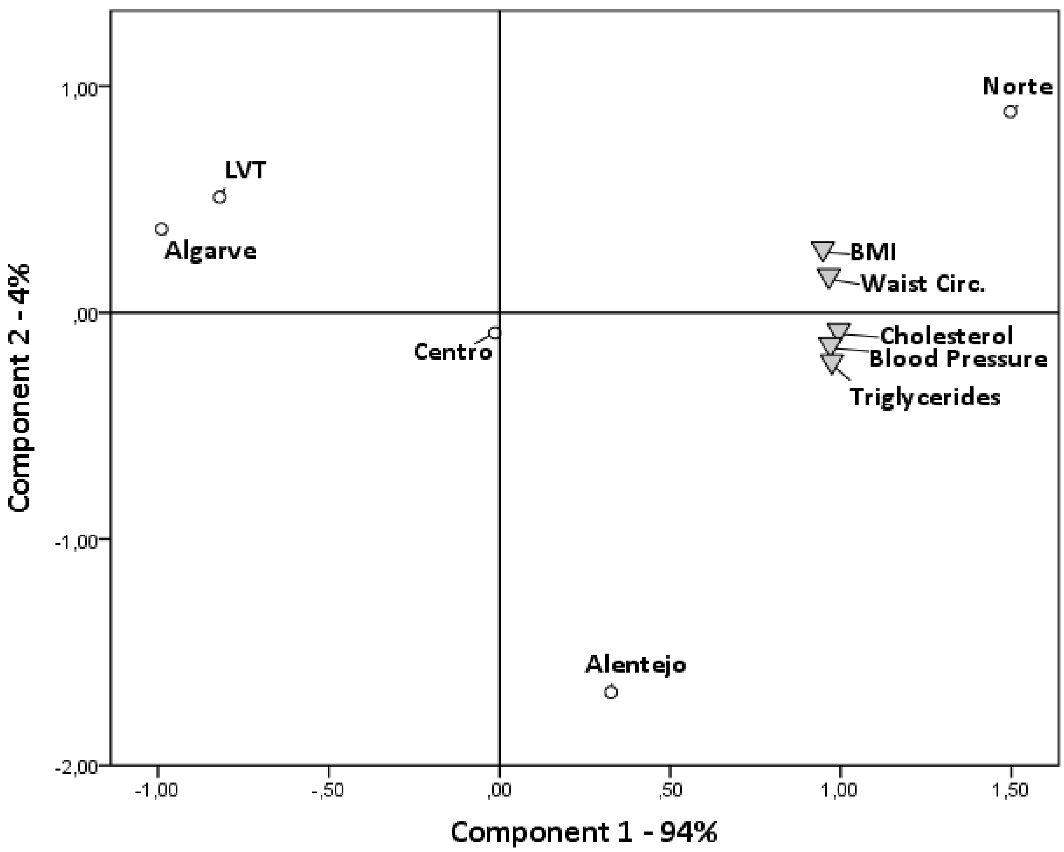
Within each region, patterns of registration for indicators may in reality not differ very much, since 95% Confidence Intervals (CI95%) overlap (SOM Tables 2 and 3 and Figure 7). Disparities become clearer when comparing CI95% for OR between regions. (SOM Figure 8). Thus CI95% related with every indicator for Norte and LVT never overlap, which means Norte is clearly very different both from LVT and Algarve. LVT presents the smallest CI95%

range for all indicators, which may be associated with a more uniform practice of registering information. Waist Circumference displays the highest CI95% range, which may be related to its higher percentages of no registration of information (percentages of no registration between 74% of Norte and more than 92% of LVT, against values always below 56% for Norte and below 78% for other regions).

Adjusted OR results (SOM Table 4) are then taken as input data for Principal Components Analysis which summarizes previous findings, again in a very visual way.

The first principal component responsible for almost all variability contained within data (94%) represents a size effect axis of registration of information, with all indicator variables placed in the far right of the factorial plan (Figure 2).

Figure 2. Principal Components Analysis Factorial Plans 1-2 based on Registered Indicators and Regions OR



Regions towards the right in the factorial plan will then be associated with higher rates of registered information regarding all these indicator variables. Inversely, regions towards the left in the factorial plan will be associated with lower rates of registered information concerning the indicator variables. One may hence rank regions from the most effective registering information, at the far right side of the factorial plan, to the least effective, at the left end side. Sequentially, one visually ranks Norte (unmistakably detached towards the right), Alentejo, Centro and then LVT and Algarve.

Stage 1 results clearly indicate there are indeed differences among regions concerning patterns of registration of health indicators under study, confirming the relevancy of proceeding with Stage 2.

Associating health indicator registration and mortality by region

Since a relevant association is found between recording information on health indicator policy and the equity aspect under study in stage 1, now with our second research aim in mind, we go onward to study associations between mortality and registration of the various health indicators within each region.

When taking the sample as a whole, the initial bivariate approach identifies statistically significant results associating outcome mortality as of December 31 2013 and having information registered at PC level for each of the indicators - Blood Pressure, Cholesterol, Triglycerides, Waist Circumference and BMI (SOM Tables 5 to 9). Deceased patients always present higher rates of no information registered: 53% of deceased patients do not have Blood Pressure recorded (versus 34% of patients alive at the end of follow-up), 84% BMI recorded (versus 63%), 91% Triglycerides recorded (versus 65%), 89% Cholesterol recorded (versus 65%) and 92% Waist Circumference recorded (versus 83%). Note that all patients studied, deceased or not, had several general practitioner appointments within the follow-up period and so have had an opportunity of having information recorded.

When considering each region separately, deceased patients also always present higher rates of no information registered for all health indicators (SOM Tables 5 to 9). For some regions and indicators, this pattern is not statistically significant since the observed information is not enough to identify differences, even if they exist, essentially because of small sample sizes for certain categories. In Norte, deceased patients always present a statistically significant higher percentage of no registration for all health indicators. In Centro and LVT the same happens, with the exception of Waist Circumference (SOM Table 8). In Alentejo, deceased patients present significantly higher percentages of no registration for Waist Circumference and BMI (SOM Tables 8 and 9, respectively). Finally, in Algarve deceased patients present a significantly higher percentage of no registration for Triglycerides (SOM Table 7).

When considering overall models without regional stratification, estimated OR with and without adjustments for age, sex and severity indicators seem quite similar (SOM Tables 10 to 14). Hence, these adjustment variables do not appear very relevant when studying overall associations between mortality and registration.

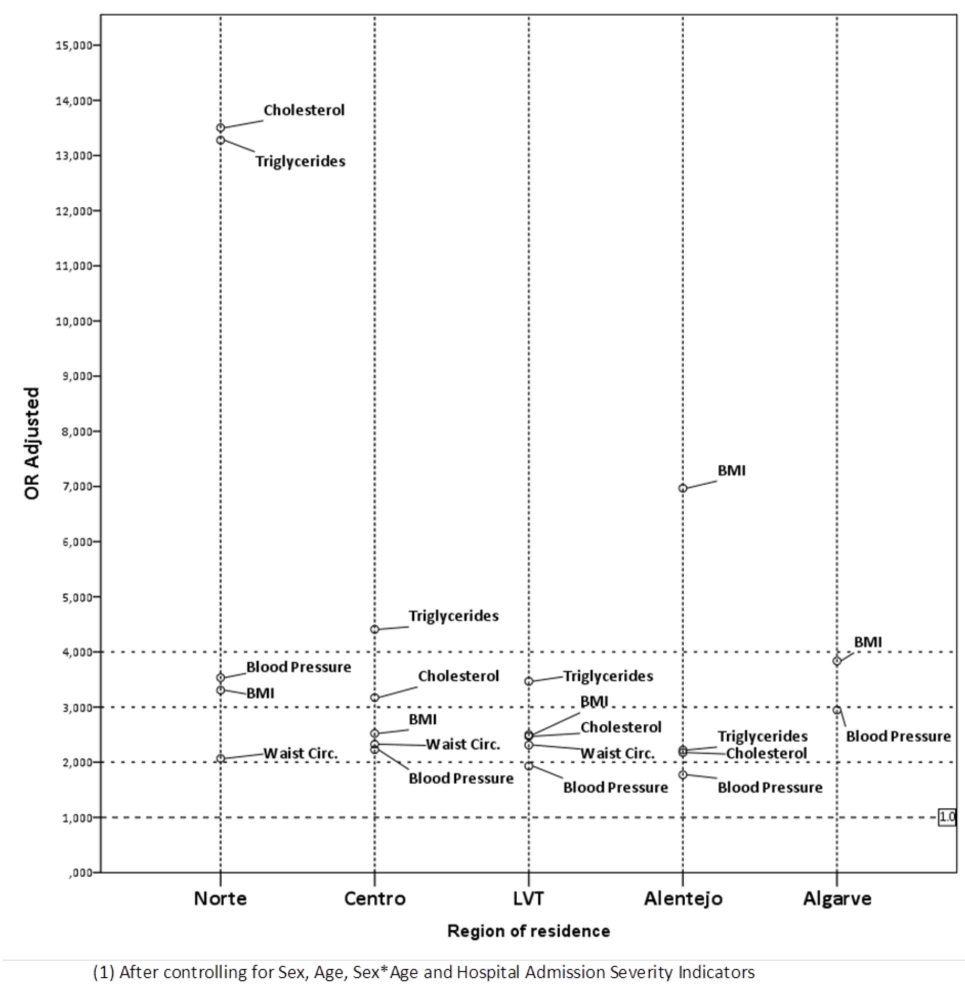
Additionally, all these OR obtained without regional stratification are statistically significant and always above a 2.00 threshold. That means that globally patients without registered information are at least twice as likely to be deceased than patients with information registered.

The lowest values of OR are generally observed for Blood Pressure (between 2.149 regarding the setup adjusted for Sex, Age and Sex*Age to 2.417 concerning the setup controlled for Sex, Age, Sex*Age, the 4 admission severity indicators and region – SOM Table 10). The highest values of OR are generally observed for Triglycerides (between 4.926 regarding the setup adjusted for Sex, Age and Sex*Age to 5.905 concerning the setup controlled only for Region – SOM Table 12). Limits of CI95% generally follow these trends of OR, with a minimum of 1.376 of the CI95% (observed in the setup regarding Waist Circumference controlled for Sex, Age and Sex*Age – SOM Table 13) and a maximum of 9.062 (detected in the setup associated with Triglycerides controlled for Region – SOM Table 12).

Stratified setups, however, display quite a few differences between regions and indicators, whether considering or not adjustments by age, sex, interaction age*sex and hospital severity indicators (SOM Tables 10 to 14), showing the importance of controlling for these aspects. Consequently, stratified adjusted setups will henceforth be the focus of our analysis.

All computed associations between mortality and no registration for all indicators are strong, the lowest OR being found for Blood Pressure in LVT and Alentejo (1.932 and 1.773, respectively) - (Figure 3). This means that, at its lowest, AMI patients with no Blood Pressure registered in Alentejo are about 1.8 times more likely to be deceased than patients with information registered.

Figure 3. Association between mortality and registration of each health indicator stratified by health region of residence - adjusted OR (1,2,3)



(1) After controlling for Sex, Age, Sex*Age and Hospital Admission Severity Indicators
(2) Stratified Models by Region
(3) Not Applicable for Waist Circumference in Alentejo and Algarve and for Triglycerides and Cholesterol in Algarve

Norte sets off as having the highest OR for Cholesterol and Triglycerides (both above 13). This means that patients without registered information for Cholesterol and Triglycerides in Norte are about over 13 times more likely to be deceased than patients with information registered. Norte also displays strong associations between mortality and no registration for Blood Pressure and BMI (OR between 3 and 4).

Alentejo stands out concerning BMI, with an OR near 7, followed by Triglycerides and Cholesterol with lower OR between 2 and 3.

Centro presents’ high OR values, especially regarding Triglycerides and Cholesterol (4.409 and 3.173, respectively), followed by BMI, Waist Circumference and Blood Pressure with lower OR between 2 and 3.

The highest association between mortality and no registration in LVT concerns Triglycerides (OR of 3.467). Most OR values in LVT are observed between 2.3 and 2.5, concerning BMI, Cholesterol and Waist Circumference.

Algarve only displays information for BMI and Blood Pressure at quite high levels of association (3.835 and 2.945, respectively).

As regards to the precision of the estimated OR, CI95% within each region always overlaps (SOM Tables 10 to 14 and SOM Figures 9 and 10), but there are certainly differences regarding regions, especially in what concerns the range of CI95%. Lack of information, due essentially to small sample sizes, observed in certain regions and indicators, does not always make possible computing reliable CI95% and in some cases creates asymmetries regarding the higher limit of intervals. Therefore, only the lower limit and its distance to the 1 threshold will be analyzed, especially in what concerns Algarve for Blood pressure and BMI, Alentejo for BMI and Norte for Cholesterol and Triglycerides. When comparing CI95% for OR within each indicator (SOM Figure 9), one may observe that lower limits for Norte are more distant from value 1 than all other regions for all indicators, with the exception of Waist circumference (lower limit of 1.076, while all others for Norte are above 1.9). Algarve has a much wider CI95% than other regions. For Cholesterol and Triglycerides it is Norte that stands out and for BMI Alentejo and Algarve. When comparing CI95% for OR within each region (SOM Figure 10), Norte presents quite narrow intervals, apart from the ones already mentioned for Cholesterol and Triglycerides. Alentejo presents a very wide CI95% for BMI, but quite narrow for the other indicators. Centro and LVT are quite stable in the precision of CI95% for all indicators, perhaps slightly wider for Triglycerides. Algarve has quite wide IC95% for Blood pressure and BMI, the only indicators with available OR in this region.

Finally, Multiple Correspondence Analysis (MCA) is used complementarily to help summarize findings, especially taking advantage of its rich visual graphical aids (Figure 4).

MCA identifies 2 main dimensions of variability within the data: a health indicator registration dimension and a demographic/hospital admission characterization dimension.

Dimension 1 represented on the horizontal axis of the factorial plan is a dimension of indicator registration. Categories towards the right in the plan are more related to no registration, while categories towards the left are more concerned with registration. In the registration quadrants of the plan, one also finds Norte, while in the non-registration quadrants, one finds Algarve and LVT. Alentejo and especially Centro position themselves within a neutral area, near the origin.

Dimension 2 represented in the vertical axis of the factorial plan concerns characteristics used as adjustment variables when calculating OR previously, namely Age, Sex and the 4 hospital admission severity indicators (having one or more hospital readmissions during the second semester of 2012, having undertaken surgery during hospital admission, having a mean admission duration over 6 days, having a hospital admission with 6 or more diagnosis associated). In the upper quadrants, one often finds patients that are female, older (more than 70 years old), longer admissions (more than 7 days), with no surgery during admission, and with more than 5 diagnoses. In the lower quadrants, one finds patients that are frequently male, younger (70 years or less), with 5 or fewer diagnoses, have undertaken surgery, with readmissions, and with shorter admissions (7 days or less).

The deceased outcome is displayed in the right upper quadrant, thus associated, on the one hand, with no registration of indicators and, on the other hand and understandably, with a more complex clinical condition and advanced age. The deceased outcome comes out as more associated with LVT and Algarve and less with Norte. Alentejo seems to lean slightly towards the deceased outcome, but more in what concerns the demographic and hospital admission severity characteristics and not regarding registration on a number of indicators (due to its location near the vertical axis origin).

Figure 4. Multiple Correspondence Analysis Factorial Plan 1-2

Consequently, there are indeed differences among regions in their association patterns regarding mortality and registration of the health indicators under study. The methodologies used lead us to different ways of visualizing information and grasping diversity in results.

Discussion

We will discuss implications of an EHR policy being applied unevenly throughout regions regarding data quality and the policy itself, links between EHR and quality of healthcare and EHR relevance for disease prevention, health promotion and sustainability. We will then debate on our research added value for HIA concerning AMI patients and visualization methods understandable by non-statisticians in a Big Data context. Finally, an HIA conceptual approach will be proposed to tackle equity, health impacts and policies in a quantified way, which may contribute to putting HIA at the center of future healthcare reforms.

Implications of Electronic Health Records policies applied unevenly throughout the regions

Differences in health information registration between regions observed at stage 1 of result section indicate an uneven regional application of EHR policies.

At PC level, there may exist various ways of recording patients' clinical information, from paper to alternative electronic platforms, depending on the institution. However, in Portugal, specific information is regularly uploaded onto a platform to calculate health contratualization indicators, in which performance of healthcare providers may be evaluated. Contratualization indicator performance and evolution over time represent much of the basis for contracts (re)negotiation, monitoring and evaluation between Health Regions Administrations and PC providers of NHS (Departamento de Gestão e Financiamento de Prestações de Saúde da ACSS 2013b; Departamento de Gestão e Financiamento de Prestações de Saúde da ACSS 2014).

Indicators selected for our research - Blood Pressure, Cholesterol, Triglycerides, Waist Circumference - are currently used to calculate some of these contractualization indicators (Departamento de Gestão e Financiamento de Prestações de Saúde da ACSS 2013a; Departamento de Gestão e Financiamento de Prestações de Saúde da ACSS 2015).

For instance, the proportion of hypertensive patients with cardiovascular risk within 3 years, representing patients' cardiovascular risk, is accessed through SCORE (Systematic Coronary Risk Evaluation) methodology, according to the General Directorate of Health guidelines under the National Health Plan of Cerebro-cardiovascular Disease (Departamento da Qualidade na Saúde da Direção-Geral da Saúde 2013). European Guidelines on Cardiovascular Disease Prevention include among parameters to access SCORE cardiovascular level all health indicators under analysis here - blood pressure, BMI, waist circumference, cholesterol level, triglycerides level (Perk et al. 2012; Piepoli et al. 2016).

These five chosen health indicators are essential to access cardiovascular risk and represent a direct incentive to PC providers to assure information is recorded. One would hence expect that this information on which healthcare providers depend to be financed would display the highest registration performance amongst all recorded clinical information. The missing information problem identified throughout our research amongst these indicators may hence constitute an even worse issue regarding other kinds of data, eventually also relevant to access patients' health and monitoring.

Since a lack of records regarding patients with AMI diagnosis followed at PC seems first to concern all regions, a stronger implementation of EHR policy guidelines may be needed nationwide.

Additionally, since there are also regions where this lack of records is even more blatant, like Algarve or LVT, EHR policy guidelines and the way they are put into practice may need to be segmented and adapted to each region's specificities.

But may regional disparities regarding EHR truly correspond to regional equity issues? What is known regarding links between EHR and quality of healthcare?

Links between Electronic Health Records and quality of healthcare

The existence of national electronic health records (EHR) at primary and hospital care levels is often indicated as a benefit for PC practice and as a quality of care indicator (Majeed, Car, and Sheikh 2008). Differences in health information registration between regions may thus indicate disparities on the quality of care supplied, and hence regional inequity issues to be improved upon.

Regional disparities regarding relevant associations between registration of various health indicators and mortality outcome found in results section may be mitigated with an effort to uniformly apply an EHR policy throughout hospital and primary care.

But although EHR are used as a quality of care indicator, this does not immediately imply that EHR will directly contribute to a better healthcare provision. Both aspects may indeed be correlated without having a direct cause-effect. Healthcare providers that have efficiency management concerns and are more recent and technologically advanced may have both EHR with more quality and better performance in supplying healthcare (Tanner et al. 2015).

Nevertheless, the existence and analysis of EHR may also directly contribute to better health at patient care level, helping clinicians collect and access information to improve their service (Burke et al. 2015).

For instance, a patient with many records registered may not necessarily have a better follow-up by PC healthcare, but many different records may imply many contacts with the PC healthcare network. This may in turn increase opportunities to identify problems, thus enhancing odds for “better health”, promoting health and preventing disease. A consistent EHR policy throughout health regions may thus support an even implementation of programs such as NHS Health Checks introduced in England in 2010 to prevent heart disease, stroke, kidney disease and diabetes. It may also help evaluate these programs regarding increasing cardiovascular risk factor detection, reducing inequalities and monitoring trends of better detection of hypercholesterolaemia, and, although to a lesser extent, obesity and hypertension (Forster et al. 2015).

Electronic Health Records for disease prevention, health promotion and sustainability

The existence of EHR that include or are linked to information on social health determinants becomes especially pertinent when considering the WHO Health 2020 framework (WHO Regional Office for Europe 2013) to promote sustainable and equitable improvements in health. Good health is no longer seen as an outcome of just one sector, the health sector, but as "the product of effective policy across all parts of government and collaborative efforts across all parts of society". Good health is also acknowledged as essential for the improvement of the lives of single individuals, families, communities, ultimately as a benefit for all sectors and the whole of society.

Assuring quality of EHR is moreover essential to empowering patients and citizens and thus improving health outcomes, health system performance and patient satisfaction by promoting and facilitating freedom of choice of PC units for NHS users (Mendes Ribeiro 2009; Mendes Ribeiro et al. 2011; Mendes Ribeiro et al. 2015; OECD - Organisation for Economic Co-operation and Development 2017).

Guarantying the quality of EHR and their link to information on the social determinants of health in a context of HIA is furthermore essential to answering a core question for policy-makers: to what extent do investments in preventive actions addressing social determinants of health represent an efficient choice to help promote and protect the health of the population?

Evidence base from controlled trials and well-designed observational studies demonstrates the cost-effectiveness of a wide range of interventions concerning health promotion and disease prevention that address risk factors to health: measures to reduce "risks of smoking and alcohol consumption, increase physical activity, promote more healthy diets, protect psychological and emotional well-being, reduce environmental harms and make road environments safer" (Merkur, Sassi, and McDaid 2013). Quality data aid the evaluation of policies and actions taken, identifying those that are more cost-effective (such as taxes to influence individual choices of tobacco, alcohol and food consumption) and the ones less so (like media campaigns). However, there is still little data on the impact of interventions on health inequities, on appraising if a public health intervention has a higher or lower effect on certain groups in society inadvertently widening avoidable health inequalities. Methodologies used in our research could help deal with equity in this broader context.

Having data available, adopting and using EHR in a widespread manner and being able to study bigger cohorts through time linking data from various sources is most important to promoting equity, cost-effectiveness (Asaria et al. 2016; Asaria, Grasic, and Walker 2016; Beresniak et al. 2016) and identifying determinants of where to act (Fehr et al. 2014), improving clinical care, preventing disease and promoting health (Hansell and Aylin 2003; Mendes Ribeiro et al. 2015; OECD - Organisation for Economic Co-operation and Development 2017). This is especially pertinent considering the evolution of the burden of chronic non-communicable disease such as cerebrocardiovascular disease.

Electronic Health Records and Acute Myocardial Infarction

Cardiovascular disease (CVD) remains a leading cause of morbidity and mortality in Europe, causing over 1.9 million deaths in the European Union (EU), amounting to 40% of all deaths in the EU. Overall CVD is estimated to cost the EU economy almost €196 billion a year, 54% being due to health care costs, 24% to productivity losses and 22% to the informal care of people with CVD (Nichols et al. 2012).

In spite of some improvements in outcomes in CVD rates in many countries in Europe since the early 1980s, owing to preventive measures, especially regarding tobacco and smoking legislation, inequalities between countries persevere and many risk factors have even been accentuated, particularly obesity and diabetes mellitus (Piepoli et al. 2016).

The OECD estimates AMI-standardized death rates in 2012 for Portugal of 47.4 and 34.4 per 100,000 male and female inhabitants, respectively (OECD - Organisation for Economic Co-operation and Development 2016). Values remain similar between 2013 and 2014 with 47.3 and 34.2 per 100,000 male and female inhabitants, respectively. However, this represents a considerable decrease from 2008 rates of 59.8 and 43.0 per 100,000 male and female inhabitants, respectively.

Information regarding AMI in Portugal indicates gender and age differences as well as regional differences regarding hospital admissions - number of admissions, deaths in the hospital, length of stay, etc. (Cruz Ferreira et al. 2016). However, no multivariate adjusted methods were applied here, and published tables are quite numerically dense, which impairs the perceiving of potential regional equities.

Our approach to use linked data at the patient level to generate multivariate results, controlled for sex, age and severity hospital admission indicators constitutes an important evidence-base for decision-makers to perceive regional disparities and associations to mortality and EHR policies at PC level.

Observed different regional magnitudes of associations between AMI mortality and registration of distinct indicators may be related to diverse patterns of relevance regarding preventive and risk factors. To study reasons behind these disparities may constitute significant clues for the HIA to undertake, identifying distinct relevant regional lifestyles, other policies that interact with these, and so on. Being able to link additional information at the patient level (clinical, on social health determinants and policies) may thus be decisive towards increasing knowledge regarding equity issues for HIA. This becomes even more relevant when addressing chronic non-communicable diseases for which promotion and prevention policies are increasingly critical. Quality-linked databases monitored regularly at the patient level are essential to designing, implementing and monitoring health and equity effects of public policies. To assess impacts of health promotion and chronic non-communicable disease prevention policies, Big Data will have to be tackled within a quantified HIA framework.

Challenges of Big Data and complexity in methods but simplicity in visualization

EHR may improve health at a secondary level, especially when clinical data is linked with additional information regarding health and social health determinants, allowing for epidemiological and clinical research and health assessment of populations (Biro et al. 2016). Yet, this cannot be achieved without high-quality data and an adequate underlying digital infrastructure (Barkhuysen et al. 2014; Lau et al. 2012; Majeed, Car, and Sheikh 2008).

The use of EHR, the higher capacity of storing and processing data and the need to assure that actions and policies are sustainable, cost-effective, maximizing positive health impacts, minimizing negative ones and equity oriented, all have led to growing amounts of data at our disposal, generated at an ever-increasing and faster rate. Big Data in a health environment (that actually goes beyond the health sector per se, through social health determinants and other sectors) is an unavoidable reality, as well as challenges of tackling information and finding new ways (or rediscovering and adapting old ones) of processing, analyzing and communicating reliable evidence-based knowledge understandable by decision-makers. The new interdisciplinary field of Data Science has emerged, feeding on statistics, data mining and predictive analytics and whose activity ultimately culminates in data visualization (Donoho 2015).

Both complementary visualization approaches used in each of the result stages are based on multivariate methodologies, more usual in a data mining context than in an HIA epidemiological research. OR were first calculated to study adjusted associations between registering or not registering indicators and the region of residence and then between registering or not registering indicators and mortality while accounting for regional equity. The use of factorial methods such as PCA and MCA complements this approach again in a very visual manner.

The way these distinct methodologies complement themselves in the result analysis and visualization represent an added value for understanding results, especially for non-statisticians. Using complex and multivariate statistical methods but obtaining a clear and quite simple way of grasping results allows for a swift but more evidence-based decision-making process.

Conceptual Path associating Policy and Health allowing for Equity

Our third research aim was to propose a conceptual quantitative path of analysis to study the association between policy and health impacts while taking equity into account.

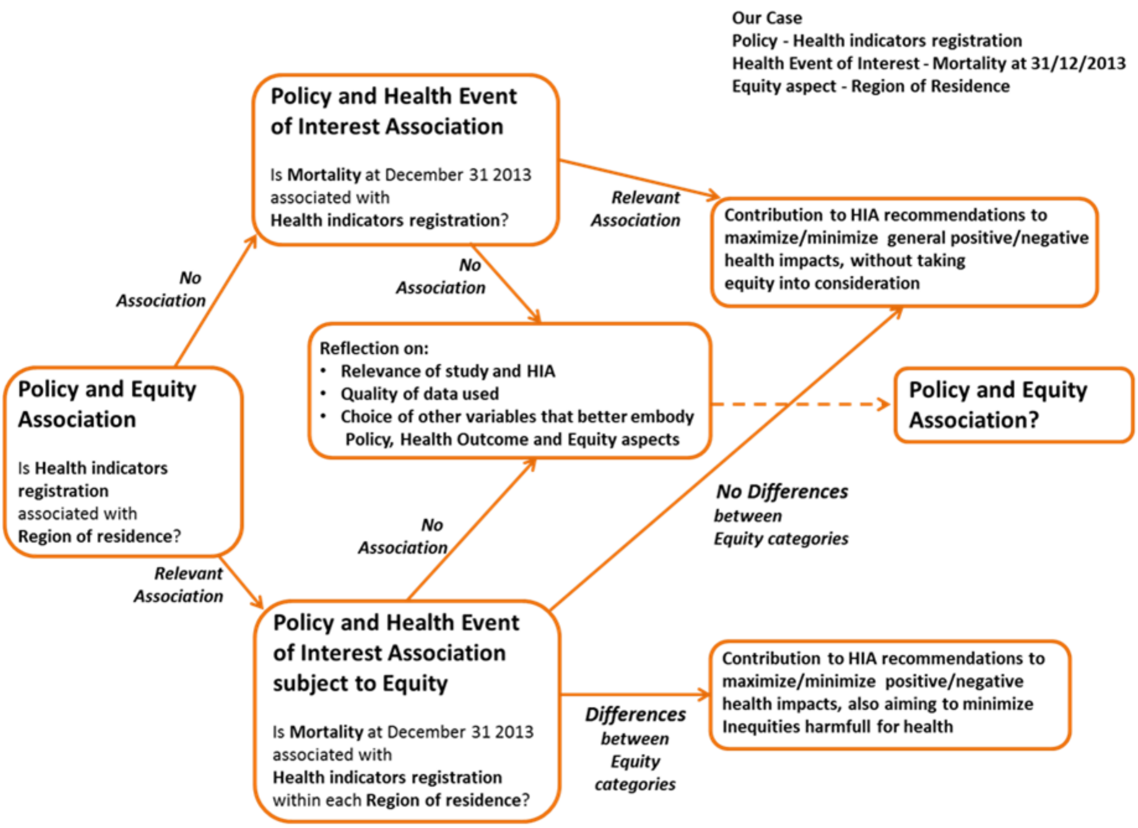
Illustrated by the case study presented in the results section, the proposed path starts by analyzing associations between the policy and the chosen equity issue (Figure 5 and SOM Figure 11).

If no association is found between the policy and the equity aspect under study, then we could go on analyzing the association between policy and the health event of interest globally without great concerns regarding these equity issues in particular. We should yet reflect on the usefulness of undertaking an HIA, which has at its core equity concerns. Additionally, we should ponder on data selected and its quality since there could indeed exist alternative or complementary information, which better embodies the spirit of the policy, health outcomes and equity aspects under study.

If a relevant association between policy and the health event of interest is found, then the association between policy and the health event of interest should be studied subject to equity aspects.

Then, if an association between the policy and the health event of interest is identified with differences among equity categories, then a contribution to HIA recommendations is potentially valuable to maximize positive health impacts and minimize negative ones while curtailing harmful inequities.

Figure 5. Putting concept into practice



IAPA states that “HIA investigate the pathways of how the inter-related determinants may be affected by a proposed policy” (Quigley et al. 2006). Following our recommended pathway, quantifying HIA using the added-value of big data and data science visualization tools may contribute to a more comprehensive way for decision-makers to understand HIA results and even to a wider HIA practice.

HIA and the Future of Health Reforms

The “Next Generation of Health Reforms” Statement was approved by OECD (Organization for Economic Co-operation and Development) health ministers on January 2017 (OECD - Organisation for Economic Co-operation and Development 2017). This new vision for the future includes reducing health inequalities in access to care and health outcomes, adapting health systems to new technologies and innovation and reorienting health systems to become more people-centered. All these challenges may be undertaken with a strong support from an HIA approach.

The equity-oriented HIA methodologies may contribute to tackling barriers to the health literacy of the population, minimizing disparities in the ever-increasing access of patients to growing amounts of information, empowering them in the decision about their treatment.

Our HIA approach may also strongly contribute to evaluating and improving health systems and their benchmarking performance, shifting their center from providers to people’s individual needs and preferences, understanding the impact of policy reform by moving from data only related to health activities, inputs and costs to information about how people lead their lives (such as indicators of comfort and quality of life, ability to function and live independently, social and economic determinants of health, as well as environmental risk factors).

The OECD states the need to further invest in delivery models that focus on primary care and its coordination with other services to assure health promotion and prevention of disease. This also represents an opportunity for our HIA-quantified approach and its practice of analyzing interrelations between policies, health determinants and outcomes.

Finally, the strong participatory experience from HIA may furthermore help “constructive dialogue across governments, with industry, and with other key stakeholders including patients, providers, payers and academics” (OECD - Organisation for Economic Co-operation and Development 2017). The importance of guaranteeing that all stakeholders participate in the decision-making process, especially communities affected by policies under scrutiny, has been recognized to make the decision process more open, optimize final decisions and improve the decision-making process itself (Kemm 2013).

The HIA approach is thus in an especially good position to contribute to health policy future reforms and “to inform and influence decision making on proposals and plans, so health protection and promotion are effectively integrated into them” (Quigley et al. 2006).

Limitations and future paths for research

Limitations in our research simultaneously represent future research opportunities. Some limitations regard data used in our case study, which may be tackled and enrich future research by:

- Taking a broader number of patients, for example, patients admitted during a longer period of time for different diagnosis;
- Considering hospital readmissions during follow-up for other diagnoses and not only for the ones of the first admission;
- Linking hospital data with more information such as PC data after but also before hospital admission, prescribed medication, social health determinants, health services characteristics and costs. This is coherent with WHO Health 2020 holistic approach and also allows deepening complementarities between HIA and Health Technology Assessment;
- Testing our pathway by analyzing other policies and public actions, within or outside the health sector.

Another potential limitation regards the fact that our proposed pathway studies the association between a public policy and its health impacts while taking into account an equity aspect and not the impact itself. The existence of an association may indeed not infer a causal effect. A future challenge is to develop more complex models to link longitudinally most relevant aspects in a patients' life, effects of policies over health impacts and equity in a big data context and ideally approximately in real time. Modeling past and current data over time to better predict the health effects in the future may additionally consider identifying population risk profiles, increasing awareness regarding unexpected equity issues and supplying HIA recommendations differentiated by profiles. This may contribute to the need to "review our own IA strategies, approaches and practices and to adapt them to a changing environment, so that we are able to meet new challenges" (Fischer 2017).

A more relevant limitation regards our goal to show how the use of the visualization output strengths of these methodologies (such as OR graphic representations or MCA factorial plans) may represent an added value for decision-makers, perhaps making it easier for them to comprehend results, more so than other statistical methodologies' outputs. Although summarizing results in a factorial plan may indeed be useful as a representation of results obtained, and informally certain decision-makers may think it is easier for their understanding of outcomes, only a deeper study would demonstrate the higher effectiveness in apprehending conclusions. A survey to a sample of decision makers from multiple sectors but with a strong emphasis on the health sector based on specific tested instruments could contribute to this effect.

Lastly, our proposed pathway suffers potential limitations from being a quantitative HIA approach: chiefly that not everything that should be taken into account in HIA is quantifiable (Fehr et al. 2012; Fehr et al. 2016; Mindell et al. 2001). Qualitative HIA approaches should generally complement quantitative ones. Nevertheless, some qualitative aspects may now also increasingly be incorporated into quantified models, with the help, for instance, of other data mining methodologies such as text mining (Lebart and Salem 1994).

These methodologies here used, originating in Data Mining and Data Science fields, may also be potentially powerful tools to use beyond HIA, to integrate health and equity into other Impact Assessments (IA), such as Environmental Impact Assessment or Strategic

Environmental Assessment (Fehr et al. 2014) whenever Big Data from various sources and natures are to be tackled and insights are to be generated from interrelations and complex multivariate contexts.

Conclusions

When targeting for HIA and EHR policy at PC level regarding AMI patients, it is crucial to assure an adequate application of guidelines throughout all health regions to minimize regional health inequities. Lessons could be learned from regions with lower disparities so that actions are to be taken in regions with worse performance.

Regional disparities in the application of an EHR policy targeted for HIA, but also for their association with Mortality, may be identified and visualized in a comprehensible way for non-statisticians. Evidence-based, quantified, multivariate knowledge in an HIA context (or even other IA whenever health is an issue) may thus improve decision makers' understanding of the importance of taking equity into consideration when assessing the health impacts of policies they should take a stand on.

The proposed path of analysis to study the association between a public policy and related health impacts while taking equity into account may be put into practice whenever data are available regarding the most relevant variables in its particular context. This means that this pathway may be helpful to put HIA at the center of future health reforms, linking data focused on individuals' hospital and primary healthcare usage patterns but also healthy lifestyles and environmental information.

References

Asaria, M., K. Grasic and S. Walker. 2016. "Using Linked Electronic Health Records to Estimate Healthcare Costs: Key Challenges and Opportunities." *Pharmacoeconomics* 34 (2): 155-160.

Asaria, M., S. Walker, S. Palmer, C.P. Gale, A.D. Shah, K.R. Abrams, M. Crowther, A. Manca, A. Timmis, H. Hemingway and M. Sculpher. 2016. "Using electronic health records to predict costs and outcomes in stable coronary artery disease." *Heart* 102 (10): 755-762.

Bacelar-Nicolau, L., J. Pereira Miguel and G. Saporta. 2008. "The Added Value of Multivariate Statistical Data Analysis in Policy HIA – A Quantitative Way of Profiling Subjects." *In HIA08 Health Impact Assessment and Sustainable Well-being - 9th Conference on Health Impact Assessment, 9-10 October 2008*, Liverpool, UK:

Bacelar-Nicolau, L., J. Pereira Miguel and G. Saporta. 2015a. "Screening Policies for Health Impact Assessment: Cluster analysis for easier decision making." *European Journal of Public Health* 25 (Supplement 3): 133-134.

Bacelar-Nicolau, L., J. Pereira Miguel and G. Saporta. 2015b. "Screening Policies in Health Impact Assessment: Easier decision making through cluster analysis." *European Journal of Epidemiology* 30 (2 (suppl.)): 852.

Barkhuysen, P., W. de Grauw, R. Akkermans, J. Donkers, H. Schers and M. Biermans. 2014. "Is the quality of data in an electronic medical record sufficient for assessing the quality of primary care?" *Journal of the American Medical Informatics Association* 21 (4): 692-698.

Beresniak, A., A. Schmidt, J. Proeve, E. Bolanos, N. Patel, N. Ammour, M. Sundgren, M. Ericson, T. Karakoyun, P. Coorevits, D. Kalra, M.G. De and D. Dupont. 2016. "Cost–benefit assessment of using electronic health records data for clinical research versus current practices: Contribution of the Electronic Health Records for Clinical Research (EHR4CR) European Project." *Contemp.Clin.Trials* 46: 85-91.

Biro, S., T. Williamson, J.A. Legget, D. Barber, R. Morkem, K. Moore, P. Belanger, B. Mosley and I. Janssen. 2016. "Utility of linking primary care electronic medical records with Canadian census data to study the determinants of chronic disease: An example based on socioeconomic status and obesity." *BMC Medical Informatics and Decision Making* 16 (32).

Brodin, H. and S. Hodge. 2008. A guide to Quantitative Methods in Health Impact Assessment Stockholm, Sweden: STATENS FOLKHÄLSOINSTITUT, Östersund / Swedish National Institute of Public Health.

Burke, H.B., L.L. Sessums, A. Hoang, D.A. Becher, P. Fontelo, F. Liu, M. Stephens, L.N. Angaro, P.G. 'Malley, N.S. Baxi, C.W. Bunt, V.F. Capaldi, J.M. Chen, B.A. Cooper, D.A. Djuric, J.A. Hodge, S. Kane, C. Magee, Z.R. Makary, R.M. Mallory, T. Miller, A. Saperstein, J. Servey and R.W. Gimbel. 2015. "Electronic health records improve clinical note quality." *Journal of the American Medical Informatics Association* 22 (1): 199-205.

Cruz Ferreira, R., R. César das Neves, P. Nogueira, C. Farinha, A.L. Oliveira, A. Soares, M.I. Alves, J. Martins, T. Mendana, M. Valente Rosa, C. Silva and L. Serra. 2016. Portugal - Doenças Cérebro-Cardiovasculares em números - 2015 Ministério da Saúde do Governo de Portugal.

Daniel, W.W. 2009. Biostatistics – A Foundation for Analysis in the Health Sciences, 9th ed. John Wiley & Sons.

Departamento da Qualidade na Saúde da Direção-Geral da Saúde. 2013. Norma DGS nº5/2013 actualizada a 21/01/2015. 5 ed.

Departamento de Gestão e Financiamento de Prestações de Saúde da ACSS. 2013a. Bilhete de Identidade dos Indicadores de Monitorização dos Cuidados de Saúde Primários 2013 ACSS-Administração Central do Sistema de Saúde do Ministérios da Saúde de Portugal.

Departamento de Gestão e Financiamento de Prestações de Saúde da ACSS. 2013b. Metodologia de Contratualização para os Cuidados de Saúde Primários no Ano de 2013 ACSS-Administração Central do Sistema de Saúde do Ministérios da Saúde de Portugal.

Departamento de Gestão e Financiamento de Prestações de Saúde da ACSS. 2014. Metodologia de Contratualização para os Cuidados de Saúde Primários no Ano de 2015 ACSS-Administração Central do Sistema de Saúde do Ministérios da Saúde de Portugal.

Departamento de Gestão e Financiamento de Prestações de Saúde da ACSS. 2015. Bilhete de Identidade dos Indicadores de Contratualização com as Unidades de Cuidados na Comunidade para o Ano de 2015 ACSS-Administração Central do Sistema de Saúde do Ministérios da Saúde de Portugal.

Donoho, D. 2015. "50 years of Data Science." *In John W. Tukey 100th Birthday Celebration at Princeton University*, pp. 1-41. Princeton, New Jersey, USA.

European Centre for Health Policy. 1999. Health Impact Assessment – main concepts and suggested approach. Gothenburg Consensus Paper. Göteborg, Sweden: ECHP World Health Organization Regional Office for Europe.

Fehr, R., F. Viliani, J. Nowacki and M. Martuzzi (Eds.). 2014. Health in Impact Assessments: Opportunities not to be missed. Copenhagen: WHO Regional Office for Europe.

Fehr, R., F. Hurley, O.C. Mekel and J.P. Mackenbach. 2012. "Quantitative health impact assessment: Taking stock and moving forward." *Journal of Epidemiology and Community Health* 66 (12): 1088.

Fehr, R., O.C.L. Mekel, J. Fintan Hurley and J.P. Mackenbach. 2016. "Health impact assessment – A survey on quantifying tools." *Environmental Impact Assessment Review* 57: 178-186.

Fischer, T. 2017. "Foreword to the first issue of 2017." *Impact Assessment and Project Appraisal* 35 (1): 1.

Forster, A.S., C. Burgess, H. Dodhia, F. Fuller, J. Miller, L. McDermott and M.C. Gulliford. 2015. "Do health checks improve risk factor detection in primary care? Matched cohort study using electronic health records." *J.Public Health (Oxf)*.

Glover, D. and J. Henderson. 2010. Quantifying health impacts of governement policies Department of Health of the UK Government.

Haigh, F., E. Harris, B. Harris-Roxas, F. Baum, A.L. Dannenberg, M.F. Harris, H. Keleher, L. Kemp, R. Morgan, H.N. Chok and J. Spickett. 2015. "What makes health impact assessments successful? Factors contributing to effectiveness in Australia and New Zealand." *Bmc Public Health* 15 (1009): 1-12.

Hair, J.F., B. Black, B. Babin, R.E. Anderson and R.L. Tatham. 2006. Multivariate Data Analysis, 6th ed. Prentice Hall.

Hansell, A. and P. Aylin. 2003. "Use of health data in health impact assessment." *Impact Assessment and Project Appraisal* 21 (1): 57-64.

Harris-Roxas, B., F. Haigh, J. Travaglia and L. Kemp. 2014. "Evaluating the impact of equity focused health impact assessment on health service planning: Three case studies." *BMC.Health Serv.Res.* 14: 371.

Harris-Roxas, B., F. Viliani, A. Bond, B. Cave, M.J. Divall, P. Furu, P. Harris, M. Soeberg, A. Wernham and M. Winkler. 2012. "Health impact assessment: The state of the art." *Impact Assessment and Project Appraisal* 30 (1): 43-52.

Kemm, J. (Ed.). 2013. Health Impact Assessment: Past Achievements, Current Understanding and Future Progress. Oxford University Press.

Kleinbaum, D.G. and M. Klein. 2010. Logistic Regression - A Self-learning Text, Third Edition ed. Springer.

Lau, F., M. Price, J. Boyd, C. Partridge, H. Bell and R. Raworth. 2012. "Impact of electronic medical record on physician practice in office settings: A systematic review." *BMC Medical Informatics and Decision Making* 12: 1-10.

Lebart, L. and A. Salem. 1994. Statistique Textuelle Dunod.

Majeed, A., J. Car and A. Sheikh. 2008. "Accuracy and completeness of electronic patient records in primary care." *Family Practice* 25 (4): 213-214.

Mendes Ribeiro, J. 2009. Saúde - A Liberdade de Escolher Gradiva Publicações SA.

Mendes Ribeiro, J., A.X.D. Barreto, J.A.V. Varanda, J.M.V. Penedo, J.C.F. Caiado, J.M. Nunes, N.S. Santos, P.A.F. Boto, R.S. Ivo and T.A.C. Santos. 2011. Relatório Final do Grupo Técnico para a Reforma Hospitalar - Os Cidadãos no centro do Sistema, os Profissionais no centro da mudança Ministério da Saúde do Governo de Portugal.

Mendes Ribeiro, J., R. Silva, P. Caetano, J. Picoto, P. Nogueira, S. Sequeira, G. Ferreira, A. Ferreira and C. Nunes. 2015. Relatório Final do Grupo Técnico para a Informação no Sistema de Saúde: Iniciativa para a Informação Centrada no Utente do Sistema de Saúde. Lisboa: Ministério da Saúde do Governo de Portugal.

Merkur, S., F. Sassi and D. McDaid. 2013. Promoting health, preventing disease: Is there an economic case? WHO Regional Office for Europe and European Observatory on Health Systems and Policies.

Mindell, J., A. Hansell, D. Morrison, M. Douglas and M. Joffe. 2001. "What do we need for robust, quantitative health impact assessment?" *Journal of Public Health Medicine* 23 (3): 173-178.

Nichols, M., N. Townsend, R. Luengo-Fernandez, J. Leal, A. Gray, P. Scarborough and M. Rayner. 2012. European Cardiovascular Disease Statistics 2012, European Heart Network ed. Brussels: European Society of Cardiology.

OECD - Organisation for Economic Co-operation and Development. 2016. "Database access in the OECD website" [accessed on August 25, 2016].

OECD - Organisation for Economic Co-operation and Development. 2017. Ministerial Statement: The next generation of health reforms.

Perk, J., G. De Backer, H. Gohlke, I. Graham, Z. Reiner, W.M.M. Verschuren, C. Albus, P. Benlian, G. Boysen, R. Cifkova, C. Deaton, S. Ebrahim, M. Fisher, G. Germano, R. Hobbs, A. Hoes, S. Karadeniz, A. Mezzani, E. Prescott, L. Ryden, M. Scherer, M. Syvanne, W.J.M.S. Reimer, C. Vrints, D. Wood, J.L. Zamorano and F. Zannad. 2012. "European Guidelines on cardiovascular disease prevention in clinical practice (version 2012): The Fifth Joint Task Force of the European Society of Cardiology and Other Societies on Cardiovascular Disease Prevention in Clinical Practice." *European Heart Journal* 33: 1635-1701.

Piepoli, M.F., A. Hoes, S. Agewall, C. Albus, C. Brotons, A.L. Catapano, M. Cooney, U. Corra, B. Cosyns, C. Deaton, I. Graham, M.S. Hall, R. Hobbs, ML. Lochen, H. Lollgen, P. Marques-Vidal, J. Perk, E. Prescott, J. Redon, D.J. Richter, N. Sattar, Y. Smulders, M. Tiberi, H.B. Van der Worp, I. van Dis and W.M.M. Verschuren. 2016. "2016 European Guidelines on cardiovascular disease prevention in clinical practice: The Sixth Joint Task Force of the European Society of Cardiology and Other Societies on Cardiovascular Disease Prevention in Clinical Practice." *European Heart Journal*.

Quigley, R. et al. 2006. Health Impact Assessment International Best Practice Principles. Fargo, USA, IAIA-International Association for Impact Assessment.

Saporta, G. 2011. Probabilités, Analyse des Données et Statistique, 3e édition ed. Éditions Technip.

Tanner, C., D. Gans, J. White, R. Nath and J. Pohl. 2015. "Electronic health records and patient safety: Co-occurrence of early EHR implementation with patient safety practices in primary care settings." *Appl.Clin.Inform.* 6 (1): 136-147.

Veerman, J.L., J.J. Barendregt and J.P. Mackenbach. 2005. "Quantitative health impact assessment: Current practice and future directions." *Journal of Epidemiology and Community Health* 59 (5): 361-370.

WHO Regional Office for Europe. 2013. Health 2020: A European Policy Framework and Strategy for the 21st Century World Health Organization.

World Health Organization. 13-8-2015. "Examples of HIA" [accessed on August 12, 2015]. Available at: http://www.who.int/hia/examples/en/

Chapter 5 – Discussion, Conclusions and Future Perspectives

CONTENTS

Chapter 5 – Discussion, Conclusions and Future Perspectives

"It is a capital mistake to theorize before one has data." Sherlock Holmes/ Arthur Conan Doyle
"Data allow your political judgments to be based on fact, to the extent that numbers describe realities." Hans Rosling
"Sit down before a fact as a little child, be prepared to give up every preconceived notion. Follow humbly wherever and to whatever abysses nature leads, or you shall learn nothing." Thomas H. Huxley
"In life, unlike chess, the game continues after checkmate." Isaac Asimov

1. Discussion

1.1. Adding Value to HIA steps

The importance of quantification within HIA was recognized very early in HIA history [1,2]. The advantages identified include being potentially more informative and influential with decision-makers, complementing qualitative analyses to achieve more robust, evidence-based and whole estimations of health impacts and taking better into account than qualitative HIA the magnitude of health impacts, while still considering its nature, direction and distribution. Nevertheless, HIA is still regularly being used more often with a qualitative emphasis [1].

More quantitative approaches have been essentially limited to the project appraisal steps of HIA and more recently when evaluating HIA effectiveness [3-5]. Our research shows how it may be possible to include quantification throughout other HIA steps.

Profiling individuals [6] may thus be informative when characterizing populations targeted for HIA. Profiling papers and guides (chapter 2) is useful to search bibliography both during the initials screening and scoping steps of HIA, helping to set a base line context where the policy will act upon and identifying main health impacts and target subpopulations to study in more detail.

Clustering hospital reform policies and national programs enrich the screening step of HIA (chapter 3 and [7,8]), by helping to rank and prioritize potential policies and projects targeted for HIA. Our research shows also how this approach may be adapted to diverse contexts and changing different priority criteria.

In what concerns the project appraisal step, quantified HIA are usually either based on health economic evaluation [9,10] or risk assessment and epidemiology modelling [1,11]. Although nearer the later approach in Chapter 4, our research goes beyond it by applying multivariate statistical methodologies more in line with data science and data mining methodologies, that may also include in the future health economic evaluation features, integrating both currently done HIA quantification approaches.

The main necessary improvements regarding quantitative HIA have recently been identified regarding two aspects: its application in various real-life contexts and especially in “whether and how they estimate impacts on health inequalities” [11,12]. Our research tackles both these limitations, contributing to the future evolution of the HIA field, as it may also be seen in more detail in the following sub-sections: our approach in chapter 4 takes real data at national level and offers a path of analysis to deal with equity at the project appraisal step.

1.2. Tackling Big Data

It has been recognized that one of the main reasons that quantification within HIA is rarely done, is that it “is often hard or impossible” because of a lack of information regarding initial conditions, effects of the proposal, and the theoretical framework linking conditions to health outcomes” [1]. A major difficulty is thus to find available and reliable data to model interrelations, explicitly between health determinants, health impacts, policies and related costs [4,11,12].

The situation becomes even more complex when dealing with growing amounts of data of various sources and natures. As everyday life becomes increasingly digital and “digitalisable” and technological progress make data storage capacity easily available, huge amounts of structured and non-structured data are being collected [13-15]. The term “Big Data” usually refers to “very large amounts of data that are routinely or automatically collected and stored". It is often defined by 3 characteristics known as the 3 V's - volume, velocity and variety - or by 5 characteristics, when adding veracity and value [16].

The editor's comment of WHO's Eurohealth 2017 Spring issue states that "there is a growing awareness that harnessing "big data", if done properly, could transform both the quality of healthcare for patients and how health systems perform" [17]. Linking databases by sharing electronic health records and integrating other non-health care systems information sources (geographic location, socio-economic status, lifestyle and social networks) may support the transformation policy-makers, patients and providers need towards a data driven and value-based health care [13]. The United Nations Global Pulse Program to "harness big data for development and humanitarian action" is also a clear statement of "how data science and analytics can contribute to sustainable development", with projects from areas such as public health, climate and resilience, economic well-being, but also data privacy and protection or real-time evaluation[18].

The information used in Chapter 4 is precisely linked data at individual level from different natures and sources, namely hospital and primary care, national registries of pharmaceuticals and mortality. It consists of a pilot approach before scaling up to bigger and even more complex databases, taking advantage of the innovative health information management national approaches in Portugal [19].

Expected advantages from using this big data approach include [13]:

- improving the quality of care:
    - individualizing treatment plans,
    - decreasing duplicate diagnostic tests,
    - monitoring and benchmarking provider performance;
- increasing the healthcare systems efficiency towards value-based healthcare systems:
    - reducing waste from underuse of effective treatments, overuse of ineffective treatments (for example, identifying the most cost-effective treatments for each patient and hence improving patient outcomes in a cost-effective way) and failure to coordinate, manage and execute care

(for example, coordinating primary and hospital care levels towards an effective disease management),
    - fast-tracking the development of innovative and more effective health technologies (for example, linked long-run real data on outcomes to assess comparative effectiveness of new medicines, leading to more informed decisions),
    - creating efficiency gains in collecting and using data, analyzing available secondary data rather than primary data (decreasing information collection costs and research time).
- generating high quality research that guaranties evidence-based clinical practice and decision-making procedures (linked data at national and even international levels collected over time constitute a wealth of research possibilities, allowing researchers to work on real data about populations rather than samples, improving especially important knowledge regarding chronical non-communicable diseases).

Acknowledged difficulties to use a big data integrated approach include [13,16]:

- technical challenges such as different standards used in databases that may prevent data from being comparable and compatible (for example a unique patient identifier is not always available), the complexity of linking data from different natures (many analytical tools are not appropriated to deal with this integration) and data reliability (for example missing data and error or/and bias deriving from human entry of manually fed electronic records);
- ethical challenges such as data privacy concerns (for example an opting-out option may have to be available, distinguishing consent to use data in a service provision context or in a research context) and data security issues;
- legal challenges such as diversity of legal framework between countries, even within the European Union, and between diseases (for example mandatory registries for infectious diseases, but requirements of explicit patient consent for others), that may be mitigated by assuring good practice measures are taken into account (for example establishing steering committees with patient

representatives, using trusted third parties for data linkages, creating clear rules for requesting and granting data access, as well as tracking its use);

- governance challenges demonstrated in the disparities in speed at which different countries are building big data governance frameworks to integrate technical, legal, ethical and politic aspects (even the European personal data protection regulation being updated may not keep up to the speed of continuous changes of a big data environment [20].

These difficulties are still injuring the process of further using and taking advantage of big data potential benefits [21]. Nevertheless, there are international measures being taken such as the recent OECD ministerial statement to assure that countries and all stakeholders are taken on board to guaranty that big data really represents the future of health systems [22].

The HIA field has thus every chance to benefit from the increased use of big data, linked throughout health care and additional information sources related to social health determinants, obtainable for whole populations but discriminable to sub-populations and available over time.

Nevertheless, embracing big data also means an additional methodological challenge regarding analytical statistical procedures, since conventional inductive statistical methodologies are fairly limited for big data. The imminent revolution is not just the big data scaling up, but the need to develop and use new approaches to mine data from different sources and natures and extract knowledge and insights. A multi-disciplinary perspective is being adopted and the new field of Data Science is emerging and growing [23,24]. Data analysis is no longer focused on outcomes related to a particular, perhaps more clinical, area of knowledge in what concerns predicting health impacts, but is present across all of science and reality.

Our current research and proposed approaches focus precisely on how to overcome big data difficulties in the point of view of statistical methodologies and thus contributes to improve quantified HIA. The statistical methodologies used throughout chapters 2, 3 and 4 (such as text mining, cluster analysis, multiple correspondence analysis, for example) are typically used in data mining and data science contexts. Moreover, they also solve other concerns important for the HIA field: dealing with equity and generating clear graphical representations of results, as detailed in the following sections.

1.3. Dealing with Equity

Health equity has arisen more strongly as policy concern since the late 1980s [25] and constitutes a core value of HIA since its beginnings. Any HIA aims to decrease inequities and improve policy features, in order to identify and help population subgroups who may be more fragile and less able on their own to diminish any avoidable negative health impacts of a policy [1].

The pursuit of equity is even more relevant when addressing HIA on health sector policies and often justifies how HIA may still add value to health sector initiatives as compared to assessments in other sectors [5], since during planning and policy development there may have been few opportunities to:

- survey health disparities within and between population subgroups;
- identify how certain policy features regarding its design and implementation may increase health inequities widening the social gradient in health, by benefiting higher income social subgroups more than they benefit lower income social subgroups.

Nevertheless, many HIA still treat health impacts homogenously across target populations and have difficulties to assess impacts taking equity into consideration for a variety of reasons [25,26]:

- Considering equity may add a layer of complexity to an already complex setup;
- Adequate available data and evidence are wanting;
- Guidance may be inadequate and clear definitions absent;
- Methods and tools are perceived as lacking;
- Practitioners are unwilling or unable to address fairness and social justice values.

Thus, more immediate and direct health impacts are primarily being considered but not the root causes of inequities. Hence the importance of linking data sources, as discussed in this chapter's previous subsection 1.2.

A few methodological initiatives have been proposed to link social mechanisms, macro-social and economic determinants of health, equity and relevant outcomes [27] and to develop a set of equity metrics to guide HIA practice and evaluate its progress toward equity [28]. Nevertheless, the fact is that quantitative HIA still quite seldom uses multivariate statistical methods to estimate health impacts while taking equity into account [1,29]. A need to "develop conceptual models describing the interrelationships of the complex processes and values that promote or undermine health equity" is emergent [26] and especially important when considering a big data context.

Our research shows how to take advantage of already existent available information, secondary data not primary data collected for the only purpose of applying it within a specific HIA, and use it to add value to different HIA steps, always with a concern of equity.

In Chapter 4 particularly we propose a conceptual quantitative path of analysis for HIA to study associations between regional health equity, health impacts and policies, based on linked data from different origins. Our choice of statistical methodologies also aimed at dealing with equity: statistical stratification regarding logistic models based on the equity aspect under scrutiny (region), factorial methods such as principal components and multiple correspondence analyses that identify profiles grounded on variability. We thus give a possible path to apply HIA in a real-life context to identify whether and how impacts on health inequalities may be estimated, which has been identified as the current HIA challenges to address [11,12].

1.4. Reaching Out to Decision-Makers

Being in its essence a tool to inform the decision-making process, HIA has to be useful for decision-makers and perceived as so by them. To guaranty its widespread use, one could think it simple just making it mandatory, like Environmental Impact Assessment is in many contexts. Nevertheless, as one can see from chapter 2 and the country origins from published HIA papers and guidelines, HIA does not necessarily thrive in mandatory settings and primarily is indeed extensively used outside legislative and regulatory frameworks [1,4].

Making HIA mandatory may even be counter-productive by potentially degenerating into a simple tick-box exercise while planning a policy and becoming a recipe to actually ignore health altogether [1,2].

To assure that health is indeed considered in all policies and to establish HIA as an everyday used methodology, decision-makers have to be convinced of the added-value of HIA by [1,2,4,11,30]:

- Considering policies and impacts that most concern decision-makers, although not exclusively obviously;
- Applying more often quantified HIA, since:
  - international recommendations have been consistent with the adoption of the ROAMEF (Rationale, Objectives, Appraisal, Monitoring, Evaluation) cycle, the importance of integrating regulatory impact assessment at early stages of policy design and the need to evaluate performance and cost-effectiveness of interventions,
  - generally, policy makers seem more responsive to quantified impacts;
- Applying quantitative methods that generate clear results, understandable to all decision-makers, seldom experts in HIA or statistical methodologies;
- Encourage a closer collaboration between policy-makers and HIA experts while designing and implementing policies;

- Building capacity in decision-makers on health issues, namely public health and particularly HIA, making them more aware of the importance of health determinants;
- Building capacity also in future and present HIA experts on policy making procedures regarding its design, implementation and evaluation, institutions and organizations involved, to increase the usefulness of HIA being applied;
- Increase the use of evaluation of HIA, to demonstrate that estimation based on sound evidence does inform the decision-making process.

While screening policies in chapter 3 different possible priority criteria were used that may simultaneously answer decision makers concerns more adequately while taking health into consideration in the process. Taking into consideration impacts, criteria and policies that policy-makers might be more sensitive to, will make decision-makers more easily open to the use of HIA use. It will always be an advantageous situation both in the point of view of decision-makers and of health and equity concerns.

The quantitative approach proposed in chapter 4 aims to overcome the barrier of complex statistical methodologies used in HIA frequently generating results difficult to understand by non-statisticians, including decision-makers. Multivariate methodologies (logistic regressions, ORs and factorial methods such as PCA and MCA) are used complementary to present main results regarding health impacts and equity in a visual manner, that may allow for a clearer, simpler and swifter way to grasp and understand results, even for non-statisticians.

Training in health determinants and HIA is essential to create awareness, build capacity within these areas and allow for productive interdisciplinary work and teams. The future of universities and of Universidade de Lisboa in particular may be to find a way to integrate health determinants, public health and a culture of evaluation in all its courses available at all its institutions [31]. Regarding Faculdade de Medicina, in the last decade, while simultaneously the work on this thesis was evolving, HIA has indeed been integrated at:

- under graduate level within health economics disciplines of Mestrado Integrado em Medicina (annually since 2008), Licenciatura em Ciências da Saúde (since 2009), Licenciatura em Ciências da Nutrição (expected for 2018);
- post graduate level within Special Topics of Mestrado em Epidemiologia (annually since 2014) and Social Sciences Applied to Health of Mestrado em Comunicação em Saúde (2 editions since 2007);
- research level within the CUTEHeart Project (an international project between Faculdade de Medicina da Universidade de Lisboa and Universidade do Porto and Harvard Medical School (2014-2016), a thesis orientation of Mestrado Integrado em Medicina (2017) and various scientific publications, as may be consulted in Leonor Bacelar Nicolau Curriculum Vitae, annexed to the present thesis.

Using quantification in HIA by applying multivariate methodologies in a big data context that generate graphical output results understandable for non-statisticians, embracing interdisciplinary work and building capacity related to HIA, health determinants and public health is crucial to guaranty that decision-makers take the upmost of the potential added-value of HIA.

Our approach is also in tune, and in a way anticipates, the recently proposed Action plan to strengthen the use of evidence, information and research for policy-making in the WHO European Region [32].This document covers the domains of health information, public health research and knowledge translation within four action areas:

- "Strengthening national health information systems, harmonizing health indicators and establishing an integrated health information system for the European Region;
- Establishing and promoting national health research systems to support the setting of public health priorities;
- Increasing country capacities for the development of evidence-informed policies (knowledge translation);
- Mainstreaming the use of evidence, information and research in the implementation of Health 2020 and other major regional policy frameworks."

Each of these four action areas have indeed been approached within this thesis at some point and our research may contribute already to some of the answers sought.

2. Conclusions and Future Perspectives

Our research has contributed to HIA practice demonstrating the potential added-value of applying selected data mining and data science methodologies throughout several of HIA steps.

By using complementary multivariate methods such as cluster analysis or multiple correspondence analysis among others within HIA, it becomes possible to study interrelations between health outcomes, determinants of health and relevant equity issues in big data settings.

These methodologies also allow for presenting results with a strong graphical support that may help non-statisticians, like most decision-makers are, to visualize and better understand health impacts of policies within a deeply evidence-based context, promoting HIA awareness.

Used complementary with HTA, quantitative HIA may also thus contribute to rethink a health systems efficiency framework based on allocative efficiency [30], considering broader health gains at global level and health equity gains throughout a population.

The "Next Generation of Health Reforms" [22] includes a vision of reducing health inequities in access to care and health outcomes, by adapting health systems to new health technologies, using big data linking health systems performance indicators from providers to social and economic determinants of health from users, improving performance and evaluation of health systems through benchmarking models that shift their center form providers to people's individual needs and preferences.

More qualitative oriented data mining methodologies such as text mining may soon also be used to better link quantitative and qualitative aspects within HIA, assessing through quantitative methods the magnitude of health impacts globally and throughout sub-population groups and exploring why certain health problems are viewed as more relevant by local communities through more qualitative approaches that may even include social media information.

Research paths are also already being followed regarding the use of classification methodologies such as cluster analysis, regarding complex multivariate data sets, where observations are no longer described by single values of a characteristic, but by distributions of values within each feature [33-36]. This may allow us to better identify population subgroups prone to inequities and to be able to predict the risk group of new individuals or, more interestingly, sets of individuals (regions, districts, neighborhoods, etc.).

Our approach within HIA may thus strongly contribute to the needs of these future health reforms, giving HIA the quantitative tools to better tackle these challenges, taking advantage simultaneously of its more qualitative participatory nature to guaranty that all stakeholders participate in the decision-making process, including targeted disadvantaged communities involved.

References

1. Kemm J, editor. Health Impact Assessment: Past Achievements, Current Understanding and Future Progress: Oxford University Press; 2013.
2. Mindell J, Hansell A, Morrison D, Douglas M, Joffe M. What do we need for robust, quantitative health impact assessment? *Journal of Public Health Medicine* 2001; **23**(3): 173-8.
3. Haigh F, Harris E, Harris-Roxas B, Baum F, Dannenberg AL, Harris MF, Keleher H, Kemp L, Morgan R, Ng Chok H, Spickett J. What makes health impact assessments successful? Factors contributing to effectiveness in Australia and New Zealand. *BMC Public Health* 2015; **15**(1009): 1009.
4. Harris-Roxas B, Viliani F, Bond A, Cave B, Divall MJ, Furu P, Harris P, Soeberg M, Wernham A, Winkler M. Health impact assessment: the state of the art. *Impact Assessment and Project Appraisal* 2012; **30**(1): 43-52.
5. Harris-Roxas B, Haigh F, Travaglia J, Kemp L. Evaluating the impact of equity focused health impact assessment on health service planning: three case studies. *BMC Health Serv Res* 2014; **14**: 371.
6. Bacelar-Nicolau L, Pereira Miguel J, Saporta G. The Added Value of Multivariate Statistical Data Analysis in Policy HIA – A Quantitative Way of Profiling Subjects (Poster). HIA08 Health Impact Assessment and Sustainable Well-being - 9th Conference on Health Impact Assessment, 9-10 October 2008; 10/9/2008; Liverpool, UK; 2008.

7. Bacelar-Nicolau L, Pereira Miguel J, Saporta G. Screening Policies for Health Impact Assessment: cluster analysis for easier decision making. *European Journal of Public Health* 2015; **25**(suppl_3): 133-4.
8. Bacelar-Nicolau L, Pereira Miguel J, Saporta G. Screening Policies in Health Impact Assessment: easier decision making through cluster analysis. European Journal of Epidemiology European Congress of Epidemiology Healthy Living 2015: Bols E.; Smits L.; Weijenberg M. (Eds.); 2015. p. 852-.
9. Brodin H, Hodge S. A guide to Quantitative Methods in Health Impact Assessment. Stockholm, Sweden: STATENS FOLKHÄLSOINSTITUT, Östersund / Swedish National Institute of Public Health; 2008.
10. Glover D, Henderson J. Quantifying health impacts of governement policies, 2010.
11. Fehr R, Hurley F, Mekel OC, Mackenbach JP. Quantitative health impact assessment: taking stock and moving forward. *J Epidemiol Community Health* 2012; **66**(12): 1088-91.
12. Fehr R, Mekel OCL, Hurley JF, Mackenbach JP. Health impact assessment – A survey on quantifying tools. *Environmental Impact Assessment Review* 2016; **57**: 178-86.
13. Salcher M. Connecting the Dots: Putting Big Data to Work for Health Systems. *Eurohealth* 2017; **23**(1): 4.
14. Kluge H. Priorities for Strengthning People-Centred Health Systems. *Eurohealth* 2016; **22**(2): 3.
15. Renner A-TB, J.; Ostermann, H. Big Data for Health Service Research: Balancing Potencials and Challenges. *Eurohealth* 2016; **22**(3): 3.
16. Salas-Vega S, Haimann A, Mossialos E. Big Data and Health Care: Challenges and Opportunities for Coordinated Policy Development in the EU. *Health Systems & Reform* 2015; **1**(4): 285-300.
17. Merkur SM, A. ; McDaid, D. Editor's Comment. *Eurohealth* 2017; **23**(1): 1.
18. Nations U. United Nations Global Pulse . Harnessing big data for development and humanitarian action. 2016. http://unglobalpulse.org/programme-type/public-health (accessed 19/08/2017).
19. Lobo M, Fernandes E, Nisa C, Bacelar-Nicolau L. Main results and lessons to be learned from the CUTEheart project. 2nd CUTEheart Workshop on Health Technology Assessment in Cardiovascular Disease, in Congresso Português de Cardiologia; 4/23/2016; Vilamoura, Portugal; 2016.
20. European Parliament and Council of the European Union. Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC (General Data Protection Regulation). In: Union EPaCotE, editor. 2016/679. Official Journal of the European Union: European Union; 2016. p. 88.
21. Szócska MJ, S.; Smand, C.; Salimullah, T.; Reed, C.; Hanif, S. Big Data for Better Outcomes: Supporting Health Care Systems Transformation in Europe. *Eurohealth* 2017; **23**(1): 3.
22. OECD. Ministerial Statement: The next generation of health reforms. 2017.
23. Donoho D. 50 years of Data Science. John W Tukey 100th Birthday Celebration at Princeton University; 2015 9/18/2015; Princeton, New Jersey, USA; 2015. p. 1-41.
24. Wu Z, Chin OB. From Big Data to Data Science: A Multi-disciplinary Perspective. *Big Data Research* 2014; **1**: 1.
25. Harris-Roxas B, Harris E. Differing forms, differing purposes: A typology of health impact assessment. *Environmental Impact Assessment Review* 2011; **31**(4): 396-403.
26. Povall SL, Haigh FA, Abrahams D, Scott-Samuel A. Health equity impact assessment. *Health Promot Int* 2014; **29**(4): 621-33.
27. Shankardass K, Renahy E, Muntaner C, O'Campo P. Strengthening the implementation of Health in All Policies: a methodology for realist explanatory case studies. *Health Policy Plan* 2015; **30**(4): 462-73.

28. Heller J, Givens ML, Yuen TK, Gould S, Jandu MB, Bourcier E, Choi T. Advancing efforts to achieve health equity: equity metrics for health impact assessment practice. *Int J Environ Res Public Health* 2014; **11**(11): 11054-64.
29. Veerman JL, Barendregt JJ, Mackenbach JP. Quantitative health impact assessment: current practice and future directions. *J Epidemiol Community Health* 2005; **59**(5): 361-70.
30. Cylus JP, I. ; Smith, P.C., editor. Health System Efficiency: How to make measurement matter for policy and management: World Health Organization; 2016.
31. Pereira Miguel J. Homenagem da Universidade de Lisboa ao Professor Doutor José Pereira Miguel. 2ª Conferência "Saúde Pública@ULisboa"; 29/05/2017; Lisboa, Portugal: Universidade de Lisboa; 2017.
32. WHOEurope. Action plan to strengthen the use of evidence, information and research for policy-making in the WHO European Region. WHO Regional Committee for Europe 66th Session. Denmark, 2016.
33. Bacelar-Nicolau H, Costa Nicolau F, Sousa A, Bacelar-Nicolau L. Clustering of variables with a three-way approach for health sciences. *TPM-Testing, Psychometrics, Methodology in Applied Psychology* 2014; **21**(4): 435-47.
34. Bacelar-Nicolau H, Nicolau F, Sousa A, Bacelar-Nicolau L. Measuring Similarity of Complex and Heterogeneous Data in Clustering of Large Data Sets. *Biocybernetics and Biomedical Engineering* 2009; **29**(2): 9-18.
35. Bacelar-Nicolau H, Nicolau F, Sousa A, Bacelar-Nicolau L. Clustering Complex Heterogeneous Data Using a Probabilistic Approach. International Conference on Stochastic Modeling Techniques and Data Analysis - SMTDA2010; 6/8/2010; Chania, Crete, Greece; 2010.
36. Bacelar-Nicolau H, Nicolau F, Sousa A, Bacelar-Nicolau L. On cluster analysis of complex and heterogeneous data. In: C.H.Skiadas, editor. 3rd Stochastic Modeling Techniques and Data Analysis International Conference (SMTDA2014); 6/11/2014; Lisbon, Portugal; 2014. p. 99-108.

Appendices

Appendix 1: Authorization Data from ACSS/SPMS

Appendix 2: Summary of Databases and Statistical Methodologies Used

1. Data

Different databases were used throughout the course of our research presented within the various thesis chapters, from chapter 2 to chapter 4. Here we list and identify them briefly.

All through our research our purpose was to use secondary data sources whenever possible, taking advantage of available databases and avoiding collecting primary information. That obviously implied that strong and robust data validation and management procedures had to be put in place to assure that data used had the adequate quality, formats and evidence contents to serve our purposes.

1.1. Chapter 2

Two datasets were considered in chapter 2: an HIA guides dataset and an HIA papers dataset.

The HIA guides dataset used was based on the table of characteristics published by authors of paper “Health impact assessment: A comparison of 45 local, national and international guidelines” (Hebert et al. 2012), describing 45 selected HIA guides, published from 1995 to 2011. Qualitative characteristics were recoded into 26 nominal active variables and 2 additional supplementary variables were included, from our own analysis of the sample, regarding the region of origin and the kind of screening procedures presented within each HIA Guide (table 1).

The HIA papers dataset was based on the list of HIA Bibliography published and updated regularly by the HIA Gateway associated to Public Health England (HIA Gateway 2014), last updated on March 2014.

Inclusion criteria were: being a paper from the Health Impact Assessment Section of the HIA Gateway Bibliography published in a scientific journal during 2012 to 2014 with available abstract and/or complete text. Exclusion criteria were: being a book (4 references) or a conference abstract (17 references); being published on a different year than 2012, 2013 or 2014 (erroneously catalogued in the HIA Gateway Bibliography – 4 references); not having available simultaneously an abstract nor complete text (1 reference); being duplicated in the original bibliography (5 pairs of references, usually because dates of online publication preceded dates of paper publication).

Table 1. Features characterizing sample of 45 HIA guidelines

Variables and their categories	
Active Variables	
Focus of HIA	**Includes_List_Health_Determinants**
Focus All / Focus Policy / Focus Project	List H Determin Y / List H Determin N
Type of HIA	**Includes_Examples_CaseStudies_Resources**
Type All / Type Prospective / Type Retrospective	Examples Y / Examples N
Level Rapid	**Screening_Partial**
Level Rapid Y / Level Rapid N	Screening Y / Screening Partial
Level Intermediate	**Screening_Meetings**
Level Intermed Y / Level Intermed N	Screening Meetings Y / Screening Meetings N
Level Comprehensive	**Screening_ComprehensiveTools**
Level Comprehens Y / Level Comprehens N	Screening Tools Y / Screening Tools N
Level NoMultiple	**Scoping_Partial**
Level NoMultip Y / Level NoMultip N	Scoping Y / Scoping Partial
Discusses_Integration_with_other_IA	**Scoping_DiagramsLevel**
Integrat Other IA Y / Integrat Other IA N	Scoping Diagrams Y / Scoping Diagrams N
Mentions_Supportive_Policy_Authority	**Assessment_Partial**
Supportive Policy Y / Supportive Policy N	Assessment Y / Assessment Partial
Includes_Principles_or_Values	**Recommendations_Partial**
Principles Values Y / Principles Values N	Recommendat Y / Recommendat Partial
Considers_Equity_Inequalities_across_Population	**Reporting**
Equity Y / Equity N	Reporting Y / Reporting Partial / Reporting N
Encourages_Community_Engagement	**Reporting_Guidance**
Community Engag Y / Community Engag N	Reporting Guidance Y / Reporting Guidance N
Includes_Steering_Committee	**Evaluation_Monitoring**
Steering Committe Y / Steering Committe N	Evaluation Monitor Y / Evaluation Monitor Partial / Evaluation Monitor N
Recommends_Community_Profile	**Evaluation_Monitoring_TalkDecisionmakers**
Community Profile Y / Community Profile N	Talk Decisionmak Y / Talk Decisionmak N
Supplementary Variables	
Screening based on	**Region**
Screen Health Only	Region International
Screen Vague Other	Region Europe
Screen PoliticFinanc	Region AustralAsia
Screen Pre-screennin	Region NorthAmerica
Screen Not Available	

A total of 29 references were thus eliminated from the initial 276 references, which means 247 abstracts were analyzed: 136 references from 2012, 98 references from 2013 and 13 references from 2014. From these, 230 had the original papers also available (93%). Note that only references until March 2014 were considered in the original HIA Gateway document.

Two string variables were analyzed separately: the title of the paper, obviously present for all 247 papers, and the list of keywords, available for only 170 papers. For each string variable, a vocabulary of repeated words and expressions or segments of words from the text data was automatically defined and the frequency of appearance of words/segments was calculated. Only words and segments with a total frequency of 10 or over were taken for analysis. Table 2 presents the number of words and associated frequency for each step of the analysis.

Table 2. Process of building the lexical vocabulary

	Number of words / segments	Total frequency
Titles for 247 Papers		
Initial vocabulary only with single words	969	2386
Phase 1: Modified vocabulary only with single words	594	1677 (70% of frequency of initial vocabulary only with single words)
Phase 2: Modified vocabulary with single words and repeated text segments	655	2026
Phase 3: Modified vocabulary with frequency >=10	40	1017 (53% of frequency of total frequency of modified vocabulary with single words and repeated text segments)
Keywords for 170 papers		
Initial vocabulary only with single words	719	1581
Phase 1: Modified vocabulary only with single words	451	1535 (97% of frequency of initial vocabulary only with single words)
Phase 2: Modified vocabulary with single words and repeated text segments	513	1956
Phase 3: Modified vocabulary with frequency >=10	49	1296 (66% of frequency of total frequency of modified vocabulary with single words and repeated text segments)

Table 3. Lexical Contingency Table for Paper's Titles by Publication Year, by Journal Title mentioning "Environment" and Use of Quantification Methods

	2012	2013	2014	With Environment	Without Environment	Quantification	No quantification
Air	12	5	0	13	4	16	1
North America	11	8	0	1	18	12	7
Asian Australiasian	14	16	0	11	19	23	7
Assessment	45	31	3	34	45	42	37
Benefits	10	0	0	5	5	9	1
Cases	6	5	2	2	11	8	5
Change	8	2	0	3	7	2	8
Children Young People	5	3	3	2	9	10	1
Cities	8	7	0	6	9	12	3
Communities	9	2	0	3	8	6	5
Environment	13	12	3	7	21	15	13
Europe	21	16	0	14	23	24	13
Green Spaces	4	7	1	6	6	9	3
Health	71	54	6	49	82	75	56
Impact	46	37	3	38	48	50	36
Policies	13	11	4	3	25	12	16
Pollution	10	7	0	12	5	15	2
Program	5	4	1	1	9	7	3
Public	10	6	1	5	12	11	6
Related	11	10	0	8	13	7	14
Risks	9	2	0	9	2	9	2
System	8	2	0	1	9	4	6
Through	7	3	0	4	6	1	9
Transportation	9	6	0	7	8	12	3
UK	7	9	1	5	12	10	7
Using	6	9	1	3	13	10	6
Active	6	6	0	2	10	6	6
Food Beverages	8	4	1	1	12	10	3
development	4	6	2	2	10	8	4
Effective	5	5	0	7	3	9	1
planning	3	8	1	6	6	3	9
study	5	11	1	4	13	13	4
Air Pollution	11	6	0	13	4	16	1
Built Environment	8	8	0	3	13	11	5
Climate Change	6	4	0	6	4	2	8
Health Impact	34	27	3	30	34	37	27
Health Impact Assessment	32	24	4	24	36	29	31
Impact Assessment	30	27	3	25	35	28	32
Space planning	4	7	0	9	2	5	6
local level	11	11	0	7	15	9	13

A lexical contingency table was then automatically generated with these repeated words and segments in rows and the groups defined by categories of selected nominal variables in columns. The nominal variables crossed with word/segments were: Publication year (2012, 2013 or 2014); Journal Title with or without "Environment"; Quantification of methods and results (Quantification or No quantification) – tables 3 and 4. For example, in Table 3, the word Air appears 12 times in 2012 paper titles, 5 times in 2013 paper titles and 0 times in 2014 paper titles, 13 times in titles of papers from journals with 'Environment' on their titles and 4 times in titles of papers from journals without 'Environment' on their titles, 16 times in papers with a quantification nature and 1 time in papers with no quantification nature.

Table 4. Lexical Contingency Table for Paper's Keywords by Publication Year, by Journal Title mentioning "Environment" and Use of Quantification Methods

	2012	2013	2014	With Environment	Without Environment	Quantification	No quantification
Activity	16	8	1	8	17	15	10
Air	16	13	0	20	9	26	3
Asia	8	3	0	6	5	5	6
Assessment	46	39	2	50	37	45	42
Pollutants	7	7	0	10	4	14	0
Bicycling	10	3	0	1	12	9	4
Children	4	7	2	2	11	7	6
Climate	11	4	0	9	6	7	8
Community	10	0	1	0	11	4	7
Decision-making	8	5	0	3	10	6	7
Development	10	1	0	7	4	7	4
Disadvantaged	4	3	3	2	8	8	2
Environmental	23	20	3	24	22	23	23
Equity	8	13	0	3	18	10	11
Europe	7	4	0	5	6	7	4
Food Nutrition	9	2	0	0	11	8	3
Green	3	7	1	4	7	9	2
Health	84	80	6	57	113	86	84
Impact	41	32	3	35	41	40	36
Modelling	4	6	0	5	5	5	5
Participation	5	4	1	5	5	2	8
Particulate	4	8	0	11	1	12	0
Physical	7	8	1	5	11	11	5
Planning	7	7	1	6	9	3	12
Policy	26	27	8	12	49	24	37
Pollution	13	13	0	15	11	21	5
Public	14	12	3	8	21	14	15

Risk	19	20	0	29	10	29	10
Road	8	2	0	4	6	7	3
Social	10	9	0	2	17	11	8
Spatial	7	3	0	3	7	6	4
Traffic	7	3	0	7	3	8	2
Transportation	19	8	0	10	17	16	11
Travel	9	1	0	4	6	5	5
Vehicle	7	3	0	3	7	7	3
Cities Urban	11	5	0	5	11	7	9
cost-effectiveness economic	6	4	0	3	7	7	3
Data	10	3	0	6	7	10	3
Methods	8	7	0	4	11	6	9
Studies Analysis	4	7	0	3	8	7	4
Air Pollution	16	13	0	20	9	25	4
Built Physical Environment	12	12	1	6	19	10	15
Environmental Impact Assessment	7	10	0	16	1	6	11
Health Promotion	2	12	0	2	12	8	6
Health Impact Assessment	67	57	5	61	68	66	63
Impact Assessment	35	29	2	32	34	31	35
Mental Health	1	10	0	2	9	11	0
Physical Activity	7	6	1	4	10	10	4
Public Health	7	6	1	2	12	6	8

These variables were created by going through the information usually available publically for all papers: titles, keywords and abstracts. Note that some journals without “Environment” in the title may be also considered journals in a more environmental area and journals in a more public health area may include so called environmental papers. That is a limitation of this study that could confound the following multivariate results and could be solved by a deeper analysis of the complete papers themselves. Yet it would be time-consuming and the goal was to show that even a rapid analysis could be helpful, so it was preferred to acknowledge but leave the limitation, not solving it unless results would be clearly biased.

1.2. Chapter 3.1

A dataset describing ratings from a panel of 7 public health experts from Nova University in 2011 over 76 policies proposed by a Technical Group planning the Portuguese hospital reform, on a 10-point scale (1-Very low to 10-Very high) regarding Potential Impact, Ease of implementation and Implementation costs. Hierarchical cluster analysis and other complementary methods are used to identify groups of similar policies and prioritize those more pertinent of being considered for HIA.

The report of the Technical Group planning the Portuguese hospital reform, a 417 pages document issuing 76 recommendations or policies to be undertaken over the following 3 years, was made available for public discussion in November 2011 (Mendes Ribeiro et al. 2011). The complete set of 76 policies divided by 8 areas is listed in Table 5.

A group of public health experts from the Nova University in Lisbon responded, issuing a report in December 2011 (Pita-Barros et al. 2011). This report included an analysis by a panel of 7 public health experts from the Nova University in Lisbon: Pedro Pita Barros, Adalberto Campos Fernandes, José Fragata, Francisco Ramos, José Caldas de Almeida, Gilles Dussault and Luis Lapão. This panel rated each of the 76 policies proposed by the Technical Group planning the Portuguese hospital reform on a 10-point scale (1-Very low to 10-Very high) regarding 3 dimensions: Potential Impact (in terms of a “better health at lower costs” goal), Ease of implementation/likelihood to be applied over the next 3 years, and Implementation costs (including monetary, non-monetary and political costs).

In the present study the 3 raw variables above (10-point likert scales) will be considered, but also these 3 dimensions recoded into 3 categories ordinal variables (scale values low 1-3, intermediate 4 -7, high 8-10).

Table 5. Proposed Policies by cluster profile of potential impact and implementation costs

Area	Policies
1. A more consistent hospital network	1. Draw up hospital referral network (Rede de Referenciação Hospitalar)
	2. Hospital network architecture
	3. "Heavy" Equipment Charter for Hospital Sector (Carta de Equipamentos “Pesados”)
	4. Create the National Institute of Oncology
	5. Build Oriental Lisbon Hospital and resize Great Lisbon region hospital network
	6. Further develop Strategic Partnership with Social Sector
	7. Create and develop Centers of Excellency
	8. A new cooperation model between hospitals and Medical Schools
2. A more sustainable financing policy	1. Strategic and operational planning of hospital units
	2. Hospital Benchmarking and Strategic Framework for Performance Indicators
	3. Unify hospital price tables
	4. Transform all hospitals into EPE (Entidade Pública Empresarial – Public Hospital with private management)
	5. Draft Multi-Year Program-Contracts (Contratos Programa Plurianuais) - 3 years
	6. Incorporate patients’ satisfaction level in hospital performance evaluation
	7. Develop an uniform costing and accounting system
	8. Improve billing process
3. Healthcare integration to improve patients’ access	1. Define referral criteria between Primary Healthcare and Hospital networks
	2. Promote hospital specialties appointments in Primary Healthcare Units
	3. Promote operational protocols between Primary Healthcare services (ACES - Agrupamentos de Centros de Saúde) and Hospital services
	4. Promote medical appointments through new technologies in specific cases
	5. Meet patients screened as “Not-urgent” outside Emergency Hospital Services
	6. Speed up patient referral to the RNCCI (Rede Nacional de Cuidados Continuados Integrados – Integrated Continous Care Network)
	7. Adjust appointments and surgeries contracting to respective demand
4. More efficient hospitals	1. Increase Ambulatory Surgery rates
	10. Redesign pharmaceutical and medical devices buying process
	11. Revise legal framework for drug dispensing in hospital outpatient care
	12. Develop therapeutic standards targeting therapeutical priorities supported by IT (information technologies)
	13. Subject pre-evaluation agreements to contracted programs
	14. Pharmaceuticals monitoring system – inpatient and outpatient hospital care
	15. Share services among hospital pharmacies
	16. Implement system of evaluation and cost benefit analysis of medical devices
	17. Adopt guidelines on the use of Medical Devices
	18. Implement a Medical Devices reuse Program
	19. Share support services
	2. Standardize pre-surgery protocols
	20. Implement an Energy Efficiency Program
	3. Optimize SIGIC operation
	4. Create a Use Review National Program
	5. Rationalize MCDT (Auxiliary Diagnostic and Therapeutic Means) requests
	6. Adjust hospital human resources to healthcare demand
	7. Promote health professionals mobility
	8. Promote mixed contracts with pay linked to performance
	9. Assign new tasks to nursing staff

Table 5. Proposed Policies by cluster profile of potential impact and implementation costs (Cont.)

5. Quality as cornerstone of hospital reform	1. Improve quality and patients safety
	10. Develop Clinical Trials in Portugal
	2. Reduce nosocomial infection rate
	3. Promote Health Professionals recertification
	4. Link service provider funding to quality indicators
	5. Reduce caesarean sections rate
	6. Promote use of uniform set of quality indicators
	7. Create a Medical Simulation National Center
	8 Carry out regular clinical audits
	9. Promote clinical risk control
6. Information and technologies as investment and sustainability factor	1.Guaranty reliability of information
	2. Implement shared software tools and applications throughout all the hospital network
	3 Implement an integrated computer network
	4. Guaranty faster and safer communications
	5. Implement a virtualization program in the hospital network
	6. Implement Electronic Health Registry (Registo de Saúde Electrónico)
7. Improve governance	1. Change hospital governance model
	2. Update hospital classification regarding Board of Directors members' pay
	3. Select Board of Directors members with transparency
	4. Assign management contracts
	5. Create intermediate management units
	6. Evaluate Board of Directors members performance
	7. Code of Ethics in the EPE Hospitals
8. Reinfor-cement of citizen's role	1. Make health information available to citizens
	10. Monitor comfort levels in hospital units
	2. Make information on the Health System more available
	3. Make information on wait times easily available
	4. Raise user awareness about NHS costs of each clinical episode (proforma invoice)
	5. Implement effectively citizen participation in hospital life
	6. Implement principle of freedom of choice of public healthcare providers for patients
	7. Make information on clinical benchmark available
	8. Implement effectively the Informed Consent
	9. Resume the Periodical User Satisfaction Evaluation Program

1.3. Chapter 3.2

Data consists on results of a two-part evaluation survey in 2012 regarding 31 NPs from the National Health Plan 2004-2010 (67 variables) - a characterization of NPs by their coordinator regarding 8 different areas and information on regional dissemination by

Health Regions Administrations. Hierarchical cluster analysis was used for each area separately, complemented by principal component or multiple correspondence analyses, k-means cluster analyses and Kruskal-Wallis tests.

Data used in chapter 3.2 consists on results of a two-part evaluation process regarding 31 National Health Programs (NPs) from the Portuguese National Health Plan 2004-2010 (Ministério da Saúde 2013;Ministério da Saúde de Portugal 2004;World Health Organization 2010). In the first part, program coordinators were asked to answer a questionnaire characterizing the national program they were responsible for including: legal context; financing; products such as planning documents, progress reports, published information for the general population or health professionals, websites, among others; general and specific aims, as well as related projects; monitoring process of indicators on health gains, effectiveness, self-evaluation, etc. In the second part of the evaluation process, Health Regions Administrations answered a questionnaire concerning the dissemination and implementation of National Health Programs at a regional level, regarding: the existence of a regional coordinator; active or implemented projects in 2011, annual progress reports between 2009 and 2010; the existence of a regional evaluation program.

A total of 67 variables were first considered, organized into 9 areas ensuing from the format of the questionnaire applied in the survey (Figure 1).

Figure 1. Areas and associated number and types of variables in the National Program Evaluation Survey

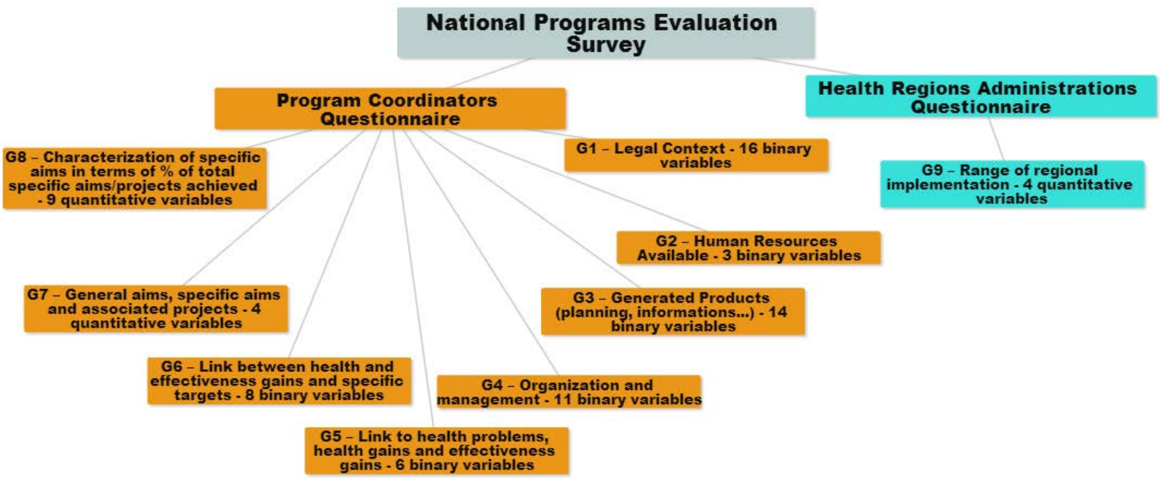


Table 6. 30 National Health Programs (NPs) analyzed

		Programa Nacional (PN)	National Program (NP)
1	ASCJR	Acção de Saúde para Crianças e Jovens em Risco	Health Action for at Risk Children and Youth
2	PNDCV	PN para as Doenças Cérebro-Cardiovasculares (Coordenação Nacional de Doenças Cardiovasculares)	NP for Cerebro-Cardiovascular Disease
3	PNIVIH/SIDA	PN de Prevenção e Controlo da Infecção VIH/SIDA (Coordenação Nacional para a Infecção VIH/SIDA)	NP for HIV/AIDS Infection
4	PNSM	PN de Saúde Mental (Coordenação Nacional para a Saúde Mental)	NP for Mental Health
5	PNPCDO	PN de Prevenção e Controlo das Doenças Oncológicas (Coordenação Nacional para as Doenças Oncológicas)	NP for Oncological Disease Prevention and Control
6	PNCDT	PN contra as Drogas e as Toxicodependências	NP against Drugs and Addictions
7	PNRPLA	PN para a Redução dos Problemas Ligados ao Álcool	NP for Reducing Alcohol Related Problems
8	PCO	Plataforma Contra a Obesidade (PN para a Promoção da Alimentação Saudável)	NP for Promoting Healthy Eating
9	PNCDR	PN Contra as Doenças Reumáticas	NP against Rheumatic Diseases
10	PNAS	PN de Acreditação em Saúde	NP for Certification in Health
11	PNCA	PN de Controlo da Asma	NP for Asthma Control
12	PNCD	PN de Controlo da Dor	NP for Pain Control
13	PNCP	PN de Cuidados Paliativos	NP for Palliative Care
14	PNEP	PN de Erradicação da Poliomielite	NP for Polio Eradication
15	PNIIDSEV	PN de Intervenção Integrada sobre Determinantes da Saúde Relacionados com os Estilos de Vida	NP for Integrated Intervention on Health Determinants related to Life Styles
16	PNLCT	PN de Luta Contra a Tuberculose	NP against Tuberculosis
17	PNPRA	PN de Prevenção das Resistências aos Antimicrobianos	NP for Resistances to Antimicrobials Prevention
18	PNPA	PN de Prevenção de Acidentes	NP for Accidents Prevention
19	PNPCD	PN de Prevenção e Controlo da Diabetes (PN para a Diabetes)	NP for Diabetes
20	PNPCDPOC	PN de Prevenção e Controlo da Doença Pulmonar Obstrutiva Crónica	NP for Chronic Obstructive Pulmonary Disease Prevention
21	PNCI	PN de Prevenção e Controlo das Infecções Associadas aos Cuidados de Saúde	NP for Healthcare associated Infections Prevention and Control
23	PNSA	PN de Saúde Ambiental	NP for Environmental Health
24	PNSE	PN de Saúde Escolar	NP for School Health
25	PNSO	PN de Saúde Ocupacional	NP for Occupational Health
26	PNSR	PN de Saúde Reprodutiva	NP for Reproductive Health
27	PNV	PN de Vacinação	NP for Vaccination
28	PNIVCLG	PN Integrado da Vigilância Clínica e Laboratorial da Gripe	National Integrated Program of Clinical and Laboratory Surveillance of Influenza
29	PNSV	PN para a Saúde da Visão	NP for Eyesight Health
30	PNSPI	PN para a Saúde das Pessoas Idosas	NP for Elderly Health
31	PNDR	PN para Doenças Raras	NP for Rare Diseases

The complete list of variables may be found in the Appendices Table 8. Group G2 was not considered for analysis as apparently the questions were not understood the same way throughout the sample, namely regarding the number of what was considered partial time and full time human resources assigned to the NPs. Group G6 was also not taken into account since it presented a high number of missing values and the health and effectiveness gains issues were already broadly being considered in group G5. The analysis was performed, therefore, using 64 variables (47 binary variables in 4 groups and 17 quantitative variables in 3 groups).

A total of 31 National Health Programs (NPs) was identified as active programs, but only 30 NPs were considered for analysis (Table 6), since the Oral Health NP (code 22) presented a very high number of missing values.

A set of priority criteria was considered to determine how important each cluster could be considered. These criteria were subjectively chosen by authors to illustrate how one can introduce criteria into this methodological approach. Nevertheless an alternative set of criteria could easily be used.

Here, a NP is considered more relevant for analysis the more often it presents the following features, by order of importance (from the more to the less important):

a) Having a regional span as extended and in depth as possible;
b) Showing a concern of monitoring health gains, health systems needs and effectiveness gains;
c) Being a high-priority NP according to the National Health Plans 2004-2010 and 2012-2016;
d) Having been generating a variety of different products for health professionals, specific population groups and general population (guidelines, published information, online presence, events, etc);
e) Listing its planning documents, general aims and linking them to specific aims and/or projects' aims;
f) Presenting an adequate number of aims (being ambitious but realistic in its ambitions), coherent with the number of specific aims for each general aim and the number of projects for each aim;
g) Considering monitoring and evaluating the way aims are being achieved, including resources allocation.

Each of these criteria is linked to one of the 7 groups of variables considered (table 7) and is used to rank clusters and respective NPs (section 3.4).

Table 7. 30 Link between each variable group and respective priority criterion, as well as importance rank

Features for being a potential priority for HIA	Group of Variables	Rank
a) Having a regional span as extended and in depth as possible	G9 – Range of regional implementation	1
b) Showing a concern to monitor health gains, health systems needs and effectiveness gains	G5 – Link to health problems, health gains and effectiveness gains	2
c) Being a high-priority NP according to the National Health Plans 2004-2010 and 2012-2016	G1 – Legal Context	3
d) Having a practice of generating a variety of different products to the health professionals, specific groups of the population and the population in general (guidelines, published information, online presence, events, etc)	G3 – Generated Products (planning, informations, etc.)	4
e) Considering the monitorization and evaluation of the way the aims are being achieved, including resources allocation	G8 – Characterization of specific aims in terms of % of total specific aims/projects achieved	5
f) Listing its planning documents, general aims and linking them to specific aims and/or projects' aims	G4 – Organization and management	6
g) Presenting an adequate number of aims and projects	G7 – General aims, specific aims and associated projects	7

1.4. Chapter 4

The database used had as source SPMS/ACSS (Serviços Partilhados do Ministério da Saúde/Administração Central do Sistema de Saúde) and linked several data origins. It regarded a pilot project to investigate how enriching it could be to have information on individual patients linking data from the Portuguese National Health Service regarding hospital admissions data, primary care data, pharmaceutical drugs consumption and prescription, as well as the mortality registry. As far as we know, it was the first time researchers in Portugal were able to get this kind of data and various procedures had to be taken in order to safeguard the anonymity of patients and their rights.

The data consisted on a sample of all adults (≥20 years old) admitted in a Portuguese National Health Service (NHS) Hospital with acute myocardial infarction diagnosis during the second semester of 2012 and followed in the NHS primary care network regularly during 2013 (over 2 quarters with appointments with a general practitioner) – data source SPMS/ACSS (Serviços Partilhados do Ministério da Saúde/Administração Central do Sistema de Saúde). Patients with no resuscitation / only comfort measures information or discharged against medical opinion were excluded.

Variables for analysis included:

- The mortality outcome under study: being deceased or not at December 31 2013;
- 4 indicators regarding having information registered or not concerning Blood Pressure, Cholesterol, Triglycerides, Waist Circumference, Body Mass Index (BMI). BMI was either existent in the database or was calculated whenever the values for weight and height were both available;
- The 5 health regions of residence Norte, Centro, LVT, Alentejo and Algarve;
- Demographic variables of sex and age;
- 4 hospital admission severity variables, namely: having one or more hospital readmissions during the second semester of 2012, having undertaken surgery during hospital admission, having a mean admission duration over 6 days, having a hospital admission with 6 or more diagnosis associated.

Note that the inclusion criterion of being followed in the NHS primary care network regularly during 2013, guarantying that each patient has at least 3 quarters with appointments with a general practitioner, means to assure that each patient has had the same opportunity of having information registered about their condition. Any patient within the study has had accordingly appointments with a general practitioner, even if he or she has died during the follow up period of 2013.

2. Main Statistical Methodologies

A diversity of statistical methodologies was used throughout the various thesis chapters, depending on our particular purpose for each of them. Table 8 presents the main statistical methodologies used in each chapter. A brief presentation of the application of these methods within each chapter follows. A significance level of 5% was used whenever statistical tests were applied.

Table 8. Main Statistical Methodologies by Chapter

	Chapter 2		Chapter 3		Chapter 4
	Guides	Papers	3.1 Hospital Reform Policies	3.2 National Programs	
Univariate and Bivariate exploratory analysis	X	X	X	X	X
Bivariate inferential analysis: hypothesis tests and CI 95%			X	X	X
Text Mining		X			
Hierarchical cluster analysis	X	X	X	X	
Non Hierarchical Cluster Analysis			X	X	
Principal Components Analysis			X	X	X
Correspondence Analysis		X			
Multiple Correspondence Analysis	X		X	X	X
Logistic Regression & ORs					X

2.1. Chapter 2

In Chapter 2, two datasets were considered:

- a table characterizing 45 Health Impact Assessment (HIA) guides proposed by authors Hebert et al. of paper "Health impact assessment: A comparison of 45 local, national and international guidelines", to which Multivariate Correspondence Analysis and Hierarchical Cluster Analysis were applied to identify common and distinct features between guides and create similar guide profiles.
- A dataset of 247 HIA papers from 2012 to 2014 included on the list of HIA Bibliography published and updated regularly by the HIA Gateway associated to Public Health England was built, taking titles of those papers on the one hand, and keywords when available on the other hand. Text mining analysis was applied to obtain a lexical contingency table , which was then related to only 3 characteristics

registered by us for each paper (publication year, whether the title of the journal where it was published had the word "environment" and if it applied some quantification methods and results) through hierarchical cluster analysis and correspondence analysis.

2.2. Chapter 3.1

In Chapter 3.1, a dataset describing ratings from a panel of 7 public health experts from Nova University in 2011 over 76 policies proposed by a Technical Group planning the Portuguese hospital reform, on a 10-point scale (1-Very low to 10-Very high) regarding Potential Impact, Ease of implementation and Implementation costs. Hierarchical cluster analysis and other complementary methods were used to identify groups of similar policies and prioritize those more pertinent of being considered for HIA.

Univariate exploratory analysis was performed regarding the 10-point scale variables (mean, standard variation, median, percentiles 25 and 75, minimum and maximum) and the recoded variables (frequency and percentage).

Hierarchical cluster analysis (with squared Euclidean distance and Ward's aggregation criteria (Hair et al. 2006) was used to identify groups of similar policies in terms of the 3 variables considered and to prioritize those more pertinent of being considered in a HIA. A 7 clusters partition of similar policies was selected for further analysis. The number and identification of policies were accessed for each cluster. Descriptive statistics were also calculated for each cluster (mean, standard variation, median, percentiles 25 and 75, min and max), and scatter diagrams were constructed to biplot the 3 analyzed variables in terms of cluster identification.

The quality of the partition was accessed by applying non-hierarchical cluster analysis (k-means) with random seeds and also using the cluster centroids as seeds, to compare the clusters' composition (Hair, Black, Babin, Anderson, & Tatham 2006). Tables with counts, column percentages and adjusted residuals were built and Fisher Exact Tests with Monte Carlo significance based on 10,000 sampled tables were used. Kruskal-Wallis tests and associated multiple comparisons tests (Daniel 2009) were additionally used to identify statistically significant differences among clusters, that is to identify which clusters were the most distinct between them, and concerning which variables or dimensions.

Principal Component Analysis (PCA) and Multiple Correspondence Analysis (MCA) were used as complementary multivariate methods (Hair, Black, Babin, Anderson, & Tatham 2006). PCA was applied to the 10-point scale variables to access the more important dimensions for cluster interpretation. The 2 first components, responsible for 80% of the total variance, were selected for analysis. MCA, applied to the recoded variables and using cluster identification as supplementary variable, further complemented the analysis, by identifying the most relevant categories to differentiate among clusters.

2.3. Chapter 3.2

In Chapter 3.2, data consists on results of a two-part evaluation survey in 2012 regarding 31 NPs from the National Health Plan 2004-2010 (67 variables) - a characterization of NPs by their coordinator regarding 8 different areas and information on regional dissemination by Health Regions Administrations.

An univariate descriptive analysis was performed to generally characterize the set of NPs and also with a data validation concern. These results were not presented within the thesis report, since the multivariate proposed approach summarizes main univariate findings and is also the main focus of this research.

In this two-steps approach, hierarchical cluster analysis was applied to each group of variables to classify NPs, using as proximity measure the Ochiai coefficient for groups of binary variables and the squared Euclidean distance for groups of quantitative variables, as well as the average linkage aggregation criterion for all variables.

For groups of quantitative variables k-means non-hierarchical clusters were used (based on centroids from the hierarchical cluster analysis' partition) to validate hierarchical cluster analysis' selected partitions (Hair, Black, Babin, Anderson, & Tatham 2006;Saporta 2011).

Multiple correspondence analysis (MCA) and principal components analysis (PCA) were applied respectively to binary and quantitative variables, as an aid in profiling the various clusters of selected partitions. Crosstabs with column percentages and adjusted residuals, as well as Fisher Exact Tests (with a significance level of 5%), were used to identify more significant binary variables and relevant clusters. For quantitative variables, descriptive statistics by cluster (mean, median, standard deviation, quartiles) and Kruskal-Wallis tests and associated multiple comparisons tests (Daniel 2009) were additionally employed to identify more relevant differences among clusters, that is to identify which clusters were the most distinct between them, and concerning which variables.

Since each group of variables corresponds to a priority criteria, for each group of variables, the partition or clusters of NPs obtained may be ranked as to being more or less evolved regarding to the associated criterion. The clusters of each partition are given a color coded priority level and each NP is then evaluated according to this color coded priority scheme. For each group of variables, color green is associated with the clusters more evolved regarding the criterion linked to that group of variables, color yellow to an intermediate level of evolvement and color red to a low level of evolvement. Clusters with only one NP associated are identified in light grey and are analyzed individually. The top NPs candidates for HIA are consequently easily identifiable, by being the ones integrated more often in clusters linked to the color green.

2.4. Chapter 4

In Chapter 4, we started by analyzing the association between a policy and equity. If a relevant association between policy and inequities was found, then the association between the policy and the health event of interest should be studied subject to equity aspects. If not, the study could ultimately carry on without great concerns regarding these equity issues in particular.

We took all the adults admitted in hospitals for acute myocardial infarction during the second semester of 2012, followed regularly in primary care during 2013, always within the National Health Service in Portugal. The policy whose impact is to be assessed in a HIA context is an Electronic Health Records (EHR) policy to promote a uniform registration of information regarding indicators Blood Pressure, Cholesterol, Triglycerides, Waist Circumference and Body Mass Index. The health impact of interest is the mortality status at the end of the period of study, running from after the hospital admission during the 2nd semester of 2012 until December 31 2013. The equity aspect under analysis concerns regional differences in Portugal, since not assuring a uniform application of the policy throughout all the 5 health regions of residence (Norte, Centro, LVT, Alentejo and Algarve) may increase regional health inequities.

Statistical methodologies differ depending on the stage of the study undertaken. In the first stage an association between registering or not indicators and regions of residence was regarded and in the second stage the association between mortality and registering or not indicators by region was considered. In each stage, a bivariate approach was first undertaken with contingency tables, independence chi-square or Fisher exact tests (Daniel 2009), followed by a multivariate approach based on logistic regression with Odds Ratios (Kleinbaum and Klein 2010), where crude results were calculated and then adjusted results after controlling for sex, age and sex and age interaction, as well as hospital admission severity indicators, and on multivariate exploratory data analysis such as principal components analysis or multivariate correspondence analysis (Hair, Black, Babin, Anderson, & Tatham 2006;Saporta 2011).

In the first stage, the association between each of the registered indicators (Blood Pressure, Cholesterol, Triglycerides, Waist Circumference, BMI) and the region of residence (Norte, Centro, LVT, Alentejo and Algarve) was analyzed initially with a bivariate approach. Contingency tables were built for each health indicator by region of residence with percentages of registration and no registration by region, adjusted residuals, multiple comparisons, comparing proportions adjusted by Bonferroni whenever justified and Independence Chi Square Tests. Regarding this approach, only percentages and Independence Chi-Square Tests results are presented here.

Then, a multivariate statistical approach was undertaken in a crude way (with Algarve as reference category whenever necessary) and then after controlling for Sex, Age and Sex*Age. Crude Odds Ratios (OR) were calculated, as well as respective CI95% and statistical significance, with Logistic Regressions using each Registered Indicator as dependent variable and Region of residence as independent variable (with Algarve as reference category). Adjusted OR were calculated, as well as respective CI95% and statistical significance, with Logistic Regressions using each Registered Indicator as a dependent variable, Region of residence as independent variable (with Algarve as reference category), adjusted by Sex, Age and considering their interaction Sex*Age. Adjustments by the 4 Admission Severity indicators weren't considered since the small sample size when compared with the number of categories created instability in the estimated models. Algarve was chosen as reference category since it presented the higher percentage of no registration for almost all indicators. Finally, Principal Component Analysis (PCA) was applied on the OR from different indicators and regions to help summarize the previous findings as an easier way to visualize results.

In the second stage, the association between not registering each of the indicators and the mortality outcome was first assessed through 2x2 contingency tables for each Registered Indicator by Outcome, with percentages of registration and no registration within the overall sample and for each region, adjusted residuals and Fisher Exact Tests. Only percentages and Fisher Exact Tests results are presented in this document.

Crude OR were calculated, as well as respective CI95% and statistical significance, initially in an overall approach with Logistic Regressions using the Mortality Outcome as dependent variable and each Registered Indicator as independent variable. Then adjusted OR were calculated, as well as respective CI95% and statistical significance, with Logistic Regressions using the Mortality Outcome as a dependent variable and each Registered Indicator as independent variable, adjusted by Sex, Age and considering interaction Sex*Age and afterwards also by the 4 Admission Severity indicators. Subsequently the overall OR and both types of adjusted OR were calculated also controlling for region (with Algarve as reference region). Finally, the overall OR and both types of adjusted OR were stratified by region. Our focus for analysis was the OR obtained through the stratified models, adjusted by Sex, Age, Sex*Age interaction and the 4 Admission Severity indicators. Note that data from Algarve did not generate reliable solutions for indicators Cholesterol, Triglycerides and Waist circumference and gave higher limits for the 95%CI for OR regarding Blood Pressure and especially BMI. Data from Alentejo generated reliable solutions only for Waist circumference and also gave us higher limits for the 95%CI for OR regarding BMI. Norte generated high OR and related limits of the 95%CI for OR regarding Cholesterol and Triglycerides.

All the logistic regression approaches were produced imposing the presence of all the variables with the Enter method. Complementary variables were also additionally selected through a Stepwise forward method to check the robustness of the choice process of variables. The results of the models obtained through the Enter method are the ones analyzed here.

Lastly Multiple Correspondence Analysis (MCA) was applied using all categorical variables under study.

3. Statistical Software

Statistical analyses were generally conducted using the IBM-SPSS software (versions 19 through 22) and SPAD version 3.5.

Table 9. Statistical Software used by Chapter

	Chapter 2		Chapter 3		Chapter 4
	Guides	Papers	3.1 Hospital Reform Policies	3.2 National Programs	
IBM SPSS version 19			X		
IBM SPSS version 21	X			X	
IBM SPSS version 22		X			X
SPAD version 3.5	X	X			

4. References

DANIEL, W. W. (2009) *Biostatistics – A Foundation for Analysis in the Health Sciences*, 9th ed. John Wiley&Sons.

HAIR, J. F., BLACK, B., BABIN, B., ANDERSON, R. E. & TATHAM, R. L. (2006) *Multivariate Data Analysis*, 6th ed. Prentice Hall.

HEBERT, K. A., WENDEL, A. M., KENNEDY, S. K. & DANNENBERG, A. L. (2012) Health impact assessment: A comparison of 45 local, national and international guidelines. *Environmental Impact Assessment Review*, 34, 74-82.

HIA GATEWAY (2014) HIA, MWIA and SEA Bibliography 21. HIA Gateway, West Midlands Public Health Observatory.

KLEINBAUM, D. G. & KLEIN, M. (2010) *Logistic Regression - A Self-learning Text*, Third Edition ed. Springer.

MENDES RIBEIRO, J., BARRETO, A. X. D., VARANDA, J. A. V., PENEDO, J. M. V., CAIADO, J. C. F., NUNES, J. M., SANTOS, N. S., BOTO, P. A. F., IVO, R. S. & SANTOS, T. A. C. (2011) *Relatório Final do Grupo Técnico para a Reforma Hospitalar - Os Cidadãos no centro do Sistema, os Profissionais no centro da mudança*, Ministério da Saúde do Governo de Portugal.

MINISTÉRIO DA SAÚDE (2013) *National Health Plan 2012-2016*, Direção Geral de Saúde do Ministério de Saúde.

MINISTÉRIO DA SAÚDE DE PORTUGAL (2004) *Plano Nacional de Saúde: Orientações Estratégicas para 2004-2010*, Direção-Geral da Saúde do Ministério da Saúde.

PITA-BARROS, P., CAMPOS-FERNANDES, A., RAMOS, F., DUSSAULT, G., CALDAS-ALMEIDA, J., FRAGATA, J. & LAPÃO, L. (2011) *"Os Cidadãos no centro do Sistema, os Profissionais no centro da mudança": Contributo para a discussão*, Nova Saúde - Universidade Nova de Lisboa, Lisboa, Portugal.

SAPORTA, G. (2011) *Probabilités, Analyse des Données et Statistique*, 3e édition ed. Éditions Technip.

WORLD HEALTH ORGANIZATION (2010) *WHO Evaluation of the National Health Plan of Portugal (2004-2010)*, World Health Organization Europe; Ministério da Saúde Portugal; Alto Comissariado da Saúde.

Appendix 3: Supplementary Material of Chapter 2

Profiling HIA Guides with cluster analysis methods

Table 4. Year of Publication and Region, for the HIA Guides Sample

		Freq	%
Year_Publication	1995	1	2.2%
	2000	1	2.2%
	2001	3	6.7%
	2002	4	8.9%
	2003	4	8.9%
	2004	6	13.3%
	2005	3	6.7%
	2006	2	4.4%
	2007	4	8.9%
	2008	4	8.9%
	2009	3	6.7%
	2010	5	11.1%
	2011	3	6.7%
	Unknown	2	
	Total	43	100,0%
Region	Region International	4	8,9%
	Region Europe	25	55,6%
	Region AustralAsia	8	17,8%
	Region NorthAmerica	8	17,8%
	Total	45	100,0%

Table 5. Focus, Type, Levels, Integration discussion with other Impact Assessments and Mention of Supportive Policy Authority, for the HIA Guides Sample

		Freq	%
Focus of HIA	Focus All	33	73,3%
	Focus Policy	8	17,8%
	Focus Project	4	8,9%
	Total	45	100,0%
Type of HIA	Type All	9	20,0%
	Type Prospective	34	75,6%
	Type Retrospective	2	4,4%
	Total	45	100,0%
Level Rapid	Level Rapid Y	31	68,9%
	Level Rapid N	14	31,1%
	Total	45	100,0%
Level Intermediate	Level Intermed Y	9	20,0%
	Level Intermed N	36	80,0%
	Total	45	100,0%
Level Comprehensive	Level Comprehens Y	29	64,4%
	Level Comprehens N	16	35,6%
	Total	45	100,0%
Level NoMultiple	Level NoMultip Y	9	20,0%
	Level NoMultip N	36	80,0%
	Total	45	100,0%
Discusses Integration with other IA	Integrat Other IA Y	29	64,4%
	Integrat Other IA N	16	35,6%
	Total	45	100,0%
Mentions Supportive Policy Authority	Supportive Policy Y	27	60,0%
	Supportive Policy N	18	40,0%
	Total	45	100,0%

Table 6. Principles and Values Inclusion, Equity Concerns Mention, Community Engagement Encouragement and Steering Committee Inclusion, for the HIA Guides Sample

		Freq	%
Includes Principles or Values	Principles Values Y	30	66,7%
	Principles Values N	15	33,3%
	Total	45	100,0%
Considers Equity Inequalities across Population	Equity Y	43	95,6%
	Equity N	2	4,4%
	Total	45	100,0%
Encourages Community Engagement	Community Engag Y	44	97,8%
	Community Engag N	1	2,2%
	Total	45	100,0%
Includes Steering Committee	Steering Committe Y	40	88,9%
	Steering Committe N	5	11,1%
	Total	45	100,0%

Table 7. Community Profile, List of Health Determinants and Examples or Case Studies Ressources Inclusion, for the HIA Guides Sample

		Freq	%
Recommends Community Profile	Community Profile Y	34	75,6%
	Community Profile N	11	24,4%
	Total	45	100,0%
Includes List Health Determinants	List H Determin Y	40	88,9%
	List H Determin N	5	11,1%
	Total	45	100,0%
Includes Examples CaseStudies Resources	Examples Y	39	86,7%
	Examples N	6	13,3%
	Total	45	100,0%

Table 8. Screening and Scoping Features, for the HIA Guides Sample

		Freq	%
Screening Partial	Screening Y	38	84,4%
	Screening Partial	7	15,6%
	Total	45	100,0%
Screening Meetings	Screening Meetings Y	15	33,3%
	Screening Meetings N	30	66,7%
	Total	45	100,0%
Screening ComprehensiveTools	Screening Tools Y	6	13,3%
	Screening Tools N	39	86,7%
	Total	45	100,0%
Screening based on	Screen Health Only	12	26,7%
	Screen Vague Other	10	22,2%
	Screen PoliticFinanc	19	42,2%
	Screen Pre-screennin	2	4,4%
	Screen Not Available	2	4,4%
	Total	45	100,0%
Scoping Partial	Scoping Y	38	84,4%
	Scoping Partial	7	15,6%
	Total	45	100,0%
Scoping DiagramsLevel	Scoping Diagrams Y	7	15,6%
	Scoping Diagrams N	38	84,4%
	Total	45	100,0%

Table 9. Assessment Stage Description, Recommendations, Reporting and Evaluation Considerations, for the HIA Guides Sample

		Freq	%
Assessment Partial	Assessment Y	23	51,1%
	Assessment Partial	22	48,9%
	Total	45	100,0%
Recommendations Partial	Recommendat Y	18	40,0%
	Recommendat Partial	27	60,0%
	Total	45	100,0%
Reporting	Reporting Y	13	28,9%
	Reporting Partial	29	64,4%
	Reporting N	3	6,7%
	Total	45	100,0%
Reporting Guidance	Reporting Guidance Y	12	26,7%
	Reporting Guidance N	33	73,3%
	Total	45	100,0%
Evaluation Monitoring	Evaluation Monitor Y	37	82,2%
	Evaluation Monitor P	4	8,9%
	Evaluation Monitor N	4	8,9%
	Total	45	100,0%
Evaluation Monitoring TalkDecisionmakers	Talk Decisionmak Y	7	15,6%
	Talk Decisionmak N	38	84,4%
	Total	45	100,0%

Figure 8. Factorial Plan 1-3 of Multiple Correspondence Analysis with Hierarchical Cluster Identification as supplementary variable, for the HIA Guides Sample

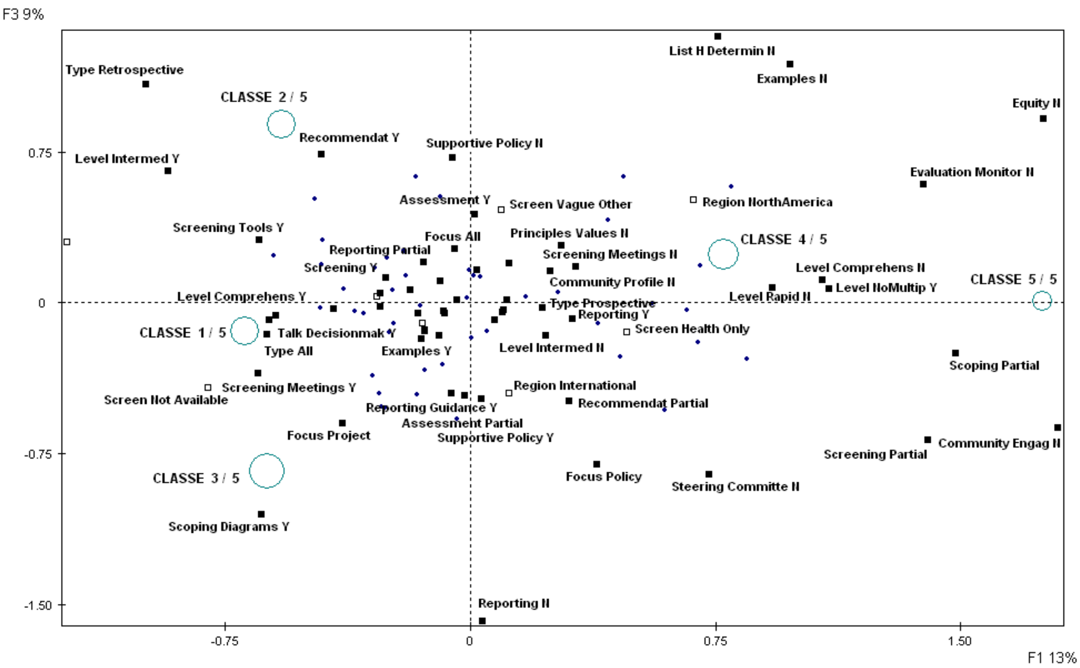


Figure 9. Zoom on Factorial Plan 1-3 of Multiple Correspondence Analysis with Hierarchical Cluster Identification as supplementary variable, for the HIA Guides Sample

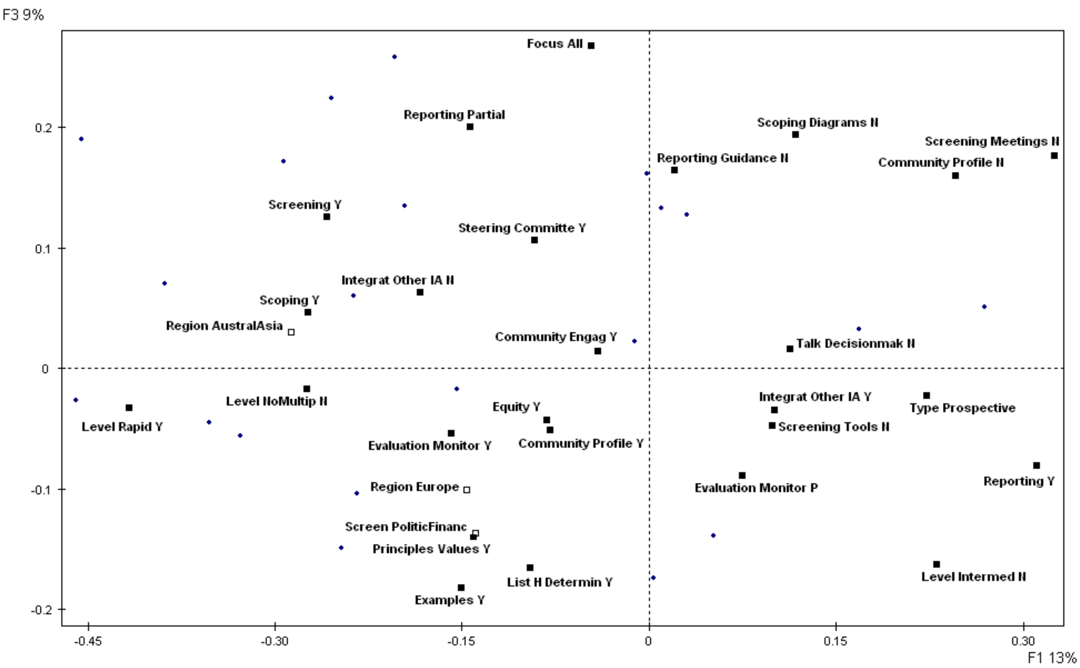


Table 10. Most relevant features for each of the 5 hierarchical Clusters of HIA Guides (percentages within cluster, total sample and modality, as well as tests and significance levels

Variables / Features or Modalities		% of modality within cluster	% of modality within sample	% cluster within modality	Test Value	Sig.
CLUSTER 1 / 5 (9 guides: 20% of total sample)						
Type of HIA	Type All	66.67	20.00	66.67	3.19	0.001
Region	Region Europe	100.00	55.56	36.00	2.83	0.002
Mentions_Supportive_Policy_Authority	Supportive Policy Y	100.00	60.00	33.33	2.56	0.005
Assessment_Partial	Assessment Partial N	88.89	48.89	36.36	2.37	0.009
Assessment_Partial	Assessment Y	11.11	51.11	4.35	-2.37	0.009
Mentions_Supportive_Policy_Authority	Supportive Policy N	0.00	40.00	0.00	-2.56	0.005
Type of HIA	Type Prospective	22.22	75.56	5.88	-3.52	p<=0.001
CLUSTER 2 / 5 (9 guides: 20% of total sample)						
No significantly distinctive features						
CLUSTER 3 / 5 (11 guides: 24% of total sample)						
Scoping_DiagramsLevel	Scoping Diagrams Y	63.64	15.56	100.00	4.34	p<=0.001
Reporting_Guidance	Reporting Guidance Y	63.64	26.67	58.33	2.70	0.003
Evaluation_Monitoring_TalkDecisionmakers	Talk Decisionmak Y	45.45	15.56	71.43	2.51	0.006
Evaluation_Monitoring_TalkDecisionmakers	Talk Decisionmak N	54.55	84.44	15.79	-2.51	0.006
Focus of HIA	Focus All	36.36	73.33	12.12	-2.70	0.003
Reporting_Guidance	Reporting Guidance N	36.36	73.33	12.12	-2.70	0.003
Scoping_DiagramsLevel	Scoping Diagrams N	36.36	84.44	10.53	-4.34	p<=0.001
CLUSTER 4 / 5 (10 guides: 22% of total sample)						
Level Rapid	Level Rapid N	100.00	31.11	71.43	4.98	p<=0.001
Level NoMultiple	Level NoMultip Y	80.00	20.00	88.89	4.63	p<=0.001
Level Comprehensive	Level Comprehens N	90.00	35.56	56.25	3.70	p<=0.001
Discusses_Integration_with_other_IA	Integrat Other IA Y	100.00	64.44	34.48	2.50	0.006
Discusses_Integration_with_other_IA	Integrat Other IA N	0.00	35.56	0.00	-2.50	0.006
Level Comprehensive	Level Comprehens Y	10.00	64.44	3.45	-3.70	p<=0.001
Level NoMultiple	Level NoMultip N	20.00	80.00	5.56	-4.63	p<=0.001
Level Rapid	Level Rapid Y	0.00	68.89	0.00	-4.98	p<=0.001

Table 10. (Continuation) Most relevant features for each of the 5 hierarchical Clusters of HIA Guides (percentages within cluster, total sample and modality, as well as tests and significance levels

Variables / Features or Modalities		% of modality within cluster	% of modality within sample	% cluster within modality	Test Value	Sig.
CLUSTER 5 / 5 (6 guides: 13% of total sample)						
Scoping_Partial	Scoping Partial	100.00	15.56	85.71	4.78	p<=0.001
Screening_Partial	Screening Partial	66.67	15.56	57.14	2.73	0.003
Evaluation_Monitoring	Evaluation Monitor N	50.00	8.89	75.00	2.55	0.005
Screening_Partial	Screening Y	33.33	84.44	5.26	-2.73	0.003
Scoping_Partial	Scoping Y	0.00	84.44	0.00	-4.78	p<=0.001

Table 11. Identification of Guides within each cluster of the 5 clusters Partition

Title of Guide	Author / Publisher
CLUSTER 1 /5	
HIAd as part of strategic environmental assessment	Breeze and Lock/WHOe Regional Office for Europe
Resource for HIA: Volume I	Ison/ NHSg Executive London
Introducing health impact assessment (HIA): Informing the decision-making process	Taylor and Blair-Stevens./ Health Development Agency, Department of Health
An easy guide to HIA for local authorities	Egbutah and Churchill/Luton Borough Council, Luton HAZh
Guidance note: health impact assessments	Essex Planning Officers Association
Healthy Urban Planning: Supplementary Planning Document	City of Stoke on Trent
A guide to HIA: focusing on social and environmental sustainability	Swedish National Institute of Public Health
HIA guidance	Metcalfe et al./ Institute of Public Health in Ireland
Introductory guide to the evaluation of impact on health in Switzerland	Diallo/ Swiss Platform on HIA and Health Promotion Switzerland
CLUSTER 2 /5	
The Merseyside guidelines for health impact assessment	Scott-Samuel et al./ International HIA Consortium
A training manual for HIA	University of Birmingham, Department of Public Health and Epidemiology
More than a statement of the crushingly obvious: a critical guide to HIA	Kemm/ West Midlands Public Health Observatory
HIA intersectoral health policy: theory and application	Penris and den Broeder/Netherlands National Institute for Public Health and the Environment
Equity focused HIA framework	Mahoney et al./Australasian Collaboration for Health Equity Impact Assessment
HIA: a guide for service providers	Public Health Services, Queensland Health
A guide to HIA	Public Health Commission
HIA quick guide	NACCHOi
UCLA HIA training manual	Agyekum et.al./UCLAj

Table 11. (Continuation) Identification of Guides within each cluster of the 5 clusters Partition

CLUSTER 3 /5	
European policy HIA: a guide	EPHIAf Project Group/ International HIA Consortium
HIA toolkit for cities: Document 1 Vision to action	WHO Regional Office for Europe
Using HIA to make better decisions: a simple guide	West Midlands Directors of Public Health Group
Leeds impact assessment toolkit for public health practitioners	Dolman and Swift/ Leeds City Council
Rapid HIA a guide to research	Harris/ New Deal for Communities
Improving health and reducing inequalities: a practical guide to HIA	Welsh HIA Support Unit, Cardiff University
HIA: a practical guide	Harris et al./ University of New South Wales, Australia
A guide to HIA: a policy tool for New Zealand	Public Health Advisory Committee, New Zealand
Wha-nau- Ora HIA	Ministry of Health, New Zealand
Comprehensive health assessment toolbox (CHAT)	Peter Brett Associates
Introduction to HIA	International Finance Corporation
CLUSTER 4 /5	
Local Development Framework: HIA	South Cambridgeshire District Council
Developing HIA in Wales	Health Promotion Division, National Assembly for Wales
HIA: a guide for local authorities	Health Scotland
HIA guidelines	National Public Health Partnership, Commonwealth of Australia
Minimum elements and practice standards for HIA	North American HIA Practice Standards Working Group
Canadian handbook on HIA: volume 1: the basics	Federal/ Provincial/ Territorial Committee on Environmental and Occupational Health
HIA: a guide for practice	Bhatia/ Human Impact Partners
A guide for HIA	Bhatia/ California Department of Health
Thailand's rules and procedures for the HIA of public policies	HIA Coordinating Unit/ National Health Commission Office Thailand
HIA: international best practice principles	Quigley et al./ International Association for Impact Assessment
CLUSTER 5 /5	
The Lincolnshire HIA process and tool	Benson
Human impact assessment as a tool of welfare management	Kauppinen and Nelimarkka/ National Research and Development Centre for Welfare and Health
Impact assessment of policies and services: guidelines and proforma	West Dunbartonshire Council
Community HIA tool	Antigonish Town & County Community Health Board
Rapid HIA toolkit	Forsyth/University of Minnesota, Design for Health
GEOk Health: methodology for integrated environment and health assessment a focus on Latin America and the Caribbean	Eduardo Schutz et al./ UNEPl/ PAHOm/WHO

Profiling HIA papers with text mining analysis methods

General Description of HIA Papers Sample

Table 12. Origin of Author's Affiliation, for the HIA Papers Sample

		Count	%
Origin of Affiliations	UK	77	31,7%
	USA	65	26,7%
	Australia	26	10,7%
	The Netherlands	16	6,6%
	Canada	14	5,8%
	Spain	12	4,9%
	Italy	11	4,5%
	France	11	4,5%
	Denmark	10	4,1%
	Ireland	9	3,7%
	Switzerland	8	3,3%
	Belgium	7	2,9%
	Germany	7	2,9%
	Sweden	6	2,5%
	China	6	2,5%
	Norway	6	2,5%
	Finland	5	2,1%
	Israel	5	2,1%
	South Africa	5	2,1%
	New Zealand	4	1,6%
	Korea	4	1,6%
	Hungary	3	1,2%
	Brazil	3	1,2%
	India	3	1,2%
	Poland	3	1,2%
	Austria	3	1,2%
	Greece	3	1,2%
	Estonia	2	0,8%
	Iran	2	0,8%
	Portugal	2	0,8%
	Colombia	2	0,8%
	Japan	2	0,8%
	Slovenia	1	0,4%
	Fiji	1	0,4%
	Taiwan	1	0,4%
	Total	243	100,0%

Table 13. Country Focus of Analysis, for the HIA Papers Sample

		Count	%
Country Focus	UK	45	26,5%
	USA	40	23,5%
	Europe	23	13,5%
	Australia	14	8,2%
	Spain	8	4,7%
	Canada	7	4,1%
	The Netherlands	7	4,1%
	Italy	6	3,5%
	Ireland	5	2,9%
	Israel	5	2,9%
	New Zealand	3	1,8%
	China	3	1,8%
	Hungary	2	1,2%
	Belgium	2	1,2%
	Iran	2	1,2%
	Denmark	2	1,2%
	Germany	2	1,2%
	Korea	2	1,2%
	India	2	1,2%
	France	2	1,2%
	Norway	2	1,2%
	Finland	2	1,2%
	Cameroon	1	0,6%
	Poland	1	0,6%
	Vanuatu	1	0,6%
	Taiwan	1	0,6%
	Total	170	100,0%

Table 14. Number of Authors, Affiliations and Countries within Affiliations, for the HIA Papers Sample

	Mean	Standard Deviation	Median	Percentile 25	Percentile 75	Minimum	Maximum	N
Number of authors	4,4	2,8	4,0	2	6	1	17	247
Number of affiliations	3,0	1,9	2,0	2	4	1	13	246
Number of countries in affiliations	1,5	,9	1,0	1	2	1	6	247

Text mining Analysis of the Titles of Papers

Table 15. Lexical Contingency Table for Paper's Titles by Publication Year, by Journal Title mentioning "Environment" and Use of Quantification Methods

	2012	2013	2014	With Environment	Without Environment	Quantification	No quantification
Air	12	5	0	13	4	16	1
North America	11	8	0	1	18	12	7
Asian Australiasian	14	16	0	11	19	23	7
Assessment	45	31	3	34	45	42	37
Benefits	10	0	0	5	5	9	1
Cases	6	5	2	2	11	8	5
Change	8	2	0	3	7	2	8
Children Young People	5	3	3	2	9	10	1
Cities	8	7	0	6	9	12	3
Communities	9	2	0	3	8	6	5
Environment	13	12	3	7	21	15	13
Europe	21	16	0	14	23	24	13
Green Spaces	4	7	1	6	6	9	3
Health	71	54	6	49	82	75	56
Impact	46	37	3	38	48	50	36
Policies	13	11	4	3	25	12	16
Pollution	10	7	0	12	5	15	2
Program	5	4	1	1	9	7	3
Public	10	6	1	5	12	11	6
Related	11	10	0	8	13	7	14
Risks	9	2	0	9	2	9	2
System	8	2	0	1	9	4	6
Through	7	3	0	4	6	1	9
Transportation	9	6	0	7	8	12	3
UK	7	9	1	5	12	10	7
Using	6	9	1	3	13	10	6
Active	6	6	0	2	10	6	6
Food Beverages	8	4	1	1	12	10	3
development	4	6	2	2	10	8	4
Effective	5	5	0	7	3	9	1
planning	3	8	1	6	6	3	9
study	5	11	1	4	13	13	4
Air Pollution	11	6	0	13	4	16	1
Built Environment	8	8	0	3	13	11	5
Climate Change	6	4	0	6	4	2	8
Health Impact	34	27	3	30	34	37	27
Health Impact Assessment	32	24	4	24	36	29	31
Impact Assessment	30	27	3	25	35	28	32
Space planning	4	7	0	9	2	5	6
local level	11	11	0	7	15	9	13

Example: The word Air appears: 12 times in 2012 paper titles, 5 times in 2013 paper titles and 0 times in 2014 paper titles; 13 times in titles of papers from journals with 'Environment' on their titles and 4 times in titles of papers from journals without 'Environment' on their titles; 16 times in papers with a quantification nature and 1 time in papers with no quantification nature.

Figure 10. Factorial Plan 1-2 of lexical vocabulary of 247 papers from 2012-2014, based on paper's titles – simplified view

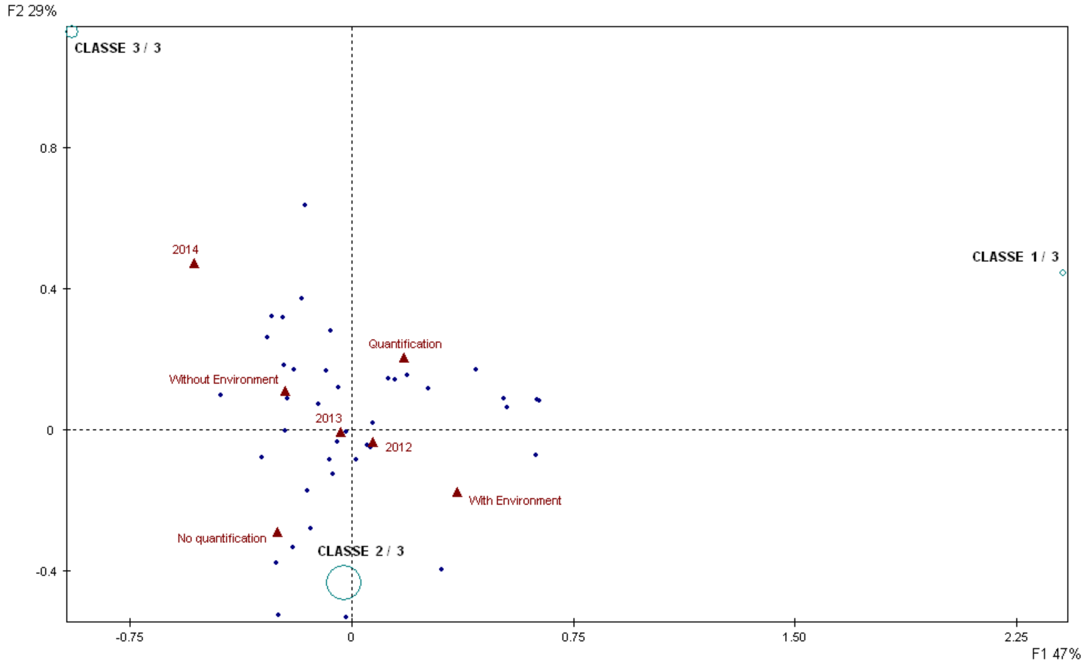


Figure 11. Factorial Plan 1-2 of lexical vocabulary of 247 papers from 2012-2014, based on paper's titles – zoom view

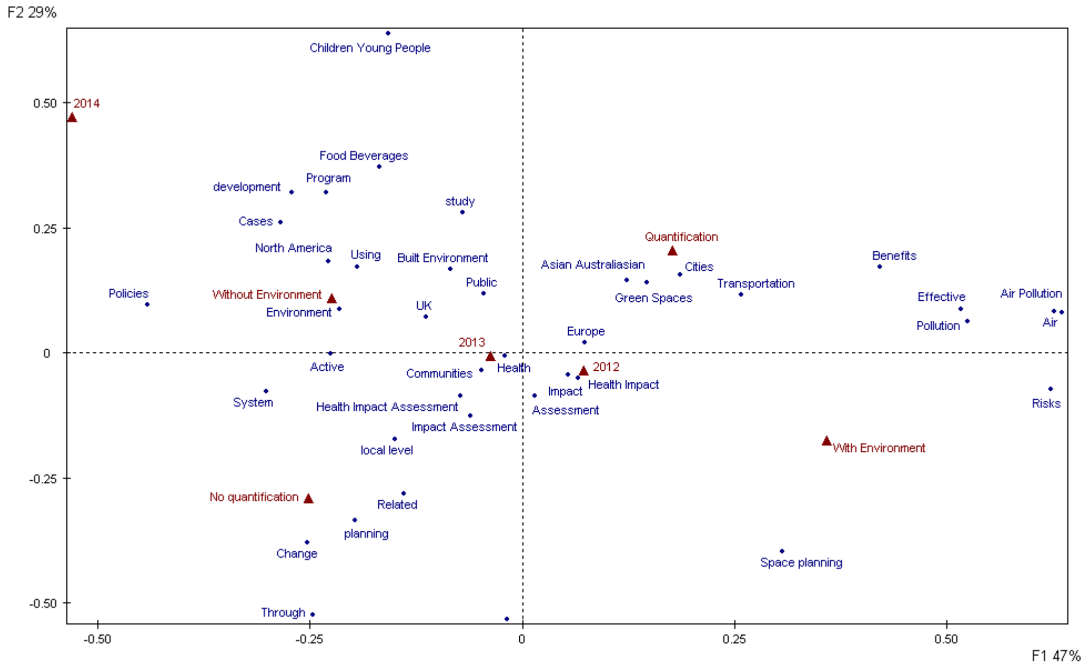


Figure 12. Factorial Plan 1-3 of lexical vocabulary of 247 papers from 2012-2014, based on paper's titles

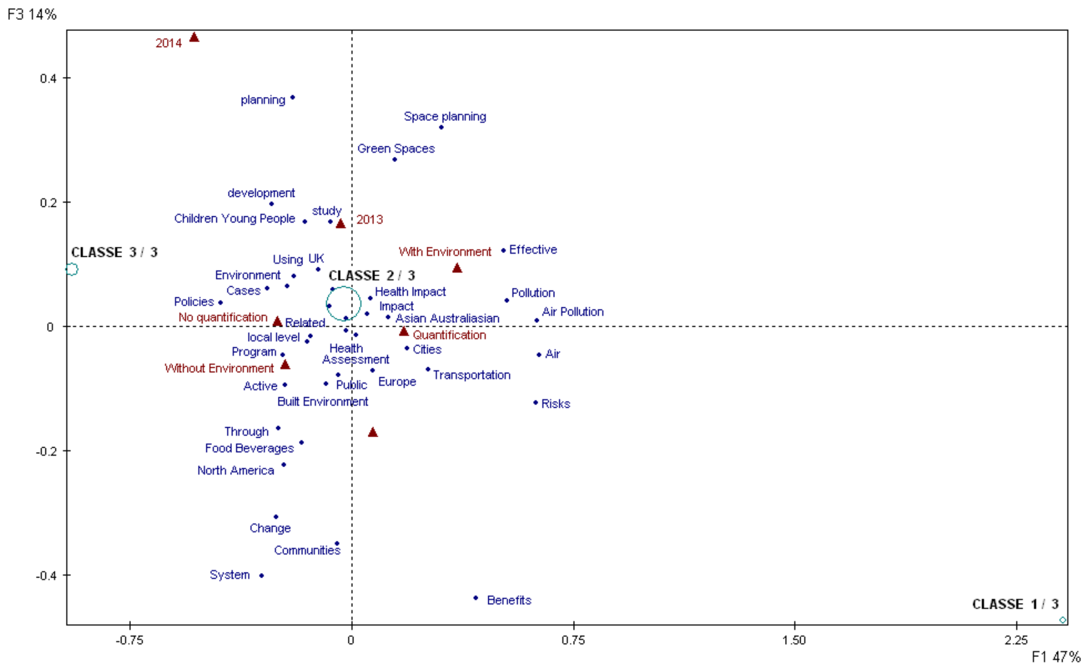
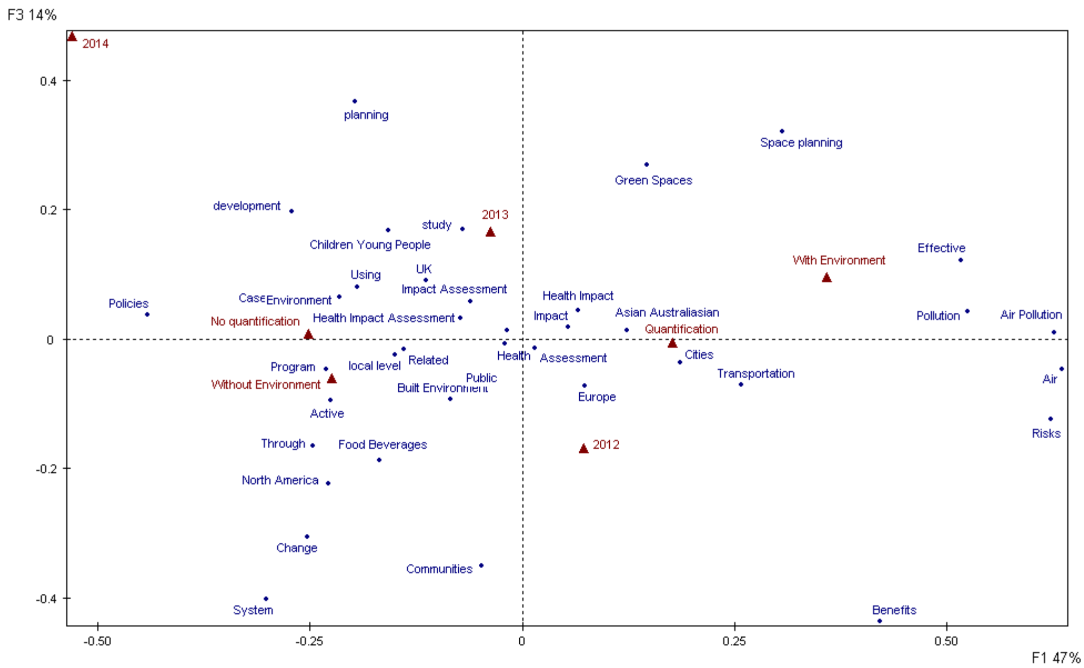


Figure 13. Factorial Plan 1-3 of lexical vocabulary of 247 papers from 2012-2014, based on paper's titles – zoom view



Text mining Analysis of Keywords

Table 16. Lexical Contingency Table for Paper's Keywords by Publication Year, by Journal Title mentioning "Environment" and Use of Quantification Methods

	2012	2013	2014	With Environment	Without Environment	Quantification	No quantification
Activity	16	8	1	8	17	15	10
Air	16	13	0	20	9	26	3
Asia	8	3	0	6	5	5	6
Assessment	46	39	2	50	37	45	42
Pollutants	7	7	0	10	4	14	0
Bicycling	10	3	0	1	12	9	4
Children	4	7	2	2	11	7	6
Climate	11	4	0	9	6	7	8
Community	10	0	1	0	11	4	7
Decision-making	8	5	0	3	10	6	7
Development	10	1	0	7	4	7	4
Disadvantaged	4	3	3	2	8	8	2
Environmental	23	20	3	24	22	23	23
Equity	8	13	0	3	18	10	11
Europe	7	4	0	5	6	7	4
Food Nutrition	9	2	0	0	11	8	3
Green	3	7	1	4	7	9	2
Health	84	80	6	57	113	86	84
Impact	41	32	3	35	41	40	36
Modelling	4	6	0	5	5	5	5
Participation	5	4	1	5	5	2	8
Particulate	4	8	0	11	1	12	0
Physical	7	8	1	5	11	11	5
Planning	7	7	1	6	9	3	12
Policy	26	27	8	12	49	24	37
Pollution	13	13	0	15	11	21	5
Public	14	12	3	8	21	14	15
Risk	19	20	0	29	10	29	10
Road	8	2	0	4	6	7	3
Social	10	9	0	2	17	11	8
Spatial	7	3	0	3	7	6	4
Traffic	7	3	0	7	3	8	2
Transportation	19	8	0	10	17	16	11
Travel	9	1	0	4	6	5	5
Vehicle	7	3	0	3	7	7	3
Cities Urban	11	5	0	5	11	7	9
cost-effectiveness economic	6	4	0	3	7	7	3
Data	10	3	0	6	7	10	3
Methods	8	7	0	4	11	6	9
Studies Analysis	4	7	0	3	8	7	4
Air Pollution	16	13	0	20	9	25	4
Built Physical Environment	12	12	1	6	19	10	15
Environmental Impact Assessment	7	10	0	16	1	6	11

Health Promotion	2	12	0	2	12	8	6
Health Impact Assessment	67	57	5	61	68	66	63
Impact Assessment	35	29	2	32	34	31	35
Mental Health	1	10	0	2	9	11	0
Physical Activity	7	6	1	4	10	10	4
Public Health	7	6	1	2	12	6	8

Figure 14. Factorial Plan 1-2 of lexical vocabulary of 247 papers from 2012-2014, based on paper's keywords – simplified view

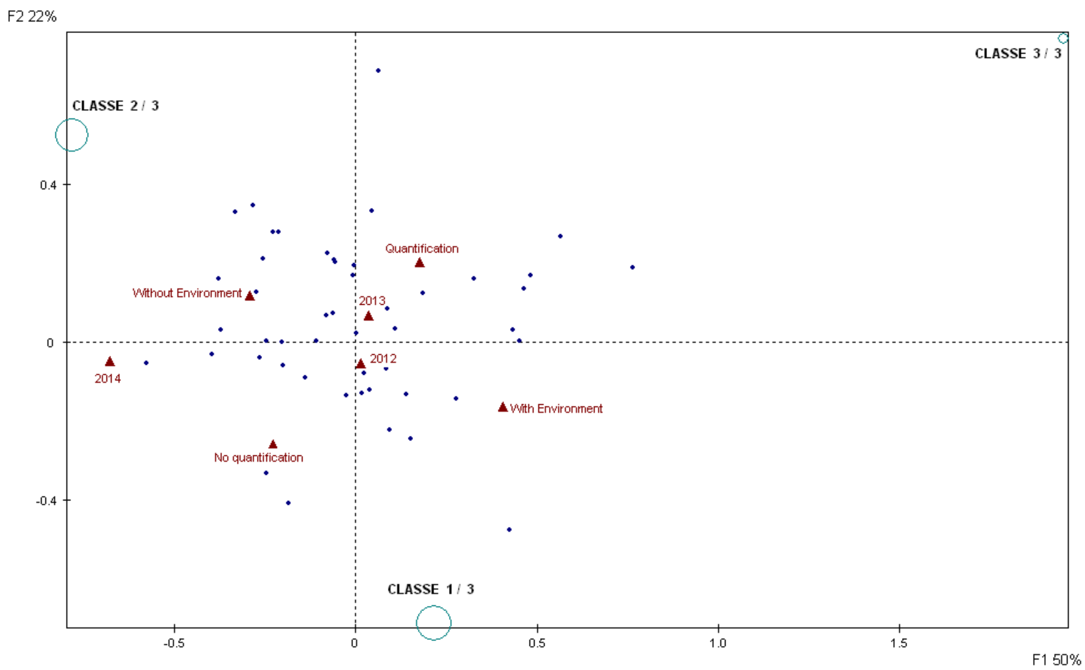


Figure 15. Factorial Plan 1-2 of lexical vocabulary of 247 papers from 2012-2014, based on paper's keywords – zoom view

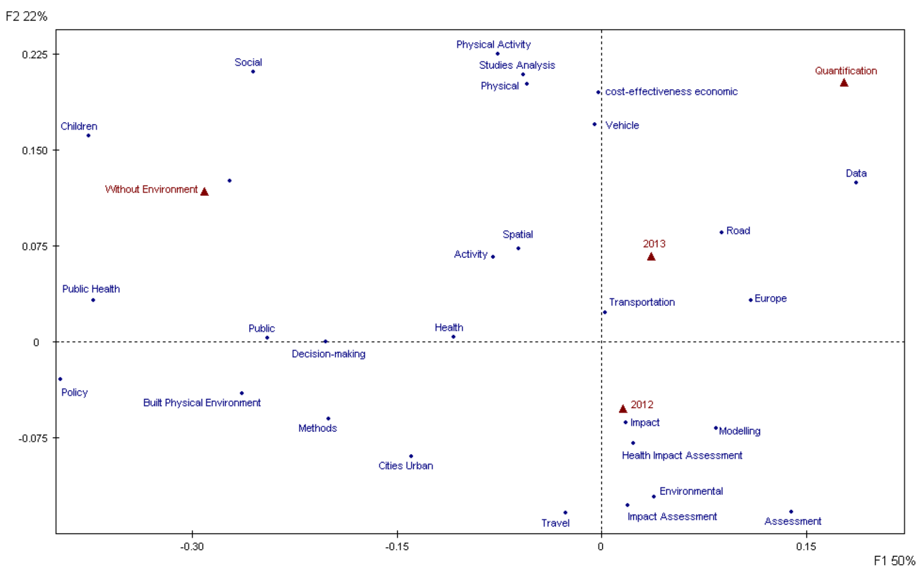


Figure 16. Factorial Plan 1-3 of lexical vocabulary of 247 papers from 2012-2014, based on paper's keywords

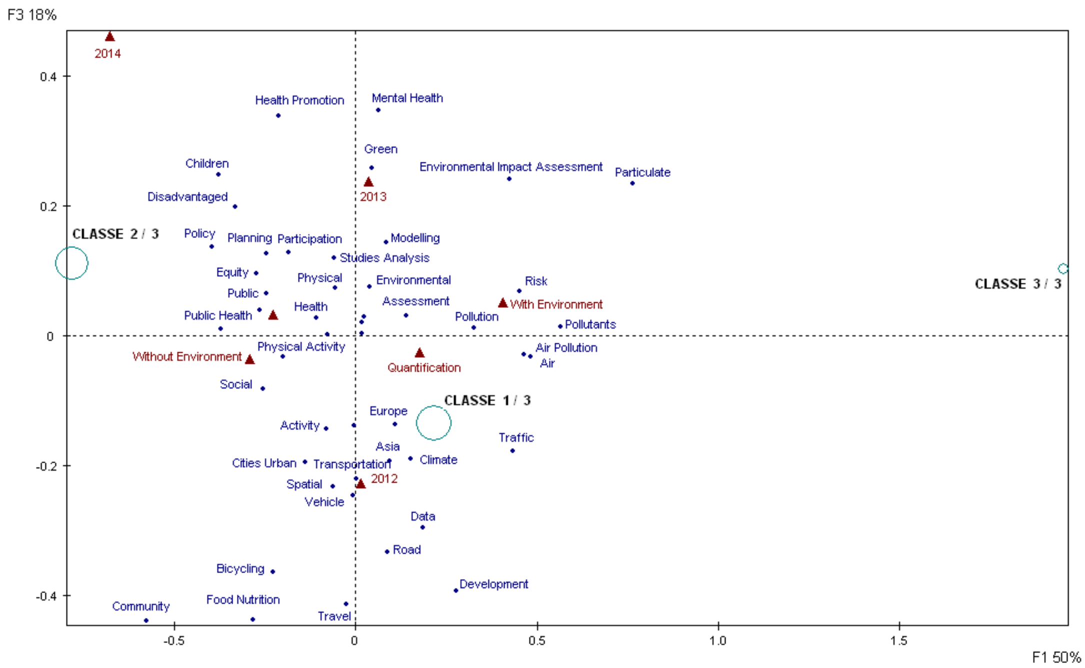
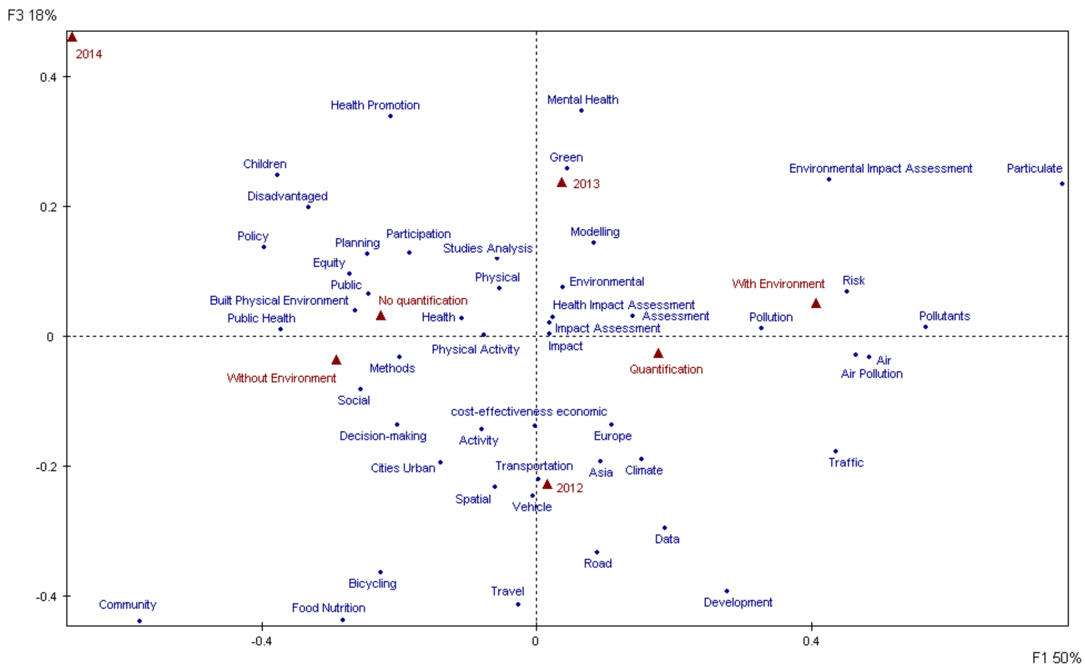


Figure 17. Factorial Plan 1-2 of lexical vocabulary of 247 papers from 2012-2014, based on paper's keywords – zoom view



Appendix 4: Supplementary Material of Chapter 3.1

Table 2. Agglomeration Schedule of the Hierarchical Cluster Analysis (Squared Euclidean Distance and Ward Linkage Criteria)

Stage	Cluster Combined		Coefficients	Coefficients Evolution
	Cluster 1	Cluster 2		
1	18	69	,025	0.03
2	15	75	,056	0.03
3	3	64	,111	0.06
TRUNCATED				
67	16	50	107,511	
68	2	20	118,554	11,04
69	1	10	134,570	16,02
70	5	54	159,491	24,92
71	1	18	187,192	27,70
72	11	16	226,969	39,78
73	2	5	270,073	43,10
74	1	11	371,117	101,04
75	1	2	511,877	140,76

Figure 6. Distribution of policies in the 7 clusters partition (frequencies, %)

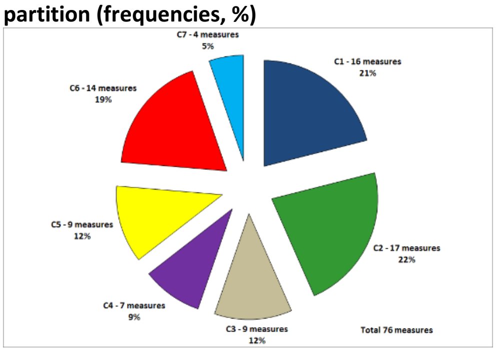


Table 3. Descriptive Analysis by cluster

		Mean	Standard Deviation	Median	P25	P75	Min	Max	N
		Potential Impact (in terms of a "better health at lower costs" goal)							
7 clusters partition	1	7,58	1,08	7,5	6,8	8,4	5,00	9,33	16
	2	6,87	,85	7,0	6,4	7,3	5,00	8,00	17
	3	8,87	,77	9,0	8,2	9,3	7,67	10,00	9
	4	4,17	,94	4,0	3,3	5,0	3,00	5,33	7
	5	4,72	1,00	5,0	4,5	5,3	2,40	5,67	9
	6	6,53	,64	6,2	6,0	7,0	5,80	7,60	14
	7	8,83	,64	9,0	8,3	9,3	8,00	9,33	4
		Ease of implementation/likelihood to be applied over the next 3 years							
7 clusters partition	1	6,98	,76	7,0	6,5	7,5	5,67	8,33	16
	2	6,24	,66	6,3	5,7	6,3	5,50	8,00	17
	3	4,91	,63	5,0	4,7	5,2	4,00	6,00	9
	4	5,63	1,24	5,7	4,3	6,7	4,00	7,50	7
	5	4,60	1,10	5,0	4,0	5,3	2,67	6,00	9
	6	5,38	,63	5,7	4,7	6,0	4,33	6,00	14
	7	6,33	,54	6,3	6,0	6,7	5,67	7,00	4
		Implementation costs (including monetary, non-monetary and political costs)							
7 clusters partition	1	3,33	,64	3,3	3,0	3,8	2,00	4,40	16
	2	5,72	,83	5,5	5,3	5,8	4,50	7,67	17
	3	5,94	,49	6,0	5,7	6,0	5,00	6,60	9
	4	2,99	,62	2,7	2,5	3,7	2,33	3,75	7
	5	5,94	,70	6,0	5,5	6,6	4,67	6,80	9
	6	3,54	,91	3,9	3,3	4,2	1,67	4,50	14
	7	8,58	,57	8,5	8,2	9,0	8,00	9,33	4

Table 4. Descriptive Statistics by cluster according with Low, Intermediate or High Classification

Column %		7 clusters partition C1 n=16	C2 n=17	C3 n=9	C4 n=7	C5 n=9	C6 n=14	C7 n=4	Total N=76
Potential Impact (in terms of a "better health at lower costs" goal)	PI Low 1-3	,0%	,0%	,0%	28,6%	11,1%	,0%	,0%	3,9%
	PI Intermediate 4-7	50,0%	76,5%	,0%	71,4%	88,9%	92,9%	,0%	61,8%
	PI High 8-10	50,0%	23,5%	100,0%	,0%	,0%	7,1%	100,0%	34,2%
Ease of implementation / likelihood to be applied over the next 3 years	EI Low 1-3	,0%	,0%	,0%	,0%	22,2%	,0%	,0%	2,6%
	EI Intermediate 4-7	75,0%	94,1%	100,0%	85,7%	77,8%	100,0%	100,0%	89,5%
	EI High 8-10	25,0%	5,9%	,0%	14,3%	,0%	,0%	,0%	7,9%
Implementation costs (including monetary, non-monetary and political costs)	IC Low 1-3	62,5%	,0%	,0%	57,1%	,0%	35,7%	,0%	25,0%
	IC Intermediate 4-7	37,5%	94,1%	100,0%	42,9%	100,0%	64,3%	,0%	68,4%
	IC High 8-10	,0%	5,9%	,0%	,0%	,0%	,0%	100,0%	6,6%

Figure 7. Differences between initial 7-clusters partition (hierarchical cluster analysis) and 7-clusters partition with non-hierarchical cluster analyses (k-means)

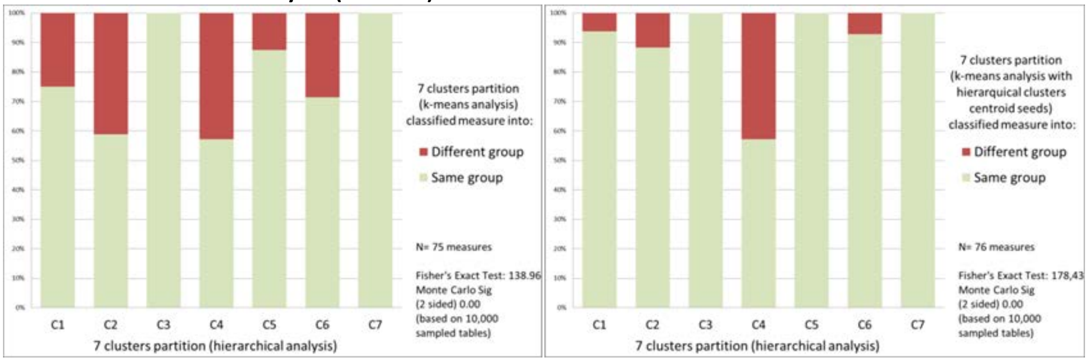


Table 5. 7 clusters partition of hierarchical cluster analysis) by 7 clusters partition of k-means analysis (75 policies) and 7 clusters partition of k-means analysis with hierarchical cluster centroids as seeds – Count Column % and Adjusted Residuals

			7 clusters partition (hierarchical analysis)							Total
			C1	C2	C3	C4	C5	C6	C7	
7 clusters partition (k-means analysis) 75 policies	CL1	Count	12	0	0	0	0	4	0	16
		% Col	75,0%	0,0%	0,0%	0,0%	0,0%	28,6%	0,0%	21,3%
		Adjusted Residual	5,9	-2,4	-1,7	-1,4	-1,6	,7	-1,1	
	CL2	Count	2	10	0	0	0	0	0	12
		% Col	12,5%	58,8%	0,0%	0,0%	0,0%	0,0%	0,0%	16,0%
		Adjusted Residual	-,4	5,5	-1,4	-1,2	-1,3	-1,8	-,9	
	CL3	Count	1	0	9	0	0	0	0	10
		% Col	6,3%	0,0%	100,0%	0,0%	0,0%	0,0%	0,0%	13,3%
		Adjusted Residual	-,9	-1,8	8,2	-1,1	-1,2	-1,6	-,8	
	CL4	Count	1	0	0	4	0	0	0	5
		% Col	6,3%	0,0%	0,0%	57,1%	0,0%	0,0%	0,0%	6,7%
		Adjusted Residual	-,1	-1,3	-,9	5,6	-,8	-1,1	-,5	
	CL5	Count	0	6	0	0	7	0	0	13
		% Col	0,0%	35,3%	0,0%	0,0%	87,5%	0,0%	0,0%	17,3%
		Adjusted Residual	-2,1	2,2	-1,5	-1,3	5,5	-1,9	-,9	
	CL6	Count	0	0	0	3	1	10	0	14
		% Col	0,0%	0,0%	0,0%	42,9%	12,5%	71,4%	0,0%	18,7%
		Adjusted Residual	-2,2	-2,2	-1,5	1,7	-,5	5,6	-1,0	
	CL7	Count	0	1	0	0	0	0	4	5
		% Col	0,0%	5,9%	0,0%	0,0%	0,0%	0,0%	100,0%	6,7%
		Adjusted Residual	-1,2	-,1	-,9	-,7	-,8	-1,1	7,7	
Total		Count	16	17	9	7	8	14	4	75
		% Col	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%

			7 clusters partition (hierarchical analysis)							Total
			C1	C2	C3	C4	C5	C6	C7	
7 clusters partition (k-means analysis with hierarchical cluster centroids as seed)	CL1	Count	15	1	0	0	0	1	0	17
		% Col	93,8%	5,9%	0,0%	0,0%	0,0%	7,1%	0,0%	22,4%
		Adjusted Residual	7,7	-1,9	-1,7	-1,5	-1,7	-1,5	-1,1	
	CL2	Count	0	15	0	0	0	0	0	15
		% Col	0,0%	88,2%	0,0%	0,0%	0,0%	0,0%	0,0%	19,7%
		Adjusted Residual	-2,2	8,1	-1,6	-1,4	-1,6	-2,1	-1,0	
	CL3	Count	0	1	9	0	0	0	0	10
		% Col	0,0%	5,9%	100,0%	0,0%	0,0%	0,0%	0,0%	13,2%
		Adjusted Residual	-1,8	-1,0	8,2	-1,1	-1,2	-1,6	-,8	
	CL4	Count	1	0	0	4	0	0	0	5
		% Col	6,3%	0,0%	0,0%	57,1%	0,0%	0,0%	0,0%	6,6%
		Adjusted Residual	-,1	-1,2	-,8	5,7	-,8	-1,1	-,5	
	CL5	Count	0	0	0	0	9	0	0	9
		% Col	0,0%	0,0%	0,0%	0,0%	100,0%	0,0%	0,0%	11,8%
		Adjusted Residual	-1,6	-1,7	-1,2	-1,0	8,7	-1,5	-,8	
	CL6	Count	0	0	0	3	0	13	0	16
		% Col	0,0%	0,0%	0,0%	42,9%	0,0%	92,9%	0,0%	21,1%
		Adjusted Residual	-2,3	-2,4	-1,6	1,5	-1,6	7,3	-1,1	
	CL7	Count	0	0	0	0	0	0	4	4
		% Col	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	100,0%	5,3%
		Adjusted Residual	-1,1	-1,1	-,8	-,7	-,8	-1,0	8,7	
Total		Count	16	17	9	7	9	14	4	76
		% Col	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%

Table 6. Kruskal-Wallis tests of each original variable by cluster membership (hierarchical solution)

Rank of	Potential Impact (in terms of a "better health at lower costs" goal)	Ease of implementation/likelihood to be applied over the next 3 years	Implementation costs (including monetary, non-monetary and political costs)
	Kruskal Wallis Tests		
Chi-Square (df = 6)	55,070	42,407	60,353
Asymp. Sig.	p<=0,001 *	p<=0,001 *	p<=0,001 *

*. Significant at the 0.05 level.

Table 7. Results Summary for PCA

	Total Variance Explained			**KMO and Bartlett's Test**		
Component	Initial Eigenvalues					
	Total	% of Variance	Cumulative %	Kaiser-Meyer-Olkin Measure of Sampling Adequacy		,402
1	1,252	41,746	41,746	Bartlett's Test of Sphericity	Approx. Chi-Square	10,246
2	1,137	37,909	79,654		df	3
3	,610	20,346	100,000		Sig.	,017

Extraction Method: Principal Component Analysis.

Table 8. Communalities and Component Matrix of PCA 2 Components Extraction

	Communalities		**Component Matrix[a]**	
	Initial	Extraction	1	2
Potential Impact (in terms of a "better health at lower costs" goal)	1,000	,800	,622	,643
Ease of implementation/likelihood to be applied over the next 3 years	1,000	,828	-,346	,842
Implementation costs (including monetary, non-monetary and political costs)	1,000	,762	,864	-,126

Table 9. Model Summary for MCA

Dimension	Variance Accounted For		
	Total (Eigenvalue)	Inertia	% of Variance
1	1,457	,486	48,556
2	1,310	,437	43,676
Total	2,767	,922	
Mean	1,383	,461	46,116

Table 10. Proposed Policies by cluster profile of potential impact and implementation costs

		Cluster profile						
	Potential Impact (H-High, I-Intermediate, L-Low)	H			I		L	
	Implementation Costs (H-High, I-Intermediate, L-Low)	**H**	I	L	H	L	H	L
Area	Policies	C7	C3	C1	C2	C6	C5	C4
1. A more consistent hospital network	1. Draw up hospital referral network (Rede de Referenciação Hospitalar)			■				
	2. Hospital network architecture				■			
	3. "Heavy" Equipment Charter for Hospital Sector (Carta de Equipamentos "Pesados")			■				
	4. Create the National Institute of Oncology			■				
	5. Build Oriental Lisbon Hospital and resize Great Lisbon region hospital network		■					
	6. Further develop Strategic Partnership with Social Sector				■			
	7. Create and develop Centers of Excellency		■					
	8. A new cooperation model between hospitals and Medical Schools			■				
2. A more sustainable financing policy	1. Strategic and operational planning of hospital units		■					
	2. Hospital Benchmarking and Strategic Framework for Performance Indicators			■				
	3. Unify hospital price tables							■
	4. Transform all hospitals into EPE (Entidade Pública Empresarial – Public Hospital with private management)				■			
	5. Draft Multi-Year Program-Contracts (Contratos Programa Plurianuais) - 3 years			■				
	6. Incorporate patients' satisfaction level in hospital performance evaluation							■
	7. Develop an uniform costing and accounting system				■			
	8. Improve billing process						■	
3. Healthcare integration to improve patients' access	1. Define referral criteria between Primary Healthcare and Hospital networks			■				
	2. Promote hospital specialties appointments in Primary Healthcare Units					■		
	3. Promote operational protocols between Primary Healthcare services (ACES - Agrupamentos de Centros de Saúde) and Hospital services			■				
	4. Promote medical appointments through new technologies in specific cases				■			
	5. Meet patients screened as "Not-urgent" outside Emergency Hospital Services					■		
	6. Speed up patient referral to the RNCCI (Rede Nacional de Cuidados Continuados Integrados – Integrated Continous Care Network)					■		
	7. Adjust appointments and surgeries contracting to respective demand			■				
4. More efficient hospitals	1. Increase Ambulatory Surgery rates			■				
	10. Redesign pharmaceutical and medical devices buying process							■
	11. Revise legal framework for drug dispensing in hospital outpatient care			■				
	12. Develop therapeutic standards targeting therapeutical priorities supported by IT (information technologies)				■			
	13. Subject pre-evaluation agreements to contracted programs							■
	14. Pharmaceuticals monitoring system – inpatient and outpatient hospital care				■			
	15. Share services among hospital pharmacies					■		
	16. Implement system of evaluation and cost benefit analysis of medical devices		■					
	17. Adopt guidelines on the use of Medical Devices						■	
	18. Implement a Medical Devices reuse Program						■	

	19. Share support services				■			
	2. Standardize pre-surgery protocols					■		
	20. Implement an Energy Efficiency Program							■
	3. Optimize SIGIC operation				■			
	4. Create a Use Review National Program					■		
	5. Rationalize MCDT (Auxiliary Diagnostic and Therapeutic Means) requests					■		
	6. Adjust hospital human resources to healthcare demand			■				
	7. Promote health professionals mobility					■		
	8. Promote mixed contracts with pay linked to performance			■				
	9. Assign new tasks to nursing staff		■					
5. Quality as cornerstone of hospital reform	1. Improve quality and patients safety		■					
	10. Develop Clinical Trials in Portugal					■		
	2. Reduce nosocomial infection rate		■					
	3. Promote Health Professionals recertification						■	
	4. Link service provider funding to quality indicators				■			
	5. Reduce caesarean sections rate					■		
	6. Promote use of uniform set of quality indicators				■			
	7. Create a Medical Simulation National Center							
	8 Carry out regular clinical audits		■					
	9. Promote clinical risk control		■					
6. Information and technologies as investment and sustainability factor	1.Guaranty reliability of information	■						
	2. Implement shared software tools and applications throughout all the hospital network	■						
	3 Implement an integrated computer network	■						
	4. Guaranty faster and safer communications				■			
	5. Implement a virtualization program in the hospital network				■			
	6. Implement Electronic Health Registry (Registo de Saúde Electrónico)	■						
7. Improve governance	1. Change hospital governance model			■				
	2. Update hospital classification regarding Board of Directors members' pay							■
	3. Select Board of Directors members with transparency					■		
	4. Assign management contracts			■				
	5. Create intermediate management units			■				
	6. Evaluate Board of Directors members performance					■		
	7. Code of Ethics in the EPE Hospitals					■		
8. Reinfor-cement of citizen's role	1. Make health information available to citizens				■			
	10. Monitor comfort levels in hospital units						■	
	2. Make information on the Health System more available				■			
	3. Make information on wait times easily available					■		
	4. Raise user awareness about NHS costs of each clinical episode (proforma invoice)				■			
	5. Implement effectively citizen participation in hospital life						■	
	6. Implement principle of freedom of choice of public healthcare providers for patients						■	
	7. Make information on clinical benchmark available						■	
	8. Implement effectively the Informed Consent							
	9. Resume the Periodical User Satisfaction Evaluation Program				■			

Appendix 5: Supplementary Material of Chapter 3.2

Table 8. List of Variables

Cod_id	
V1	Sigla
V2	Designação
G1_V10	Q Portaria
G1_V11	Q Despacho
G1_V12	Q Circular Normativa / Informativa
G1_V13	Q Criação antes PN
G1_V14	Q Criação durante PN
G1_V16	Q Orçamento de Estado
G1_V17	Q Jogos Sociais
G1_V18	Q Ambos
G1_V19	Q Sem financiamento específico
G1_V3	Q DGS
G1_V4	Q ACS
G1_V5	Q INSA
G1_V6	Q UMCCI
G1_V7	Q IDT
G1_V8	Q Lei, Decreto Lei, Resolução AR/CM
G1_V9	Q Decreto Regulamentar
G2_V24	Q Colaboradores sem indicação de horas
G2_V25	Q Colaboradores com indicação de horas
G2_V27	Q Comissão de acompanhamento ou Grupo de Trabalho Nº Entidades
G3_V31	Q DP Programa Planos Estratégicos
G3_V32	Q DP Programa Planos de Actividades
G3_V33	Q DP Projectos Planos de Implementação
G3_V35	Q DP Relatórios de Actividades
G3_V36	Q DP Relatórios de Avaliação
G3_V37	Q DP Relatórios de Projecto
G3_V39	Q OP Orientações técnicas Recomendações
G3_V40	Q OP Manuais de Boas Práticas
G3_V41	Q OP Documentos de Formação
G3_V42	Q OP Artigos Científicos
G3_V43	Q OP Apresentações em reuniões Científicas
G3_V44	Q OP Sites de Internet
G3_V45	Q OP Outros materiais informativos e divulgacao população
G3_V46	Q OP Outros
G4V30	Q Docs de Planeamento
G4V34	Q Docs de Avaliação
G4V38	Q Outras Publicações/Produtos Nº
G4V47	Q Missão Explicitada
G4V63	Q Argumentação justificada de forma sistemática
G4V69_1	Existência de Objectivos específicos associados aos objectivos gerais
G4V75_1	Identificação possível de cumprimento de objectivos propostos
G4V87	Q Cronograma associado a metas
G4V88	Q Análise de risco, barreiras e dificuldades de implementação
G4V89	Q Descrição de processo de responsabilização/"accountability"
G4V90	Q Descrição do processo de avaliação global do plano/programa
G5V49	Q OG caracterizados pbs saude que justifiquem criação do plano
G5V50	Q OG caracterizadosaspectos da organização/resposta do SS e outros que justifiquem criação do plano
G5V51	Q OG adequados aos pbs saude identificados
G5V52	Q OG Descrição dos processos de eleição e definição
G5V53	Q OG Identificados ganhos de saúde
G5V58	Q OG Identificados ganhos de efectividade
G7V48_N	Objectivos Gerais Nº
G7V68_N	Q Objectivos Específicos Nº
G7V69_N	Q OE Projectos próprios a cada objectivo específico Nº total previsto inicialmente
G7V70_N	Q OE Projectos próprios a cada objectivo específico Nº total implementado
G8V76_N	Q OE Definidas necessidades saúde/população alvo/determinantes
G8V77_N	Q OE Definidos ganhos esperados
G8V78_N	Q OE Análise de acções propostas prevista
G8V79_N	Q OE Parcerias com instituições regionais/locais
G8V80_N	Q OE Atribuição de recursos materiais
G8V83_N	Q OE Orçamentos e Relatórios de Execução
G8V84_N	Q OE Indicadores de operacionalização e concretização
G8V85_N	Q OE Avaliação através de metas
G8V86_N	Q OE Análise de integração nos sistemas/serviços existentes
G9V111	Tem Coordenador Regional? (nº regiões)
G9V112	Está a ser implementado e tem projectos activos em 2011? (nº regiões)
G9V113	Tem Relatórios de Progresso Anual nos anos 2009-2010? (nº regiões)
G9_V114	Foi realizada ou está prevista uma Avaliação do Programa a nível regional? (nº regiões)

Figure 5. Hierarchical cluster analysis of NP's, regarding variables from group G1 – Legal Context

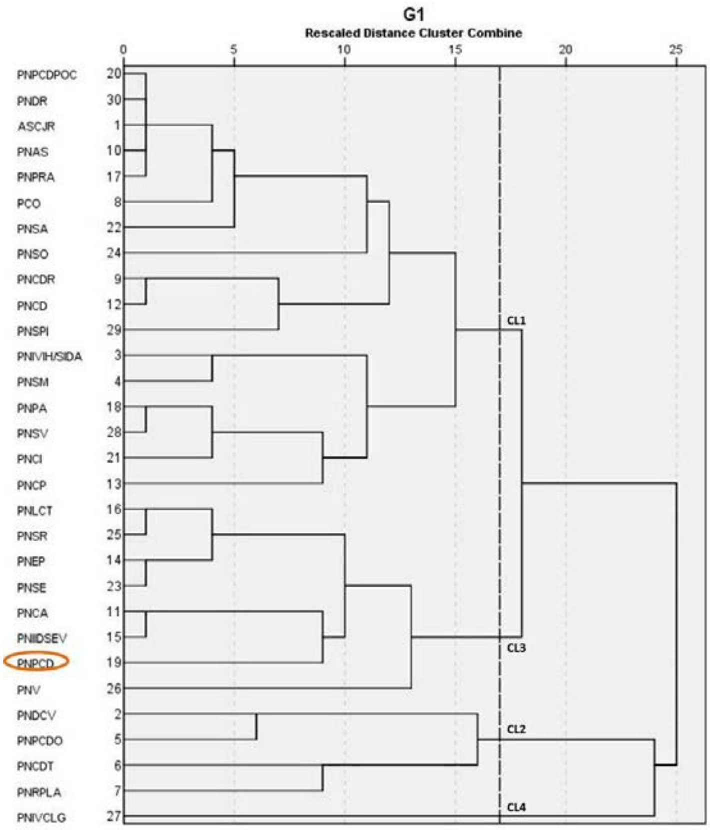


Table 9. Variables from group G1 – Legal Context crossed by 4 cluster partition of hierarchical cluster analysis of NP's regarding group G1

		Partição de 4 clusters G1							
		1		2		3		4	
		Freq	%	Freq	%	Freq	%	Freq	%
DGS	0	3	17,6%	4	100,0%	0	0,0%	1	100,0%
	1	14	82,4%	0	0,0%	8	100,0%	0	0,0%
ACS	0	15	88,2%	2	50,0%	8	100,0%	1	100,0%
	1	2	11,8%	2	50,0%	0	0,0%	0	0,0%
INSA	0	17	100,0%	4	100,0%	8	100,0%	0	0,0%
	1	0	0,0%	0	0,0%	0	0,0%	1	100,0%
UMCCI	0	16	94,1%	4	100,0%	8	100,0%	1	100,0%
	1	1	5,9%	0	0,0%	0	0,0%	0	0,0%
IDT	0	17	100,0%	2	50,0%	8	100,0%	1	100,0%
	1	0	0,0%	2	50,0%	0	0,0%	0	0,0%
Lei, Decreto Lei, Resolução AR/CM	0	16	94,1%	0	0,0%	7	87,5%	1	100,0%
	1	1	5,9%	4	100,0%	1	12,5%	0	0,0%
Decreto Regulamentar	0	16	94,1%	3	75,0%	8	100,0%	1	100,0%
	1	1	5,9%	1	25,0%	0	0,0%	0	0,0%
Portaria	0	16	94,1%	4	100,0%	8	100,0%	1	100,0%
	1	1	5,9%	0	0,0%	0	0,0%	0	0,0%
Despacho	0	2	11,8%	2	50,0%	1	12,5%	1	100,0%
	1	15	88,2%	2	50,0%	7	87,5%	0	0,0%
Circular Normativa / Informativa	0	12	70,6%	3	75,0%	6	75,0%	1	100,0%
	1	5	29,4%	1	25,0%	2	25,0%	0	0,0%
Criação antes PN	0	17	100,0%	0	0,0%	0	0,0%	0	0,0%
	1	0	0,0%	4	100,0%	8	100,0%	1	100,0%
Criação durante PN	0	0	0,0%	4	100,0%	8	100,0%	1	100,0%
	1	17	100,0%	0	0,0%	0	0,0%	0	0,0%
Orçamento de Estado	0	9	52,9%	4	100,0%	3	37,5%	0	0,0%
	1	8	47,1%	0	0,0%	5	62,5%	1	100,0%
Jogos Sociais	0	15	88,2%	1	25,0%	7	87,5%	1	100,0%
	1	2	11,8%	3	75,0%	1	12,5%	0	0,0%
Ambos	0	11	64,7%	3	75,0%	8	100,0%	1	100,0%
	1	6	35,3%	1	25,0%	0	0,0%	0	0,0%
Sem financiamento específico	0	16	94,1%	4	100,0%	6	75,0%	1	100,0%
	1	1	5,9%	0	0,0%	2	25,0%	0	0,0%

Table 10. Fisher Exact Tests for Group G1 variables crossed by selected 4 cluster partition

Variáveis	**Valor da Estatística de teste**	**Sig. (teste bilateral)**	**Resultado para alfa de 5%**
DGS	14,605	0.001	Significativo (1)
ACS	5,091	0.174	Não significativo
INSA	8,696	0.033	Significativo (2)
UMCCI	3,030	1.000	Não significativo
IDT	8,487	0.023	Significativo (3)
Lei, Decreto lei, Resolução AR/CM	13,850	0.001	Significativo (4)
Decreto regulamentar	3,631	0.375	Não significativo
Portaria	3,030	1.000	Não significativo
Despacho	6,107	0.081	Não significativo
Circular normativa/informativa	0,752	1.000	Não significativo
Criação antes PN	33,003	p<=0.001	Significativo (5)
Criação durante PN	33,003	p<=0.001	Significativo (6)
Orçamento de estado	5,103	0.139	Não significativo
Jogos sociais	6,918	0.042	Significativo (7)
Ambos	4,185	0.278	Não significativo
Sem financiamento específico	3,099	0.297	Não significativo

(1) Diferenças patentes entre a classe 2 em que nenhum PNs é da responsabilidade da DGS e a classe 3 em que todos os PNs o são.
(2) Só a classe 4, a que está associado apenas 1 PN, é que apresenta valores de resíduos ajustados importantes, pelo que o teste não é adequado
(3) A classe 2 distingue-se das restantes por ser a única que inclui PNs da responsabilidade do IDT
(4) Todos os PNs da classe 2 foram criados por Lei, Decreto lei, Resolução AR/CM, mas apenas 1 PN da classe 1 o foi.
(5) Apenas os PNs que compõem a classe 1 não existiam antes do Plano Nacional de Saúde 2004-2010.
(6) Apenas os PNs que compõem a classe 1 foram criados durante a vigência do Plano Nacional de Saúde 2004-2010
(7) A esmagadora maioria dos PNs da classe 2 receberam financiamento dos Jogos Sociais.

Figure 6. Hierarchical cluster analysis of NP's, regarding variables from group G3– Generated Products (planning, informations, etc.)

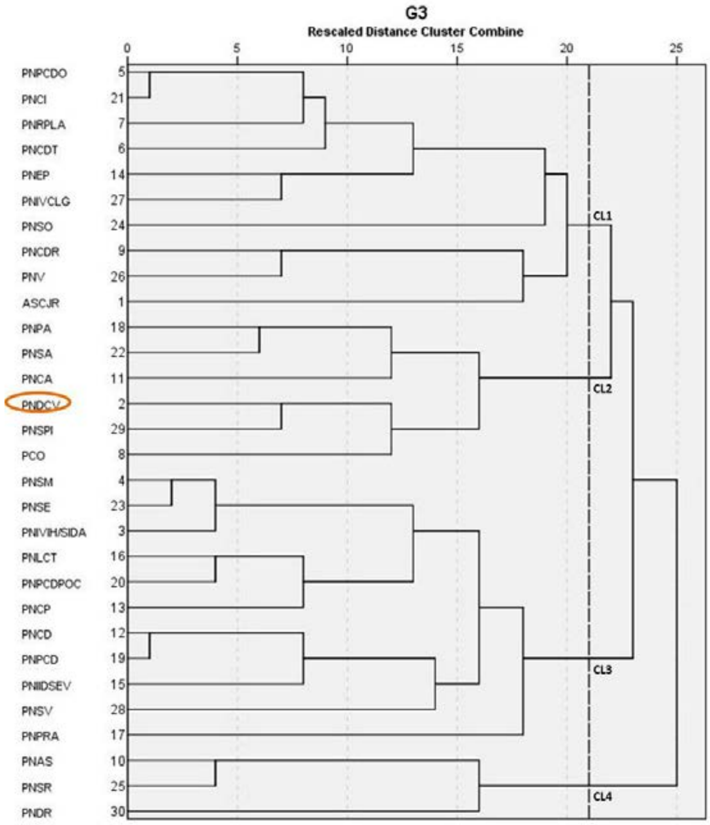


Table 11. Variables from group G3– Generated Products (planning, informations, etc. crossed by 4 cluster partition of hierarchical cluster analysis of NP's regarding group G3

		Partição de 4 clusters G3							
		1		2		3		4	
		Freq	%	Freq	%	Freq	%	Freq	%
DP Programa Planos Estratégicos	0	0	0,0%	1	16,7%	0	0,0%	0	0,0%
	1	10	100,0%	5	83,3%	11	100,0%	3	100,0%
DP Programa Planos de Actividades	0	4	40,0%	4	66,7%	0	0,0%	3	100,0%
	1	6	60,0%	2	33,3%	11	100,0%	0	0,0%
DP Projectos Planos de Implementação	0	3	30,0%	0	0,0%	9	81,8%	0	0,0%
	1	7	70,0%	6	100,0%	2	18,2%	3	100,0%
DP Relatórios de Actividades	0	3	30,0%	6	100,0%	3	27,3%	2	66,7%
	1	7	70,0%	0	0,0%	8	72,7%	1	33,3%
DP Relatórios de Avaliação	0	2	20,0%	6	100,0%	11	100,0%	3	100,0%
	1	8	80,0%	0	0,0%	0	0,0%	0	0,0%
DP Relatórios de Projecto	0	1	10,0%	1	16,7%	7	63,6%	3	100,0%
	1	9	90,0%	5	83,3%	4	36,4%	0	0,0%
OP Orientações técnicas Recomendações	0	3	30,0%	2	33,3%	2	18,2%	1	33,3%
	1	7	70,0%	4	66,7%	9	81,8%	2	66,7%
OP Manuais de Boas Práticas	0	6	60,0%	4	66,7%	10	90,9%	3	100,0%
	1	4	40,0%	2	33,3%	1	9,1%	0	0,0%
OP Documentos de Formação	0	7	70,0%	1	16,7%	10	90,9%	3	100,0%
	1	3	30,0%	5	83,3%	1	9,1%	0	0,0%
OP Artigos Científicos	0	7	70,0%	4	66,7%	11	100,0%	3	100,0%
	1	3	30,0%	2	33,3%	0	0,0%	0	0,0%
OP Apresentações em reuniões Científicas	0	6	60,0%	5	83,3%	9	81,8%	3	100,0%
	1	4	40,0%	1	16,7%	2	18,2%	0	0,0%
OP Sites de Internet	0	4	40,0%	5	83,3%	10	90,9%	1	33,3%
	1	6	60,0%	1	16,7%	1	9,1%	2	66,7%
OP Outros materiais informativos e divulgacao população	0	9	90,0%	0	0,0%	4	36,4%	3	100,0%
	1	1	10,0%	6	100,0%	7	63,6%	0	0,0%
OP Outros	0	3	30,0%	2	33,3%	8	72,7%	3	100,0%
	1	7	70,0%	4	66,7%	3	27,3%	0	0,0%

Table 12. Fisher Exact Tests for Group G3 variables crossed by selected 4 cluster partition

Variáveis	Valor da Estatística de teste	Sig. (teste bilateral)	Resultado para alfa de 5%
DP Programa Planos Estratégicos	3,821	0.300	Não significativo
DP Programa Planos de Actividades	14,199	0.001	Significativo (1)
DP Projectos Planos de Implementação	13,540	0.001	Significativo (2)
DP Relatórios de Actividades	10,075	0.011	Significativo (3)
DP Relatórios de Avaliação	18,744	p<=0.001	Significativo (4)
DP Relatórios de Projecto	11,342	0.006	Significativo (5)
OP Orientações técnicas Recomendações	1,154	0.882	Não significativo
OP Manuais de Boas Práticas	3,606	0.326	Não significativo
OP Documentos de Formação	9,977	0.009	Significativo (6)
OP Artigos Científicos	4,962	0.113	Não significativo
OP Apresentações em reuniões Científicas	2,220	0.579	Não significativo
OP Sites de Internet	7,975	0.034	Significativo (7)
OP Outros materiais informativos e divulgação população	15,856	p<=0.001	Significativo (8)
OP Outros	6,856	0.061	Não significativo

(1) Todos os PNs da classe 3 têm Planos de actividade e nenhum dos PNs da classe 4 os têm.
(2) Todos os PNs da classe 2 têm Planos de implementação e a esmagadora maioria dos PNs da classe 3 não os têm.
(3) A classe 2 é a única em que nenhum dos PNs tem relatórios de actividades
(4) Todos os PNs da classe 2 têm Planos de implementação e a esmagadora maioria dos PNs da classe 3 não os têm.
(5) A classe 1 é a única com PN's que apresentam relatórios de avaliação.
(6) Só um dos PNs da classe 1 não apresenta relatórios de projecto, enquanto a maioria dos PNs da classe 2 e todos os PNs da classe 4 não têm relatório de projecto.
(7) A classe 2 é a única em que a maioria dos PNs apresenta documentos de formação.
(8) A maioria dos PNs da classe 1 tem site de internet, enquanto na classe 5 apenas 1 site tem site.
(9) Todos os PNs da classe 2 apresentam outros materiais informativos e de divulgação à população, enquanto só 1 PN da classe 1 é que o faz.

Figure 7. Hierarchical cluster analysis of NP's, regarding variables from group G4 – Organization and management

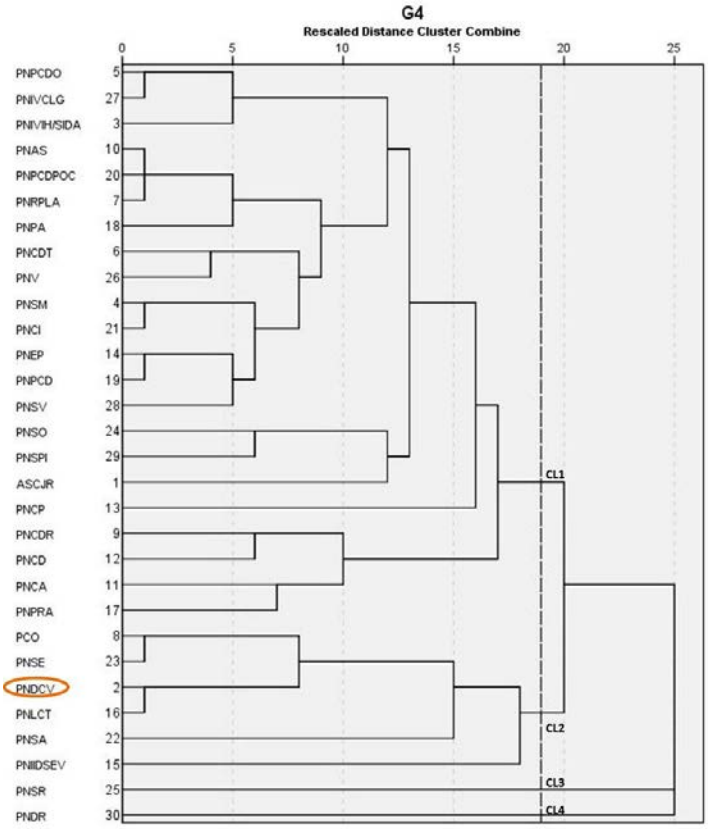


Table 13. Variables from group G4 – Organization and management crossed by 4 cluster partition of hierarchical cluster analysis of NP's regarding group G4

		Partição de 4 clusters G4							
		1		2		3		4	
		Freq	%	Freq	%	Freq	%	Freq	%
Docs de Planeamento	1	22	100,0%	6	100,0%	1	100,0%	1	100,0%
Docs de Avaliação	0	2	9,1%	0	0,0%	1	100,0%	1	100,0%
	1	20	90,9%	6	100,0%	0	0,0%	0	0,0%
Outras Publicações/Produtos Nº	0	1	4,5%	0	0,0%	0	0,0%	1	100,0%
	1	21	95,5%	6	100,0%	1	100,0%	0	0,0%
Missão Explicitada	1	22	100,0%	6	100,0%	1	100,0%	1	100,0%
Argumentação justificada de forma sistemática	0	19	86,4%	5	83,3%	1	100,0%	0	0,0%
	1	3	13,6%	1	16,7%	0	0,0%	1	100,0%
Existência de Objectivos específicos associados aos objectivos gerais	0	4	18,2%	6	100,0%	1	100,0%	0	0,0%
	1	18	81,8%	0	0,0%	0	0,0%	1	100,0%
Identificação possível de cumprimento de objectivos propostos	0	18	81,8%	6	100,0%	1	100,0%	1	100,0%
	1	4	18,2%	0	0,0%	0	0,0%	0	0,0%
Cronograma associado a metas	0	3	13,6%	3	50,0%	1	100,0%	0	0,0%
	1	19	86,4%	3	50,0%	0	0,0%	1	100,0%
Análise de risco, barreiras e dificuldades de implementação	0	14	63,6%	5	83,3%	1	100,0%	0	0,0%
	1	8	36,4%	1	16,7%	0	0,0%	1	100,0%
Descrição de processo de responsabilização/"accountability"	0	4	18,2%	6	100,0%	0	0,0%	0	0,0%
	1	18	81,8%	0	0,0%	1	100,0%	1	100,0%
Descrição do processo de avaliação global do plano/programa	0	6	27,3%	4	66,7%	1	100,0%	0	0,0%
	1	16	72,7%	2	33,3%	0	0,0%	1	100,0%

Table 14. Fisher Exact Tests for Group G4 variables crossed by selected 4 cluster partition

Variáveis	**Valor da Estatística de teste**	**Sig. (teste bilateral)**	**Resultado para alfa de 5%**
Docs de Avaliação	9,031	0.016	Significativo (2)
Docs de Planeamento (1)			
Outras Publicações/Produtos Nº	7,305	0.166	Não significativo
Missão Explicitada (1)			
Argumentação justificada de forma sistemática	4,339	0.345	Não significativo
Existência de Objectivos específicos associados aos objectivos gerais	15,222	p<=0.001	Significativo (3)
Identificação possível de cumprimento de objectivos propostos	2,120	0.663	Não significativo
Cronograma associado a metas	6,550	0.073	Não significativo
Análise de risco, barreiras e dificuldades de implementação	3,019	0.457	Não significativo
Descrição de processo de responsabilização/"accountability"	14,158	p<=0.001	Significativo (4)
Descrição do processo de avaliação global do plano/programa	5,161	0.109	Não significativo

(1) Todos os PNs de todas as classes da variável registam a mesma categoria, pelo que não se aplica o teste de hipóteses.
(2) As diferenças mais relevantes dizem respeito aos PNs das classes 3 e 4, com um PN em cada classe, pelo que o resultado do teste não é relevante.
(3) A maioria dos PNs da classe 1 regista uma ligação directa entre os objectivos específicos e os gerais, enquanto nenhum dos PNs da classe 2 o faz.
(4) A maioria dos PNs da classe 1 descreve o processo previsto ou aplicado de responsabilização / "accountability", enquanto nenhum dos PNs da classe 2 o faz.

Figure 8. Hierarchical cluster analysis of NP's, regarding variables from group G5 – Link to health problems, health gains and effectiveness gains

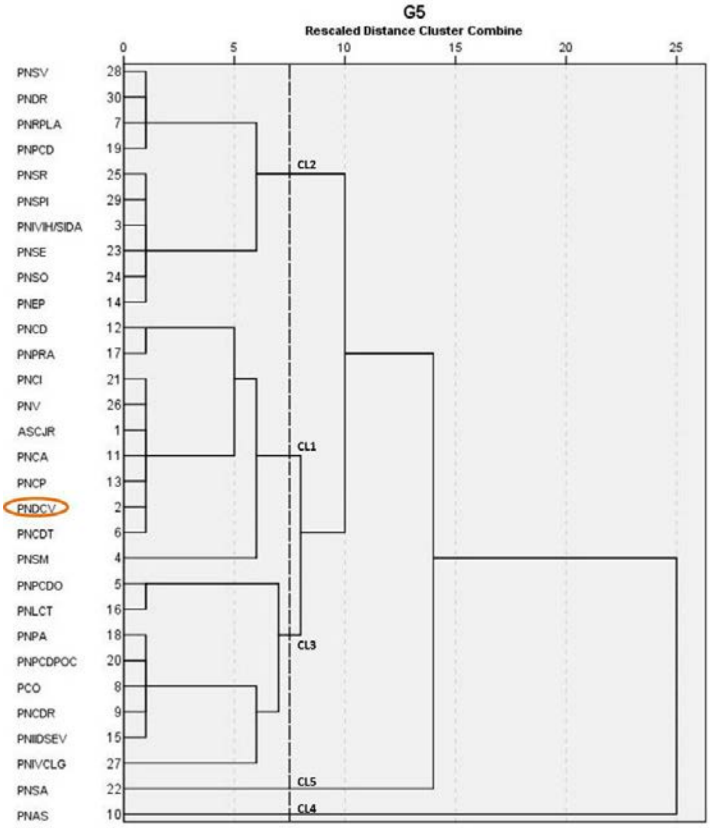


Table 15. Variables from group G5 – Link to health problems, health gains and effectiveness gains crossed by 4 cluster partition of hierarchical cluster analysis of NP's regarding group G5

		Partição de 5 clusters G5									
		1		2		3		4		5	
		Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
OG caracterizados pbs saude que justifiquem criação do plano	1	10	100,0%	10	100,0%	8	100,0%	1	100,0%	1	100,0%
OG caracterizados aspectos da organização/resposta do SS e outros que justifiquem criação do plano	0	0	0,0%	10	100,0%	0	0,0%	0	0,0%	1	100,0%
	1	10	100,0%	0	0,0%	8	100,0%	1	100,0%	0	0,0%
OG adequados aos pbs saude identificados	0	0	0,0%	0	0,0%	0	0,0%	1	100,0%	0	0,0%
	1	10	100,0%	10	100,0%	8	100,0%	0	0,0%	1	100,0%
OG Descrição dos processos de eleição e definição	0	2	20,0%	0	0,0%	2	25,0%	1	100,0%	0	0,0%
	1	8	80,0%	10	100,0%	6	75,0%	0	0,0%	1	100,0%
OG Identificados ganhos de saúde	0	1	10,0%	0	0,0%	1	12,5%	1	100,0%	1	100,0%
	1	9	90,0%	10	100,0%	7	87,5%	0	0,0%	0	0,0%
OG Identificados ganhos de efectividade	0	0	0,0%	4	40,0%	8	100,0%	1	100,0%	1	100,0%
	1	10	100,0%	6	60,0%	0	0,0%	0	0,0%	0	0,0%

Table 16. Fisher Exact Tests for Group G5 variables crossed by selected 4 cluster partition

Variáveis	**Valor da Estatística de teste**	**Sig. (teste bilateral)**	**Resultado para alfa de 5%**
OG caracterizados pbs saude que justifiquem criação do plano (1)			
OG caracterizados aspectos da organização/resposta do SS e outros que justifiquem criação do plano	30,837	p<=0.001	Significativo (2)
OG adequados aos pbs saude identificados	9,908	0.067	Não significativo
OG Descrição dos processos de eleição e definição	6,718	0.155	Não significativo
OG Identificados ganhos de saúde	9,670	0.017	Significativo (3)
OG Identificados ganhos de efectividade	21,824	p<=0.001	Significativo (4)
Argumentação justificada de forma sistemática	4,618	0.460	Não significativo

(1) Todos os PNs de todas as classes da variável registam a mesma categoria, pelo que não se aplica o teste de hipóteses.
(2) Todos os PNs das classes 1 e 3, mas nenhum PN da classe 2, apresentam uma caracterização de aspectos da organização/resposta do Sistema de Saúde como justificação de criação do PN.
(3) As diferenças mais relevantes dizem respeito aos PNs das classes 4 e 5, com um PN em cada classe, pelo que o resultado do teste não é relevante.
(4) Todos os PNs da classe 1, mas nenhum PN da classe 2, identificam ganhos de efectividade quando apresentam os seus objectivos gerais.

Figure 9. Hierarchical cluster analysis of NP's, regarding variables from group G7 – General aims, specific aims and associated projects

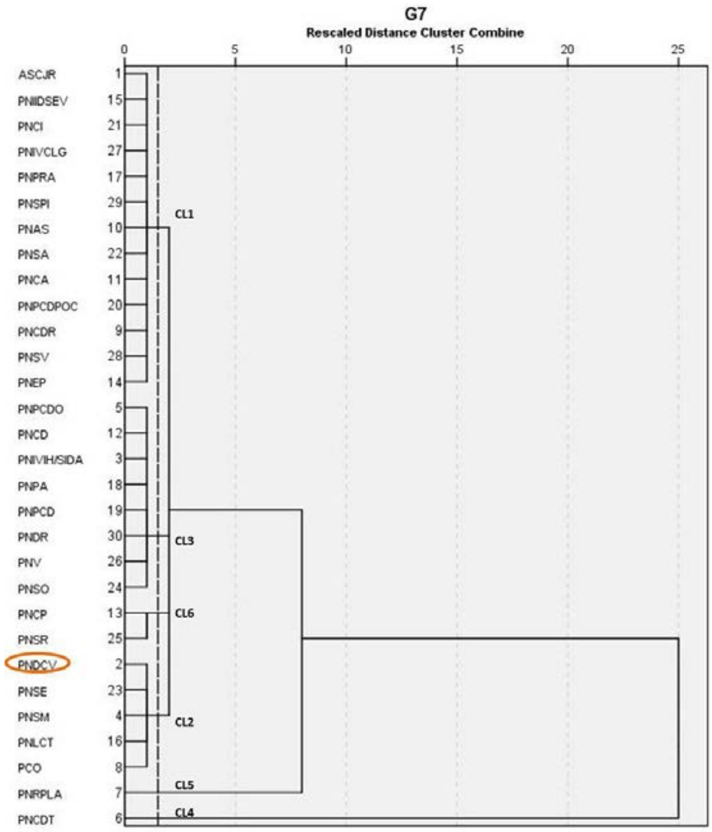


Table 17. Variables from group G7 – General aims, specific aims and associated projects crossed by 6 cluster partition of hierarchical cluster analysis of NP's regarding group G7

		Partição de 6 clusters G7					
		1	2	3	4	5	6
Objectivos Gerais Nº	Mean	1,9	5,0	2,9	6,0	7,0	8,0
	Standard Deviation	,8	,0	1,0	.	.	,0
	Median	2,0	5,0	3,0	6,0	7,0	8,0
	Percentile 25	1	5	3	6	7	8
	Percentile 75	2	5	4	6	7	8
Objectivos Específicos Nº	Mean	3,3	5,2	10,5	19,0	25,0	4,5
	Standard Deviation	1,5	2,8	2,8	.	.	,7
	Median	3,0	4,0	10,5	19,0	25,0	4,5
	Percentile 25	2	4	9	19	25	4
	Percentile 75	4	5	12	19	25	5
OE Projectos próprios a cada objectivo específico Nº total previsto inicialmente	Mean	7,7	,0	34,6	246,0	79,0	,0
	Standard Deviation	9,0	,0	11,1	.	.	,0
	Median	4,0	,0	35,0	246,0	79,0	,0
	Percentile 25	0	0	31	246	79	0
	Percentile 75	19	0	43	246	79	0
OE Projectos próprios a cada objectivo específico Nº total implementado	Mean	4,2	9,0	10,4	228,0	,0	1,5
	Standard Deviation	5,4	8,9	15,8	.	.	2,1
	Median	3,0	10,0	1,0	228,0	,0	1,5
	Percentile 25	1	0	0	228	0	0
	Percentile 75	4	15	20	228	0	3

Table 18. Hierarchical cluster analysis partition by k-means cluster partition

Variáveis Não standartizadas

		Partição de 6 clusters G7 KMEANS											
		1		2		3		4		5		6	
		Count	%	Count	%	Count	%	Count	%	Count	%	Count	%
Partição de 6 clusters G7	1	4	66,7%	2	40,0%	0	0,0%	0	0,0%	0	0,0%	7	63,6%
	2	0	0,0%	3	60,0%	0	0,0%	0	0,0%	0	0,0%	2	18,2%
	3	2	33,3%	0	0,0%	6	100,0%	0	0,0%	0	0,0%	0	0,0%
	4	0	0,0%	0	0,0%	0	0,0%	1	100,0%	0	0,0%	0	0,0%
	5	0	0,0%	0	0,0%	0	0,0%	0	0,0%	1	100,0%	0	0,0%
	6	0	0,0%	0	0,0%	0	0,0%	0	0,0%	0	0,0%	2	18,2%

Variáveis Standartizadas

		Partição de 6 clusters G7 KMEANS variaveis standartizadas											
		1		2		3		4		5		6	
		Count	%	Count	%	Count	%	Count	%	Count	%	Count	%
Partição de 6 clusters G7	1	13	100,0%	0	0,0%	0	0,0%	0	0,0%	0	0,0%	0	0,0%
	2	0	0,0%	5	100,0%	0	0,0%	0	0,0%	0	0,0%	0	0,0%
	3	0	0,0%	0	0,0%	8	100,0%	0	0,0%	0	0,0%	0	0,0%
	4	0	0,0%	0	0,0%	0	0,0%	1	100,0%	0	0,0%	0	0,0%
	5	0	0,0%	0	0,0%	0	0,0%	0	0,0%	1	100,0%	0	0,0%
	6	0	0,0%	0	0,0%	0	0,0%	0	0,0%	0	0,0%	2	100,0%

Figure 10. Hierarchical cluster analysis of NP's, regarding variables from group G8 – Characterization of specific aims in terms of % of total specific aims/projects achieved

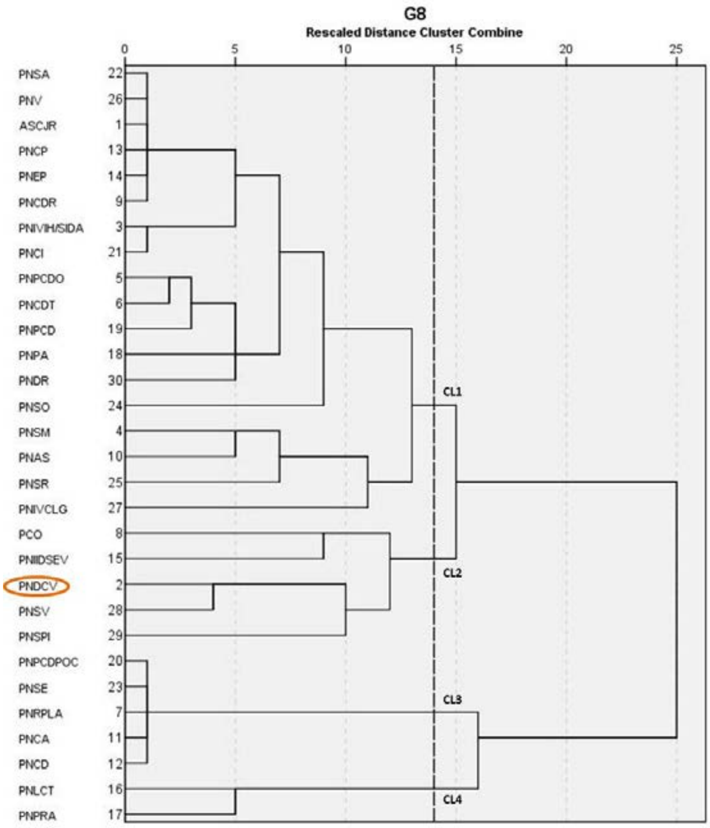


Table 19. Variables from group G8 – Characterization of specific aims in terms of % of total specific aims/projects achieved crossed by 4 cluster partition of hierarchical cluster analysis of NP's regarding group G8

		Partição de 4 clusters G8			
		1	2	3	4
OE Definidas necessidades saúde/população alvo/determinantes	Mean	92,2	100,0	,0	50,0
	Standard Deviation	24,9	,0	,0	70,7
	Median	100,0	100,0	,0	50,0
	Percentile 25	100	100	0	0
	Percentile 75	100	100	0	100
OE Definidos ganhos esperados	Mean	76,7	72,0	,0	100,0
	Standard Deviation	40,7	43,8	,0	,0
	Median	100,0	100,0	,0	100,0
	Percentile 25	75	60	0	100
	Percentile 75	100	100	0	100
OE Análise de acções propostas prevista	Mean	77,8	32,0	,0	,0
	Standard Deviation	36,4	46,0	,0	,0
	Median	100,0	,0	,0	,0
	Percentile 25	63	0	0	0
	Percentile 75	100	60	0	0
OE Parcerias com instituições regionais/locais	Mean	91,7	88,0	,0	,0
	Standard Deviation	15,1	26,8	,0	,0
	Median	100,0	100,0	,0	,0
	Percentile 25	83	100	0	0
	Percentile 75	100	100	0	0
OE Atribuição de recursos materiais	Mean	62,9	34,6	,0	,0
	Standard Deviation	42,4	40,9	,0	,0
	Median	83,5	33,0	,0	,0
	Percentile 25	25	0	0	0
	Percentile 75	100	40	0	0
OE Orçamentos e Relatórios de Execução	Mean	76,7	50,6	,0	,0
	Standard Deviation	35,5	46,6	,0	,0
	Median	100,0	33,0	,0	,0
	Percentile 25	63	20	0	0
	Percentile 75	100	100	0	0
OE Indicadores de operacionalização e concretização	Mean	92,2	50,6	,0	100,0
	Standard Deviation	14,5	46,6	,0	,0
	Median	100,0	33,0	,0	100,0
	Percentile 25	91	20	0	100
	Percentile 75	100	100	0	100
OE Avaliação através de metas	Mean	94,3	4,0	,0	100,0
	Standard Deviation	15,5	8,9	,0	,0
	Median	100,0	,0	,0	100,0
	Percentile 25	100	0	0	100
	Percentile 75	100	0	0	100
OE Análise de integração nos sistemas/serviços existentes	Mean	64,2	25,2	,0	12,5
	Standard Deviation	45,3	25,5	,0	17,7
	Median	95,5	33,0	,0	12,5
	Percentile 25	1	0	0	0
	Percentile 75	100	33	0	25

Table 20. Hierarchical cluster analysis partition by k-means cluster partition

Variáveis Não standartizadas

		Partição de 4 clusters G8 KMEANS							
		1		2		3		4	
		Count	%	Count	%	Count	%	Count	%
Partição de 4 clusters G8	1	18	100,0%	0	0,0%	0	0,0%	0	0,0%
	2	0	0,0%	5	100,0%	0	0,0%	0	0,0%
	3	0	0,0%	0	0,0%	5	100,0%	0	0,0%
	4	0	0,0%	0	0,0%	0	0,0%	2	100,0%

Variáveis Standartizadas

		Partição de 4 clusters G8 KMEANS variaveis standartizadas							
		1		2		3		4	
		Count	%	Count	%	Count	%	Count	%
Partição de 4 clusters G8	1	18	100,0%	0	0,0%	0	0,0%	0	0,0%
	2	0	0,0%	5	100,0%	0	0,0%	0	0,0%
	3	0	0,0%	0	0,0%	5	100,0%	0	0,0%
	4	0	0,0%	0	0,0%	0	0,0%	2	100,0%

Figure 11. Hierarchical cluster analysis of NP's, regarding variables from group G9 – Range of regional implementation

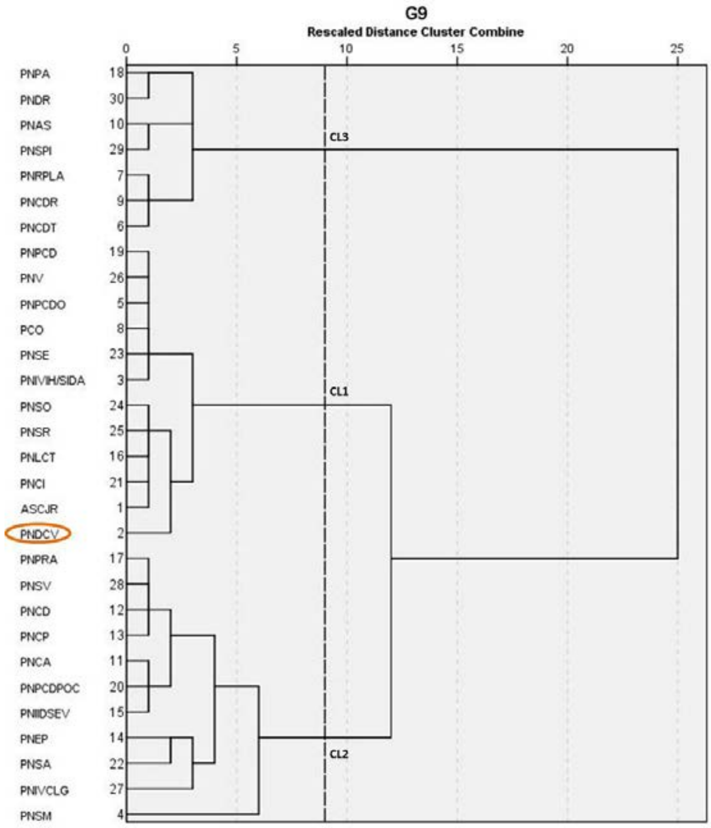


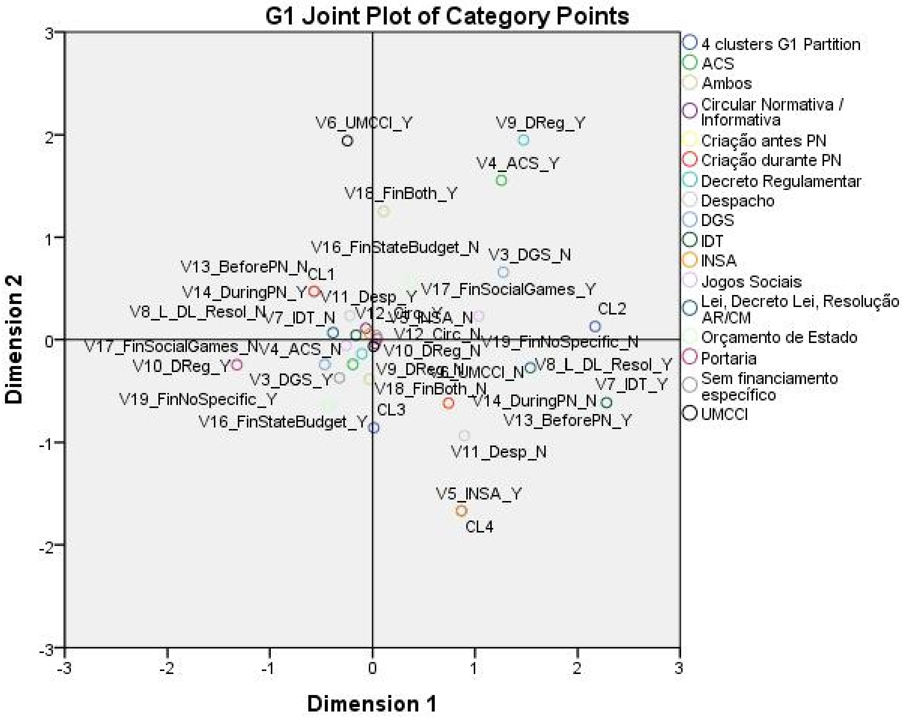
Table 21. Variables from group G9 – Range of regional implementation crossed by 3 cluster partition of hierarchical cluster analysis of NP's regarding group G9

		Partição de 3 clusters G9					
		1		2		3	
		Freq	%	Freq	%	Freq	%
Tem Coordenador Regional? (nº regiões)	0	0	0,0%	0	0,0%	3	42,9%
	1	0	0,0%	0	0,0%	1	14,3%
	2	0	0,0%	1	9,1%	3	42,9%
	3	0	0,0%	6	54,5%	0	0,0%
	4	1	8,3%	3	27,3%	0	0,0%
	5	11	91,7%	1	9,1%	0	0,0%
Está a ser implementado e tem projectos activos em 2011? (nº regiões)	0	0	0,0%	0	0,0%	3	42,9%
	1	0	0,0%	0	0,0%	2	28,6%
	2	0	0,0%	4	36,4%	2	28,6%
	3	0	0,0%	4	36,4%	0	0,0%
	4	0	0,0%	2	18,2%	0	0,0%
	5	12	100,0%	1	9,1%	0	0,0%
Tem Relatórios de Progresso Anual nos anos 2009-2010? (nº regiões)	0	0	0,0%	0	0,0%	7	100,0%
	1	0	0,0%	3	27,3%	0	0,0%
	2	0	0,0%	6	54,5%	0	0,0%
	3	3	25,0%	2	18,2%	0	0,0%
	4	4	33,3%	0	0,0%	0	0,0%
	5	5	41,7%	0	0,0%	0	0,0%
Foi realizada ou está prevista uma Avaliação do Programa a nível regional? (nº regiões)	0	0	0,0%	0	0,0%	7	100,0%
	1	0	0,0%	4	36,4%	0	0,0%
	2	0	0,0%	5	45,5%	0	0,0%
	3	3	25,0%	2	18,2%	0	0,0%
	4	2	16,7%	0	0,0%	0	0,0%
	5	7	58,3%	0	0,0%	0	0,0%

Table 22. Hierarchical cluster analysis partition by k-means cluster partition

		Partição de 3 clusters G9 KMEANS					
		1		2		3	
		Count	%	Count	%	Count	%
Partição de 3 clusters G9	1	12	100,0%	0	0,0%	0	0,0%
	2	0	0,0%	11	100,0%	0	0,0%
	3	0	0,0%	0	0,0%	7	100,0%

Figure 12. Multiple correspondence analysis (MCA) Factorial Plans for group G1 – Legal Context: binary variable categories and cases identified by National Program short name



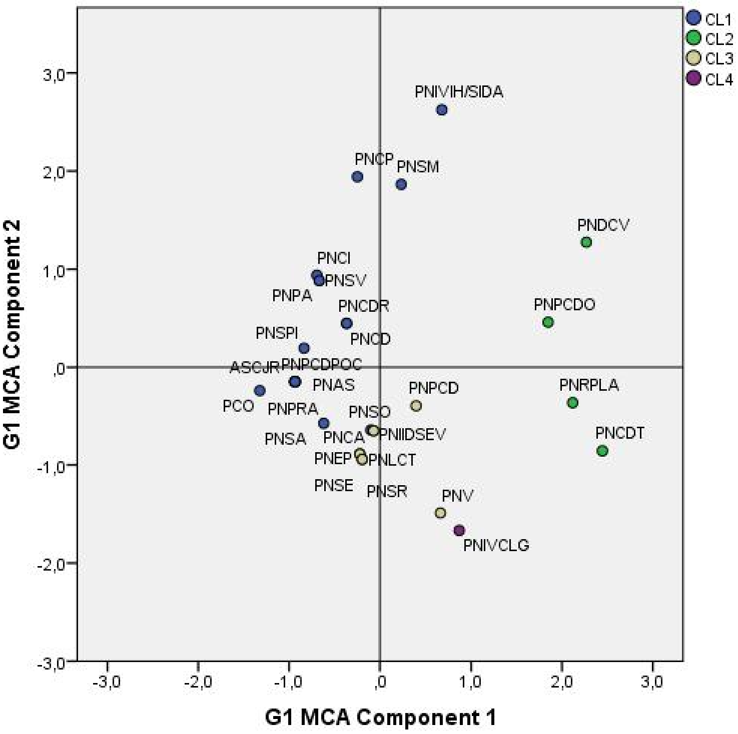
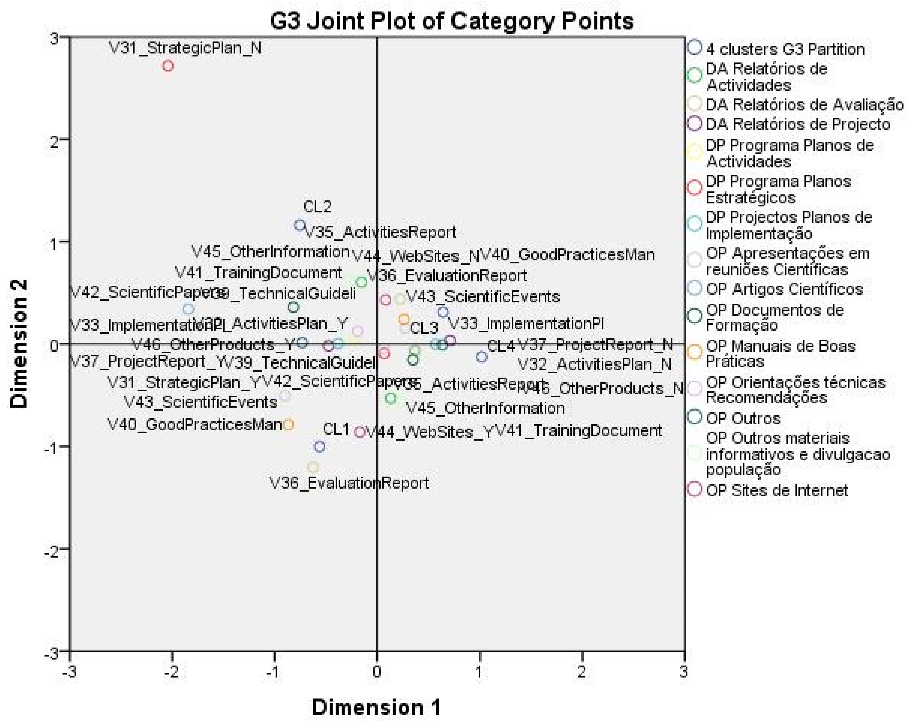


Figure 13. Multiple correspondence analysis (MCA) Factorial Plans for group G3 – Generated Products (planning, informations, etc.): binary variable categories and for cases identified by National Program short name



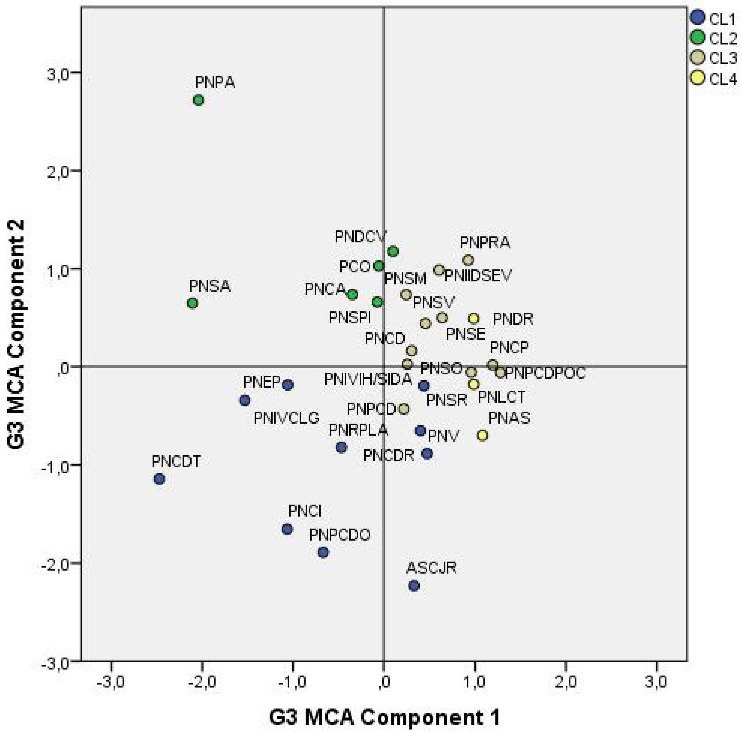
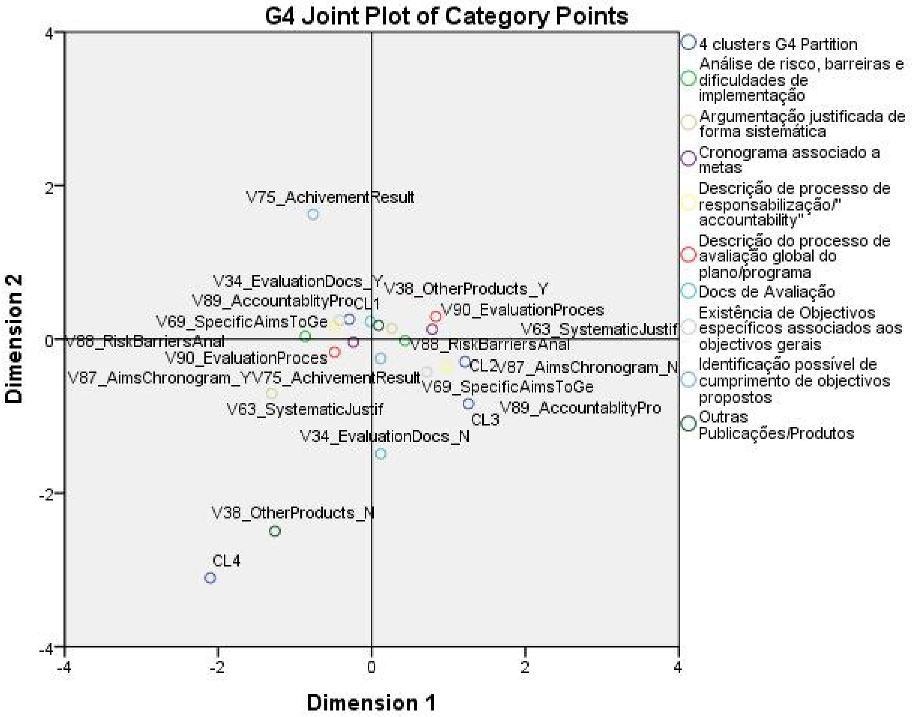


Figure 14. Multiple correspondence analysis (MCA) Factorial Plans for group G4 – Organization and management: binary variable categories and for cases identified by National Program short name



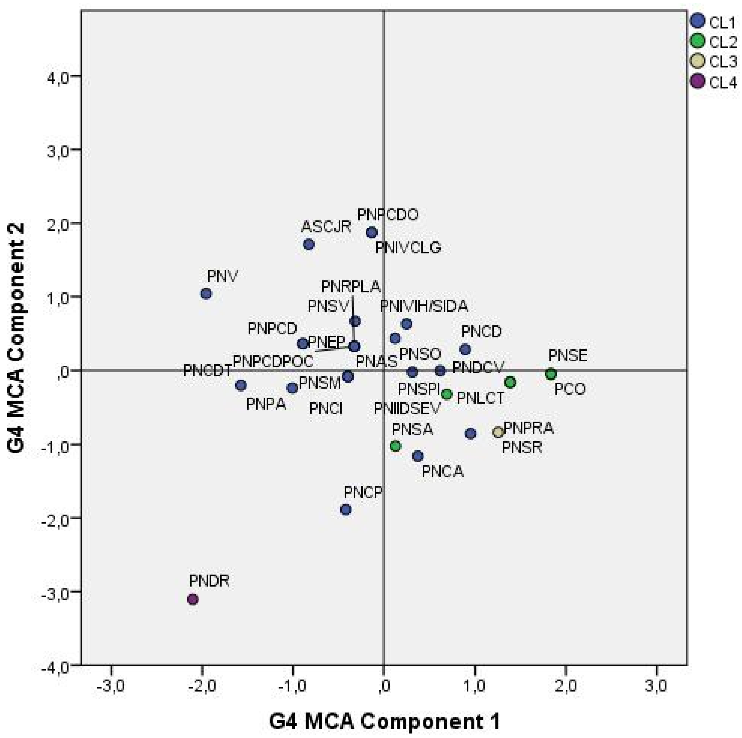
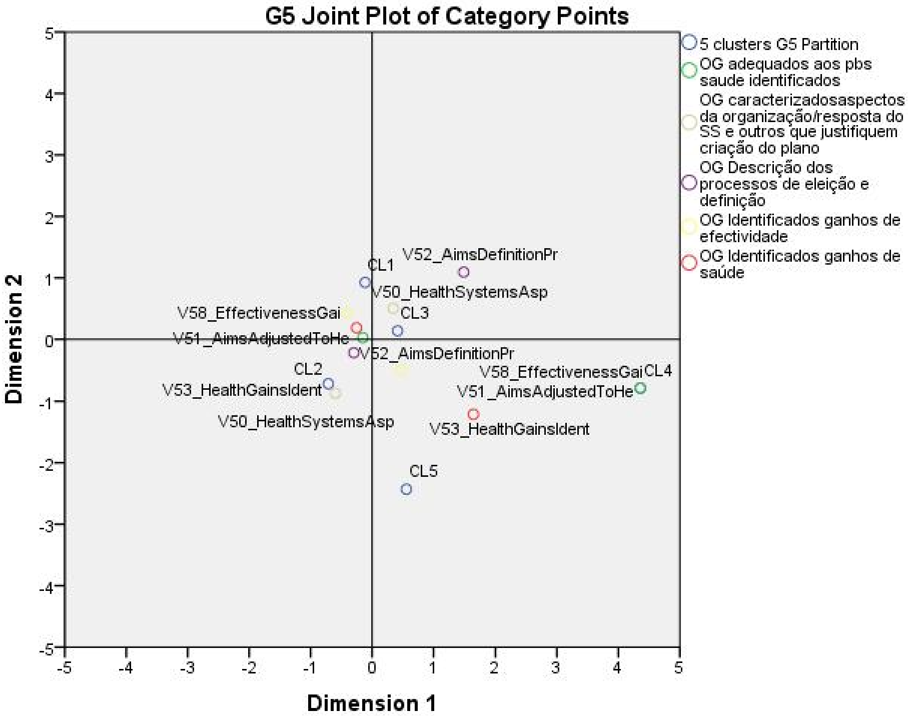


Figure 15. Multiple correspondence analysis (MCA) Factorial Plans for G5 – Link to health problems, health gains and effectiveness gains: binary variable categories and for cases identified by National Program short name



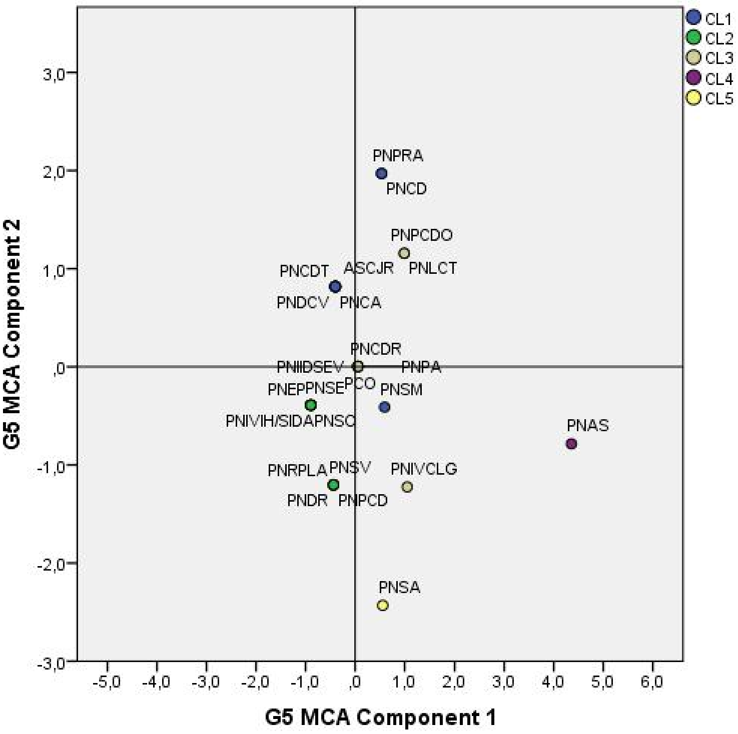
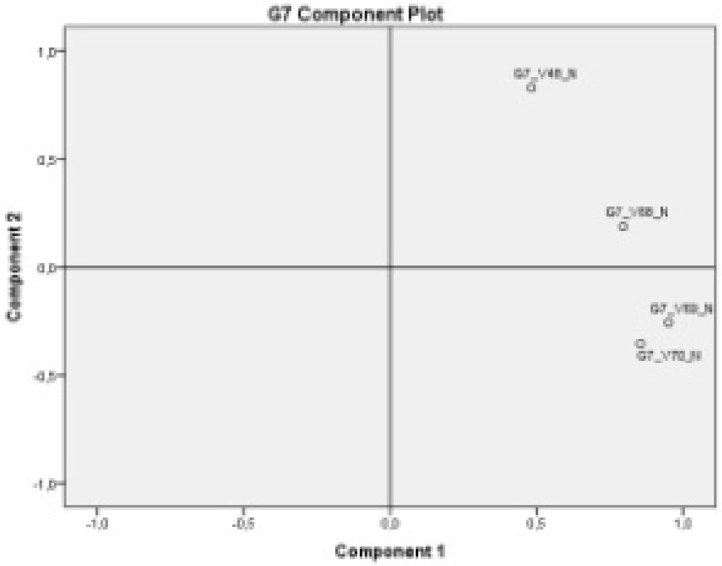


Figure 16. Principal components analysis (PCA) Factorial Plans for group of G7 – General aims, specific aims and associated projects: quantitative variables and cases identified by National Program short name and by associated cluster



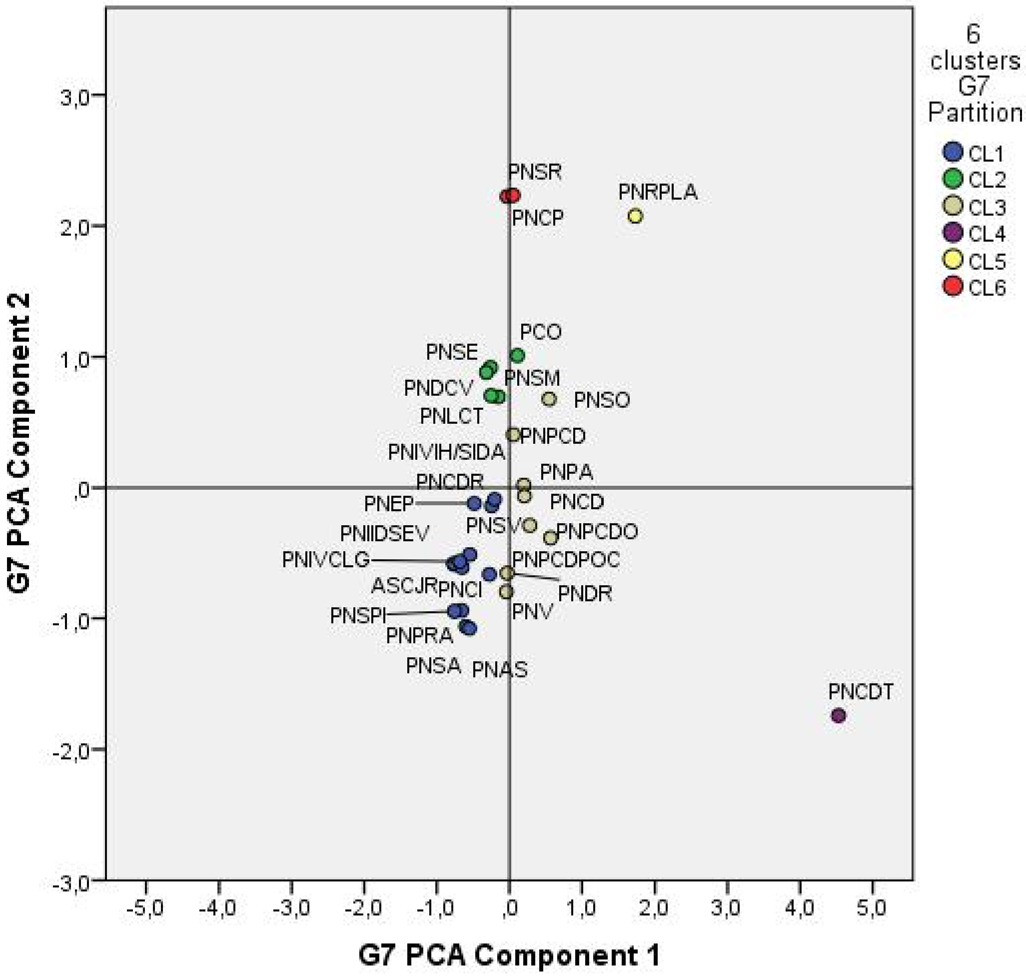
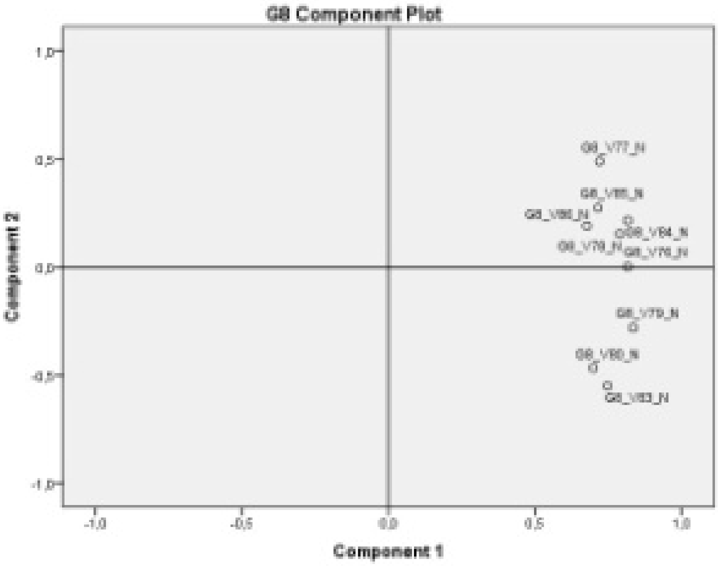


Figure 17. Principal components analysis (PCA) Factorial Plans for group of G8 – Characterization of specific aims in terms of % of total specific aims/projects achieved: quantitative variables and cases identified by National Program short name and by associated cluster



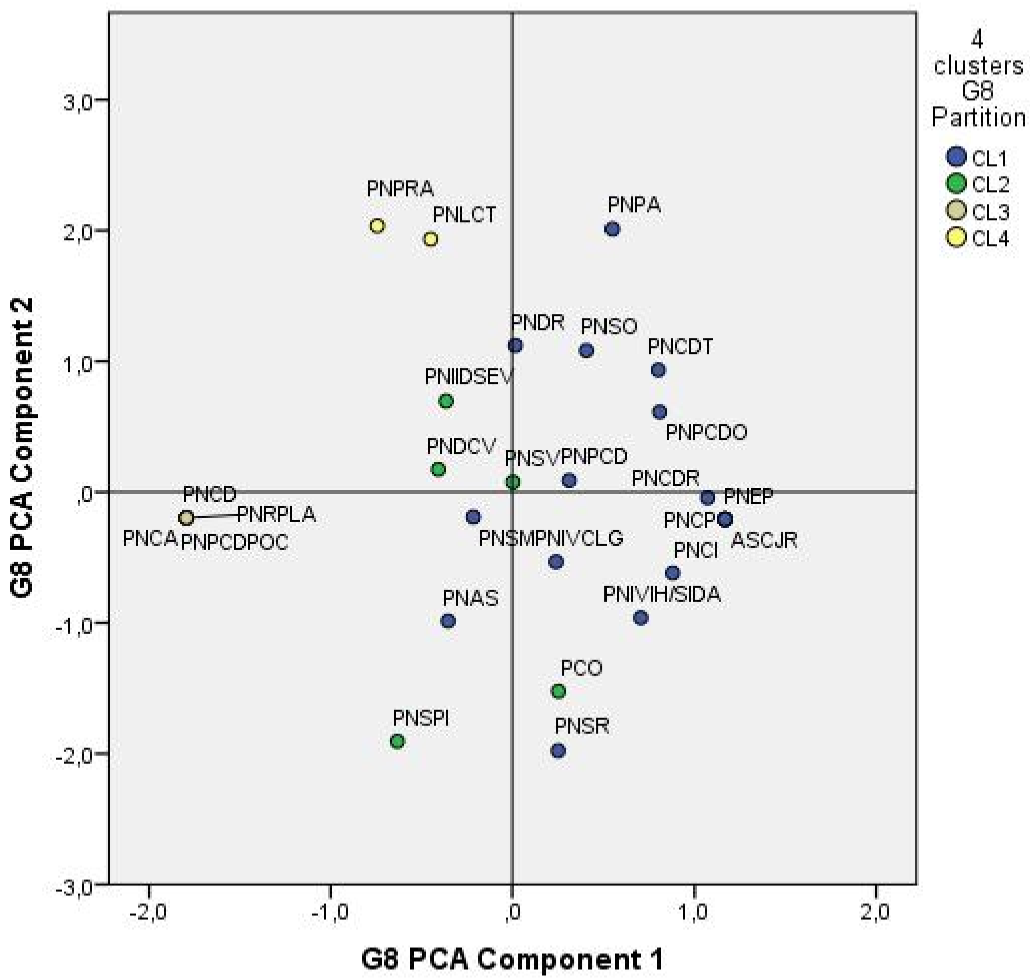
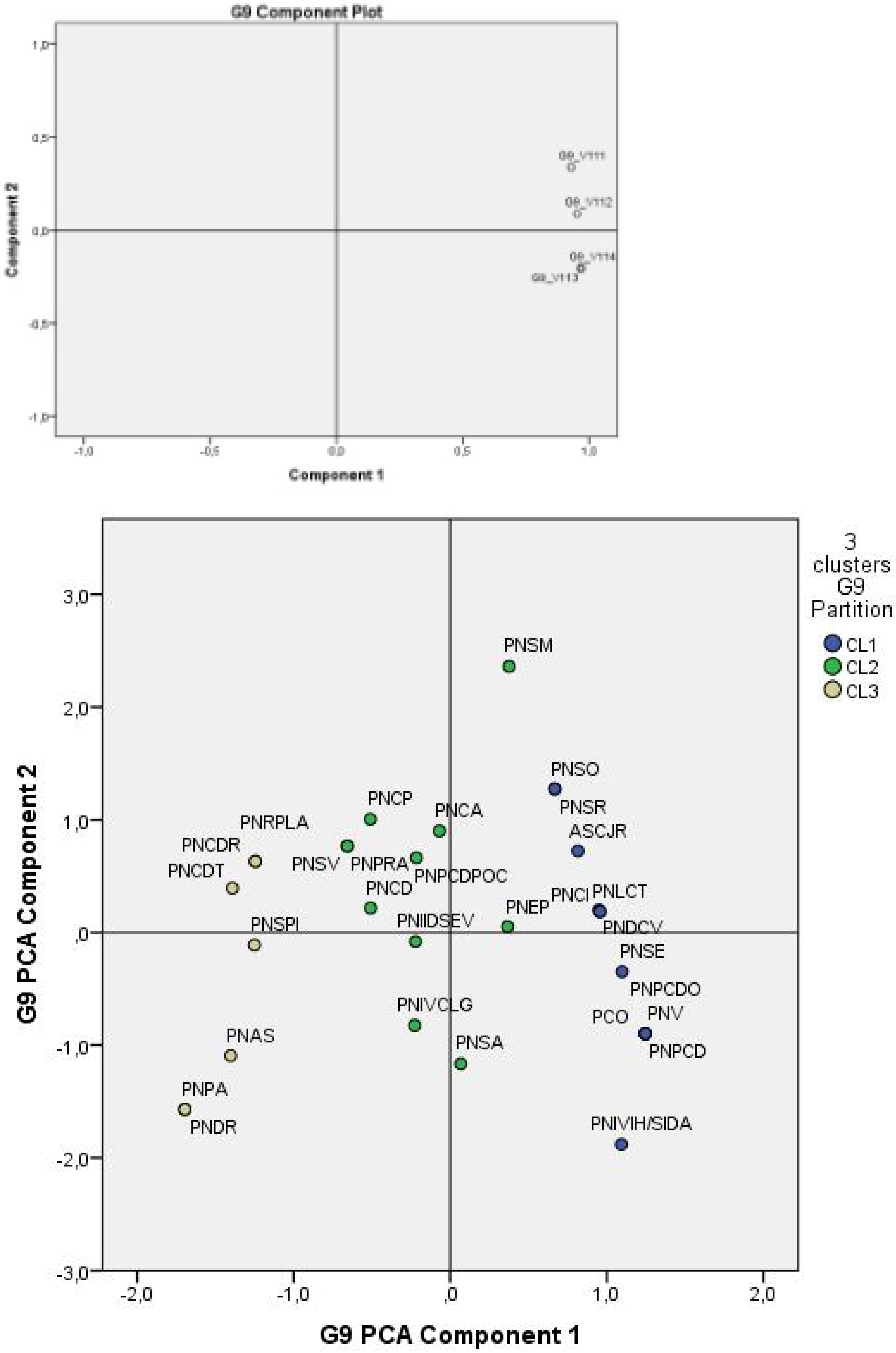


Figure 18. Principal components analysis (PCA) Factorial Plans for group of G9 – Range of regional implementation: quantitative variables and cases identified by National Program short name and by associated cluster



Appendix 6: Supplementary Material of Chapter 4

TITLE:
Picturing Inequities for Health Impact Assessment: Linked Electronic Records, Mortality and Regional Disparities in Portugal

SUPPLEMENTAL ONLINE MATERIAL

Table of Contents

I. Statistical Methodologies

Statistical methodologies differ depending on the stage of the study undertaken. In the first stage an association between registering or not indicators and regions of residence was regarded and in the second stage the association between mortality and registering or not indicators by region was considered. In each stage, a bivariate approach was first undertaken with contingency tables, independence chi-square or Fisher exact tests (Daniel 2009), followed by a multivariate approach based on logistic regression with Odds Ratios (Kleinbaum and Klein 2010), where crude results were calculated and then adjusted results after controlling for sex, age and sex and age interaction, as well as hospital admission severity indicators, and on multivariate exploratory data analysis such as principal components analysis or multivariate correspondence analysis (Hair et al. 2006;Saporta 2011).

Association between registering or not indicators and region of residence

The association between each of the registered indicators (Blood Pressure, Cholesterol, Triglycerides, Waist Circumference, BMI) and the region of residence (Norte, Centro, LVT, Alentejo and Algarve) was analyzed initially with a bivariate approach. Contingency tables were built for each health indicator by region of residence with percentages of registration and no registration by region, adjusted residuals, multiple comparisons, comparing proportions adjusted by Bonferroni whenever justified and Independence Chi Square Tests. Regarding this approach, only percentages and Independence Chi-Square Tests results are presented here.

Then, a multivariate statistical approach was undertaken in a crude way (with Algarve as reference category whenever necessary) and then after controlling for Sex, Age and Sex*Age.

Crude Odds Ratios (OR) were calculated, as well as respective CI95% and statistical significance, with Logistic Regressions using each Registered Indicator as dependent variable and Region of residence as independent variable (with Algarve as reference category).

Adjusted OR were calculated, as well as respective CI95% and statistical significance, with Logistic Regressions using each Registered Indicator as a dependent variable, Region of residence as independent variable (with Algarve as reference category), adjusted by Sex, Age and considering their interaction Sex*Age. Algarve was chosen as reference category since it presented the higher percentage of no registration for almost all indicators. Additional models with other regions as reference categories were estimated to identify significant differences between regions.

Finally, Principal Component Analysis (PCA) was applied on the OR from different indicators and regions to help summarize the previous findings as an easier way to visualize results.

Association between Mortality and registering or not indicators, by region

The association between not registering each of the indicators and the mortality outcome was first assessed through 2x2 contingency tables for each Registered Indicator by Outcome, with percentages of registration and no registration within the overall sample and for each region, adjusted residuals and Fisher Exact Tests. Only percentages and Fisher Exact Tests results are presented in this document.

Crude OR were calculated, as well as respective CI95% and statistical significance, initially in an overall approach with Logistic Regressions using the Mortality Outcome as dependent variable and each Registered Indicator as independent variable.

Then adjusted OR were calculated, as well as respective CI95% and statistical significance, with Logistic Regressions using the Mortality Outcome as a dependent variable and each Registered Indicator as independent variable, adjusted by Sex, Age and considering interaction Sex*Age and afterwards also by the 4 Admission Severity indicators.

Subsequently the overall OR and both types of adjusted OR were calculated also controlling for region (with Algarve as reference region).

Finally, the overall OR and both types of adjusted OR were stratified by region.

Our focus for analysis will be the OR obtained through the stratified models, adjusted by Sex, Age, Sex*Age interaction and the 4 Admission Severity indicators. Note that data from Algarve did not generate reliable solutions for indicators Cholesterol, Triglycerides and Waist circumference and gave higher limits for the 95%CI for OR regarding Blood Pressure and especially BMI. Data from Alentejo generated reliable solutions only for Waist circumference and also gave us higher limits for the 95%CI for OR regarding BMI. Norte generated high OR and related limits of the 95%CI for OR regarding Cholesterol and Triglycerides.

All the logistic regression approaches were produced imposing the presence of all the variables with the Enter method. Complementary variables were also additionally selected through a Stepwise forward method to check the robustness of the choice process of variables. The results of the models obtained through the Enter method are the ones analyzed here.

Lastly Multiple Correspondence Analysis (MCA) was applied using all categorical variables under study. Coordinates, relative and absolute contributions for all categories of variables regarding first 10 dimensions were analyzed.

Statistical software and significance level used

Statistical analyses were generally conducted using the IBM-SPSS version 22 software. A significance level of 5% was used whenever statistical tests were applied.

II. Complementary Tables and Figures

Stage 1: Association between registering or not indicators and region of residence

Figure 6. Registration of each health indicator by health region of residence – graphic visualization

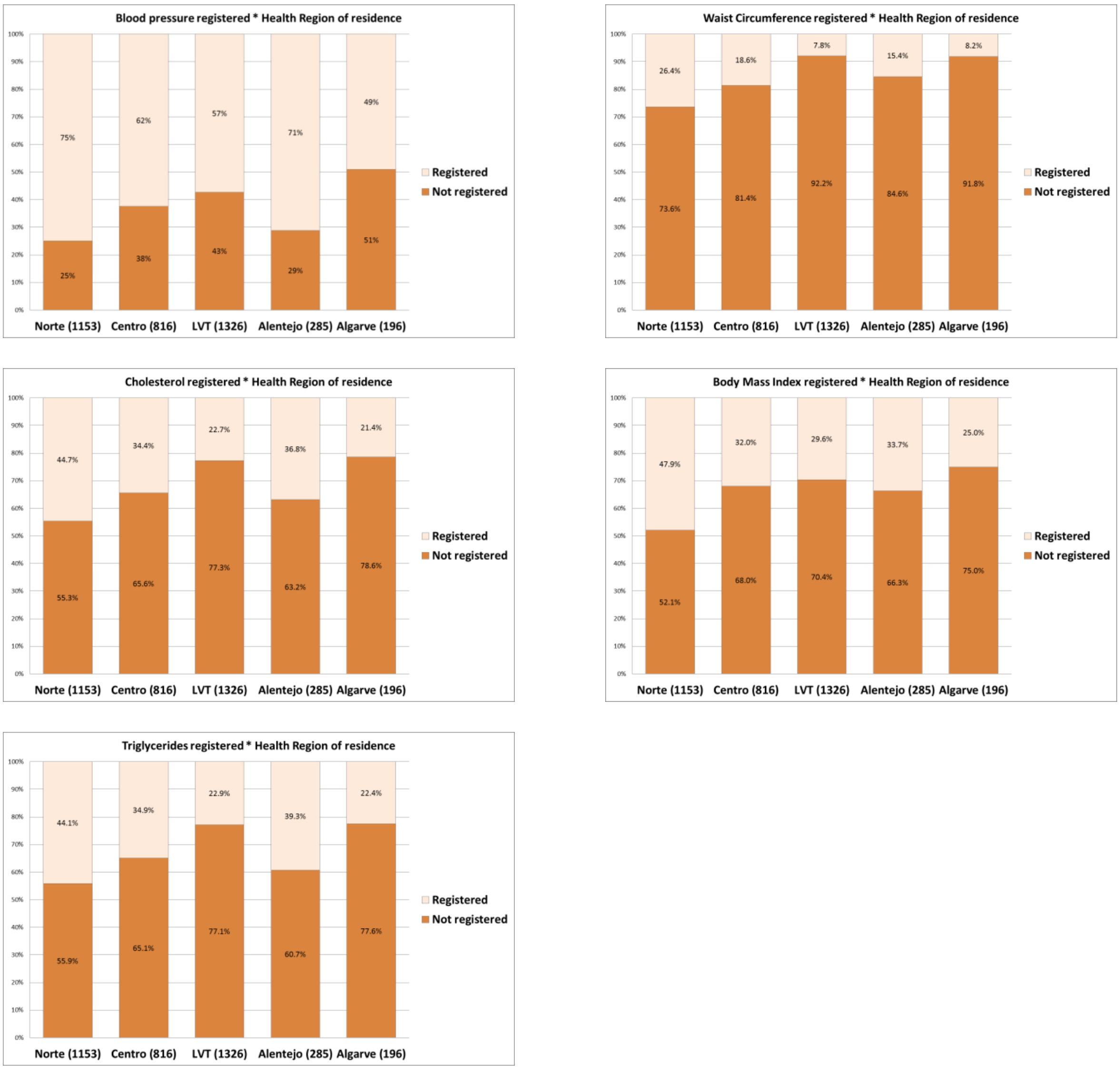


Table 10. Registration of health indicators by health region of residence - % and chi-square independence tests

Region of residence (n)	Not registered	Registered	p-value (χ^2) (1)
Blood pressure registered			
Norte (1153)	25.1%	74.9%	p<0.001 (113.02)
Centro (816)	37.6%	62.4%	
LVT (1326)	42.8%	57.2%	
Alentejo (285)	28.8%	71.2%	
Algarve (196)	51.0%	49.0%	
Cholesterol registered			
Norte (1153)	55.3%	44.7%	p<0.001 (149.255)
Centro (816)	65.6%	34.4%	
LVT (1326)	77.3%	22.7%	
Alentejo (285)	63.2%	36.8%	
Algarve (196)	78.6%	21.4%	
Triglycerides registered			
Norte (1153)	55.9%	44.1%	p<0.001 (142.454)
Centro (816)	65.1%	34.9%	
LVT (1326)	77.1%	22.9%	
Alentejo (285)	60.7%	39.3%	
Algarve (196)	77.6%	22.4%	
Waist circumference registered			
Norte (1153)	73.6%	26.4%	p<0.001 (167.024)
Centro (816)	81.4%	18.6%	
LVT (1326)	92.2%	7.8%	
Alentejo (285)	84.6%	15.4%	
Algarve (196)	91.8%	8.2%	
Body Mass Index registered			
Norte (1153)	52.1%	47.9%	p<0.001 (15.053)
Centro (816)	68.0%	32.0%	
LVT (1326)	70.4%	29.6%	
Alentejo (285)	66.3%	33.7%	
Algarve (196)	75.0%	25.0%	

(1) χ^2 Independence tests

Table 11. Odds ratios for registration of each health indicator by health region of residence

Region of residence (n)	Crude OR	CI 95%	p-value	Adjusted OR (1)	CI 95%	p-value
Blood pressure registered			**p<=0.001**			**p<=0.001**
Norte (1153)	3.114	[2.284;4.246]	p<=0.001	3.223	[2.356;4.409]	p<=0.001
Centro (816)	1.727	[1.262;2.364]	0.001	1.682	[1.226;2.309]	0.001
LVT (1326)	1.394	[1.033;1.883]	0.030	1.370	[1.012;1.855]	0.042
Alentejo (285)	2.579	[1.764;3.77]	p<=0.001	2.559	[1.746;3.751]	p<=0.001
Algarve (196) (2)	1			1		
Cholesterol registered			**p<=0.001**			**p<=0.001**
Norte (1153)	2.960	[2.064;4.244]	p<=0.001	2.948	[2.054;4.232]	p<=0.001
Centro (816)	1.926	[1.33;2.789]	0.001	1.910	[1.317;2.769]	0.001
LVT (1326)	1.077	[0.748;1.55]	0.691	1.069	[0.742;1.541]	0.719
Alentejo (285)	2.139	[1.409;3.247]	p<=0.001	2.155	[1.418;3.275]	p<=0.001
Algarve (196) (2)	1			1		
Triglycerides registered			**p<=0.001**			**p<=0.001**
Norte (1153)	2.730	[1.914;3.894]	p<=0.001	2.714	[1.901;3.876]	p<=0.001
Centro (816)	1.854	[1.287;2.671]	0.001	1.840	[1.276;2.653]	0.001
LVT (1326)	1.023	[0.714;1.465]	0.900	1.016	[0.709;1.456]	0.932
Alentejo (285)	2.236	[1.482;3.374]	p<=0.001	2.259	[1.495;3.411]	p<=0.001
Algarve (196) (2)	1			1		
Waist circumference registered			**p<=0.001**			**p<=0.001**
Norte (1153)	4.028	[2.376;6.829]	p<=0.001	4.098	[2.415;6.954]	p<=0.001
Centro (816)	2.575	[1.5;4.423]	0.001	2.530	[1.472;4.348]	0.001
LVT (1326)	0.957	[0.553;1.658]	0.877	0.952	[0.549;1.649]	0.859
Alentejo (285)	2.054	[1.123;3.757]	0.019	2.041	[1.115;3.737]	0.021
Algarve (196) (2)	1			1		
Body Mass Index registered			**p<=0.001**			**p<=0.001**
Norte (1153)	2.755	[1.955;3.884]	p<=0.001	2.783	[1.971;3.93]	p<=0.001
Centro (816)	1.411	[0.989;2.012]	0.058	1.390	[0.973;1.986]	0.070
LVT (1326)	1.264	[0.896;1.783]	0.183	1.246	[0.882;1.76]	0.213
Alentejo (285)	1.524	[1.015;2.287]	0.042	1.530	[1.018;2.3]	0.041
Algarve (196) (2)	1			1		

(1) After controlling for Sex, Age, Sex*Age (2) Algarve as Reference Category

Table 12. Odds ratios for registration of each health indicator by health region of residence taking each region as reference category in turn

	Norte as Reference Category			Centro as Reference Category			LVT as Reference Category			Alentejo as Reference Category			Algarve as Reference Category		
	OR (1)	CI 95%	p-value	OR (1)	CI 95%	p-value	OR (1)	CI 95%	p-value	OR (1)	CI 95%	p-value	OR (1)	CI 95%	p-value
Blood pressure registered															
Norte	1		p<=0.001	1.916	[1.573;2.333]	p<=0.001	2.352	[1.975;2.8]	p<=0.001	1.259	[0.941;1.686]	0.121	3.223	[2.356;4.409]	p<=0.001
Centro	0.522	[0.429;0.636]	p<=0.001	1		p<=0.001	1.228	[1.025;1.47]	0.025	0.657	[0.49;0.883]	0.005	1.682	[1.226;2.309]	0.001
LVT	0.425	[0.357;0.506]	p<=0.001	0.025	[0.68;0.975]	0.025	1		p<=0.001	0.535	[0.405;0.709]	p<=0.001	1.370	[1.012;1.855]	0.042
Alentejo	0.794	[0.593;1.063]	0.121	0.005	[1.133;2.042]	0.005	1.867	[1.411;2.471]	p<=0.001	1		p<=0.001	2.559	[1.746;3.751]	p<=0.001
Algarve	0.310	[0.227;0.424]	p<=0.001	0.001	[0.433;0.816]	0.001	0.730	[0.539;0.988]	0.042	0.391	[0.267;0.573]	p<=0.001	1		p<=0.001
Cholesterol registered															
Norte	1		p<=0.001	1.544	[1.281;1.861]	p<=0.001	2.758	[2.317;3.282]	p<=0.001	1.368	[1.046;1.79]	0.022	2.948	[2.054;4.232]	p<=0.001
Centro	0.648	[0.537;0.781]	p<=0.001	1		p<=0.001	1.786	[1.471;2.168]	p<=0.001	0.886	[0.669;1.174]	0.400	1.910	[1.317;2.769]	0.001
LVT	0.363	[0.305;0.432]	p<=0.001	0.560	[0.461;0.68]	p<=0.001	1		p<=0.001	0.496	[0.377;0.652]	p<=0.001	1.069	[0.742;1.541]	0.719
Alentejo	0.731	[0.559;0.956]	0.022	1.128	[0.852;1.495]	0.400	2.016	[1.533;2.65]	p<=0.001	1		p<=0.001	2.155	[1.418;3.275]	p<=0.001
Algarve	0.339	[0.236;0.487]	p<=0.001	0.524	[0.361;0.759]	0.001	0.935	[0.649;1.348]	0.719	0.464	[0.305;0.705]	p<=0.001	1		p<=0.001
Triglycerides registered															
Norte	1		p<=0.001	1.475	[1.224;1.778]	p<=0.001	2.673	[2.246;3.18]	p<=0.001	1.202	[0.921;1.568]	0.176	2.714	[1.901;3.876]	p<=0.001
Centro	0.678	[0.562;0.817]	p<=0.001	1		p<=0.001	1.811	[1.493;2.198]	p<=0.001	0.815	[0.616;1.077]	0.150	1.840	[1.276;2.653]	0.001
LVT	0.374	[0.314;0.445]	p<=0.001	0.552	[0.455;0.67]	p<=0.001	1		p<=0.001	0.450	[0.343;0.59]	p<=0.001	1.016	[0.709;1.456]	0.932
Alentejo	0.832	[0.638;1.086]	0.176	1.228	[0.929;1.622]	0.150	2.224	[1.696;2.916]	p<=0.001	1		p<=0.001	2.259	[1.495;3.411]	p<=0.001
Algarve	0.368	[0.258;0.526]	p<=0.001	0.544	[0.377;0.784]	0.001	0.985	[0.687;1.411]	0.932	0.443	[0.293;0.669]	p<=0.001	1		p<=0.001

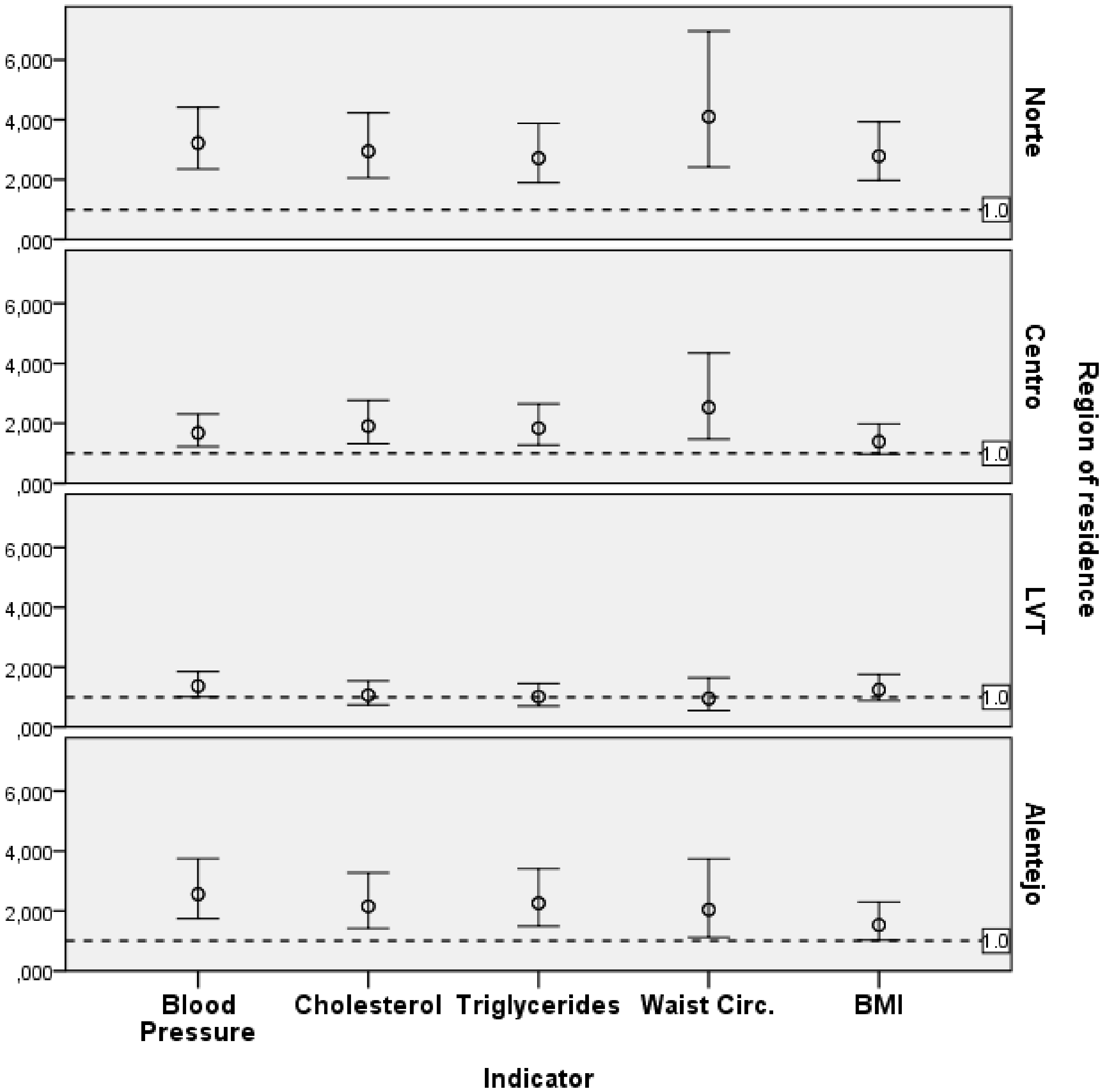
(1) After controlling for Sex, Age, Sex*Age

Table 3. (Cont.) Odds ratios for registration of each health indicator by health region of residence taking each region as reference category in turn

	Norte as Reference Category			Centro as Reference Category			LVT as Reference Category			Alentejo as Reference Category			Algarve as Reference Category		
	OR (1)	CI 95%	p-value	OR (1)	CI 95%	p-value	OR (1)	CI 95%	p-value	OR (1)	CI 95%	p-value	OR (1)	CI 95%	p-value
Waist circumference registered															
Norte	1		p<=0.001	1.620	[1.298;2.022]	p<=0.001	4.307	[3.387;5.477]	p<=0.001	2.008	[1.416;2.846]	p<=0.001	4.098	[2.415;6.954]	p<=0.001
Centro	0.617	[0.495;0.771]	p<=0.001	1		p<=0.001	2.659	[2.035;3.474]	p<=0.001	1.239	[0.858;1.79]	0.252	2.530	[1.472;4.348]	0.001
LVT	0.232	[0.183;0.295]	p<=0.001	0.376	[0.288;0.491]	p<=0.001	1		p<=0.001	0.466	[0.319;0.681]	p<=0.001	0.952	[0.549;1.649]	0.859
Alentejo	0.498	[0.351;0.706]	p<=0.001	0.807	[0.559;1.165]	0.252	2.145	[1.468;3.135]	p<=0.001	1		p<=0.001	2.041	[1.115;3.737]	0.021
Algarve	0.244	[0.144;0.414]	p<=0.001	0.395	[0.23;0.679]	0.001	1.051	[0.607;1.821]	0.859	0.021	[0.268;0.897]	0.021	1		p<=0.001
BMI registered															
Norte	1		p<=0.001	2.002	[1.657;2.418]	p<=0.001	2.234	[1.891;2.639]	p<=0.001	1.819	[1.384;2.391]	p<=0.001	2.783	[1.971;3.93]	p<=0.001
Centro	0.500	[0.414;0.604]	p<=0.001	1		p<=0.001	1.116	[0.924;1.349]	0.255	0.909	[0.682;1.211]	0.514	1.390	[0.973;1.986]	0.070
LVT	0.448	[0.379;0.529]	p<=0.001	0.896	[0.741;1.083]	0.255	1		p<=0.001	0.814	[0.619;1.07]	0.141	1.246	[0.882;1.76]	0.213
Alentejo	0.550	[0.418;0.723]	p<=0.001	1.100	[0.825;1.467]	0.514	1.228	[0.934;1.615]	0.141	1		p<=0.001	1.530	[1.018;2.3]	0.041
Algarve	0.359	[0.254;0.507]	p<=0.001	0.719	[0.503;1.028]	0.070	0.803	[0.568;1.134]	0.213	0.654	[0.435;0.983]	0.041	1		p<=0.001

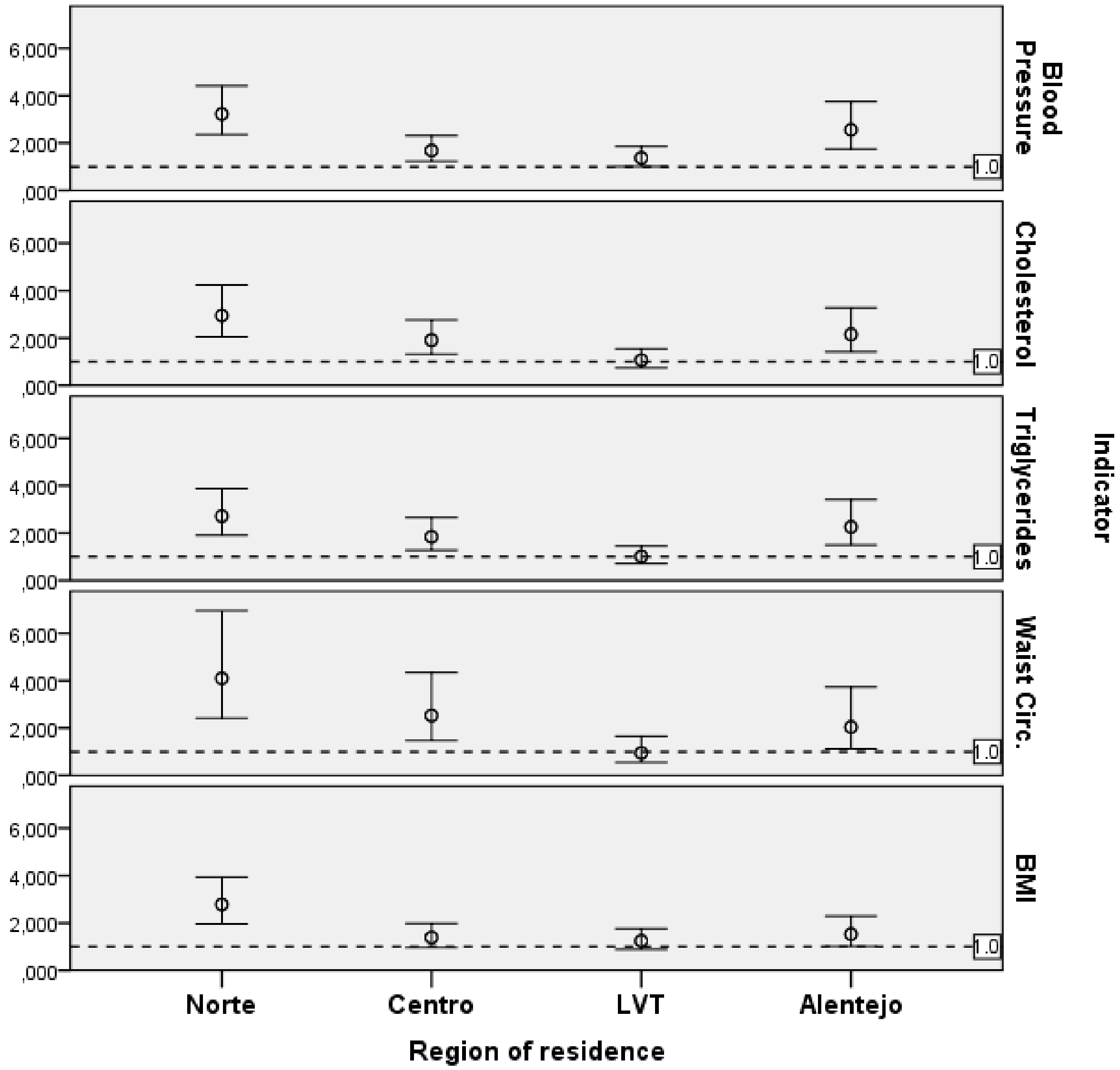
(1) After controlling for Sex, Age, Sex*Age

Figure 7. 95% Confidence Intervals of Adjusted OR for registration of each health indicator by health region of residence, visualized by health region of residence [1,2]



(1) After controlling for Sex, Age, Sex*Age
(2) Algarve as Reference Category

Figure 8. 95% Confidence Intervals of Adjusted OR for registration of each health indicator by health region of residence, visualized by health indicator registered [1,2]



(1) After controlling for Sex, Age, Sex*Age
(2) Algarve as Reference Category

Table 13. Summary of Adjusted OR for Regions by Registered Indicators, used as input for PCA

	Adjusted OR for Registered Indicator				
Region of residence	**Blood pressure**	**Cholesterol**	**Triglycerides**	**Waist circumference**	**BMI**
Norte	3.223	2.948	2.714	4.098	2.783
Centro	1.682	1.910	1.840	2.530	1.390
LVT	1.370	1.069	1.016	0.952	1.246
Alentejo	2.559	2.155	2.259	2.041	1.530
Algarve	1.000	1.000	1.000	1.000	1.000

Color Code	OR adjusted
(dark green)	>= 2.000
(light green)	[1.5 - 2.000[
(light peach)	[1.0 - 1.5[
(orange)	<1.0

Stage 2: Association between Mortality and registering or not indicators, by region

Table 14. Outcome by Registration of Blood Pressure, overall and for each region - % and Fisher Exact Tests

Blood Pressure registered or not		Outcome (at Dec 31 2013)		
		Not Deceased	Deceased	p-value *
Overall Sample	n	3507	269	
Not registered		34.3%	53.2%	p<0.001
Registered		65.7%	46.8%	
By Region				
Norte	n	1071	82	
Not registered		23.3%	47.6%	p<0.001
Registered		76.7%	52.4%	
Centro	n	755	61	
Not registered		36.2%	55.7%	0.004
Registered		63.8%	44.3%	
LVT	n	1239	87	
Not registered		41.6%	58.6%	0.002
Registered		58.4%	41.4%	
Alentejo	n	259	26	
Not registered		28.2%	34.6%	0.500
Registered		71.8%	65.4%	
Algarve	n	183	13	
Not registered		49.2%	76.9%	0.082
Registered		50.8%	23.1%	

* Fisher Exact Test

Table 15. Outcome by Registration of Cholesterol, overall and for each region - % and Fisher Exact Tests

Cholesterol registered or not		Outcome (at Dec 31 2013)		
		Not Deceased	Deceased	p-value *
Overall Sample	n	3507	269	
Not registered		65.3%	89.6%	p<0.001
Registered		34.7%	10.4%	
By Region				
Norte	n	1071	82	
Not registered		52.4%	93.9%	p<0.001
Registered		47.6%	6.1%	
Centro	n	755	61	
Not registered		64.0%	85.2%	0.001
Registered		36.0%	14.8%	
LVT	n	1239	87	
Not registered		76.4%	90.8%	0.001
Registered		23.6%	9.2%	
Alentejo	n	259	26	
Not registered		61.8%	76.9%	0.141
Registered		38.2%	23.1%	
Algarve	n	183	13	
Not registered		77.0%	100.0%	0.075
Registered		23.0%	0.0%	

* Fisher Exact Test

Table 16. Outcome by Registration of Triglycerides, overall and for each region - % and Fisher Exact Tests

Triglycerides registered or not		Outcome (at Dec 31 2013)		
		Not Deceased	Deceased	p-value *
Overall Sample	n	3507	269	
Not registered		65.0%	91.1%	p<0.001
Registered		35.0%	8.9%	
By Region				
Norte	n	1071	82	
Not registered		52.9%	93.9%	p<0.001
Registered		47.1%	6.1%	
Centro	n	755	61	
Not registered		63.2%	88.5%	p<0.001
Registered		36.8%	11.5%	
LVT	n	1239	87	
Not registered		76.0%	93.1%	p<0.001
Registered		24.0%	6.9%	
Alentejo	n	259	26	
Not registered		59.1%	76.9%	0.093
Registered		40.9%	23.1%	
Algarve	n	183	13	
Not registered		76.0%	100.0%	0.043
Registered		24.0%	0.0%	

* Fisher Exact Test

Table 17. Outcome by Registration of Waist, overall and for each region - % and Fisher Exact Tests

Waist circumference registered or not		Outcome (at Dec 31 2013)		
		Not Deceased	Deceased	p-value *
Overall Sample	n	3507	269	
Not registered		82.9%	91.8%	p<0.001
Registered		17.1%	8.2%	
By Region				
Norte	n	1071	82	
Not registered		72.7%	85.4%	0.013
Registered		27.3%	14.6%	
Centro	n	755	61	
Not registered		80.8%	88.5%	0.171
Registered		19.2%	11.5%	
LVT	n	1239	87	
Not registered		91.8%	96.6%	0.147
Registered		8.2%	3.4%	
Alentejo	n	259	26	
Not registered		83.0%	100.0%	0.019
Registered		17.0%	0.0%	
Algarve	n	183	13	
Not registered		91.3%	100.0%	0.606
Registered		8.7%	0.0%	

* Fisher Exact Test

Table 18. Outcome by Registration of BMI, overall and for each region - % and Fisher Exact Tests

BMI registered or not		Outcome (at Dec 31 2013) Not Deceased	Deceased	p-value *
Overall Sample	**n**	3507	269	
Not registered		62.7%	84.0%	p<0.001
Registered		37.3%	16.0%	
By Region				
Norte	**n**	1071	82	
Not registered		50.2%	76.8%	p<0.001
Registered		49.8%	23.2%	
Centro	**n**	755	61	
Not registered		66.8%	83.6%	0.006
Registered		33.2%	16.4%	
LVT	**n**	1239	87	
Not registered		69.2%	87.4%	p<0.001
Registered		30.8%	12.6%	
Alentejo	**n**	259	26	
Not registered		63.7%	92.3%	0.002
Registered		36.3%	7.7%	
Algarve	**n**	183	13	
Not registered		73.8%	92.3%	0.191
Registered		26.2%	7.7%	

* Fisher Exact Test

Table 19. Odds ratios for Outcome by Registration of Blood Pressure - overall crude, adjusted and stratified by region

	Outcome (deceased or not at Dec 31 2013) by								
	Blood Pressure registered or not			Blood Pressure registered or not after controlling for Sex, Age, Sex*Age			Blood Pressure registered or not after controlling for Sex, Age, Sex*Age and for 4 Admission Severity indicators		
	OR	CI 95%	p-value	OR	CI 95%	p-value	OR	CI 95%	p-value
Overall Model	2.176	[1.696;2.793]	p<0.001	2.149	[1.654;2.793]	p<0.001	2.271	[1.738;2.966]	p<0.001
Overall Model also adjusted by Region	2.277	[1.766;2.936]	p<0.001	2.326	[1.778;3.044]	p<0.001	2.417	[1.837;3.18]	p<0.001
Stratifying by Region									
Norte	2.979	[1.888;4.699]	p<0.001	3.157	[1.932;5.16]	p<0.001	3.533	[2.121;5.884]	p<0.001
Centro	2.223	[1.313;3.764]	0.003	2.151	[1.239;3.732]	0.006	2.227	[1.273;3.896]	0.005
LVT	1.985	[1.277;3.086]	0.002	1.932	[1.219;3.062]	0.005	1.932	[1.208;3.091]	0.006
Alentejo	1.349	[0.575;3.163]	0.491	1.686	[0.69;4.118]	0.252	1.773	[0.702;4.474]	0.225
Algarve	3.444	[0.918;12.924]	0.067	3.232	[0.716;14.599]	0.127	2.945	[0.637;13.625]	0.167

Table 20. Odds ratios for Outcome by Registration of Cholesterol - overall crude, adjusted and stratified by region

	Outcome (deceased or not at Dec 31 2013) by								
	Cholesterol registered or not			Cholesterol registered or not after controlling for Sex, Age, Sex*Age			Cholesterol registered or not after controlling for Sex, Age, Sex*Age and for 4 Admission Severity indicators		
	OR	CI 95%	p-value	OR	CI 95%	p-value	OR	CI 95%	p-value
Overall Model	4.568	[3.07;6.798]	p<0.001	4.062	[2.712;6.084]	p<0.001	4.241	[2.822;6.375]	p<0.001
Overall Model also adjusted by Region	4.881	[3.268;7.29]	p<0.001	4.434	[2.946;6.672]	p<0.001	4.582	[3.033;6.922]	p<0.001
Stratifying by Region									
Norte	14.000	[5.622;34.866]	p<0.001	12.576	[5.007;31.591]	p<0.001	13.504	[5.339;34.157]	p<0.001
Centro	3.254	[1.579;6.705]	0.001	3.004	[1.434;6.295]	0.004	3.173	[1.502;6.704]	0.002
LVT	3.059	[1.461;6.403]	0.003	2.513	[1.183;5.338]	0.016	2.471	[1.156;5.283]	0.020
Alentejo	2.062	[0.801;5.312]	0.134	2.205	[0.833;5.839]	0.112	2.175	[0.794;5.962]	0.131
Algarve	-	-	-	-	-	-	-	-	-

Table 21. Odds ratios for Outcome by Registration of Triglycerides - overall crude, adjusted and stratified by region

	Outcome (deceased or not at Dec 31 2013) by								
	Triglycerides registered or not			Triglycerides registered or not after controlling for Sex, Age, Sex*Age			Triglycerides registered or not after controlling for Sex, Age, Sex*Age and for 4 Admission Severity indicators		
	OR	CI 95%	p-value	OR	CI 95%	p-value	OR	CI 95%	p-value
Overall Model	5.507	[3.601;8.423]	p<0.001	4.926	[3.201;7.579]	p<0.001	5.128	[3.321;7.917]	p<0.001
Overall Model also adjusted by Region	5.905	[3.848;9.062]	p<0.001	5.391	[3.488;8.332]	p<0.001	5.560	[3.584;8.625]	p<0.001
Stratifying by Region									
Norte	13.689	[5.497;34.091]	p<0.001	12.387	[4.93;31.123]	p<0.001	13.277	[5.249;33.585]	p<0.001
Centro	4.496	[2.018;10.017]	p<0.001	4.216	[1.864;9.537]	0.001	4.409	[1.934;10.053]	p<0.001
LVT	4.256	[1.839;9.854]	0.001	3.491	[1.489;8.181]	0.004	3.467	[1.47;8.18]	0.005
Alentejo	2.309	[0.897;5.944]	0.083	2.303	[0.871;6.093]	0.093	2.221	[0.809;6.1]	0.122
Algarve	-	-	-	-	-	-	-	-	-

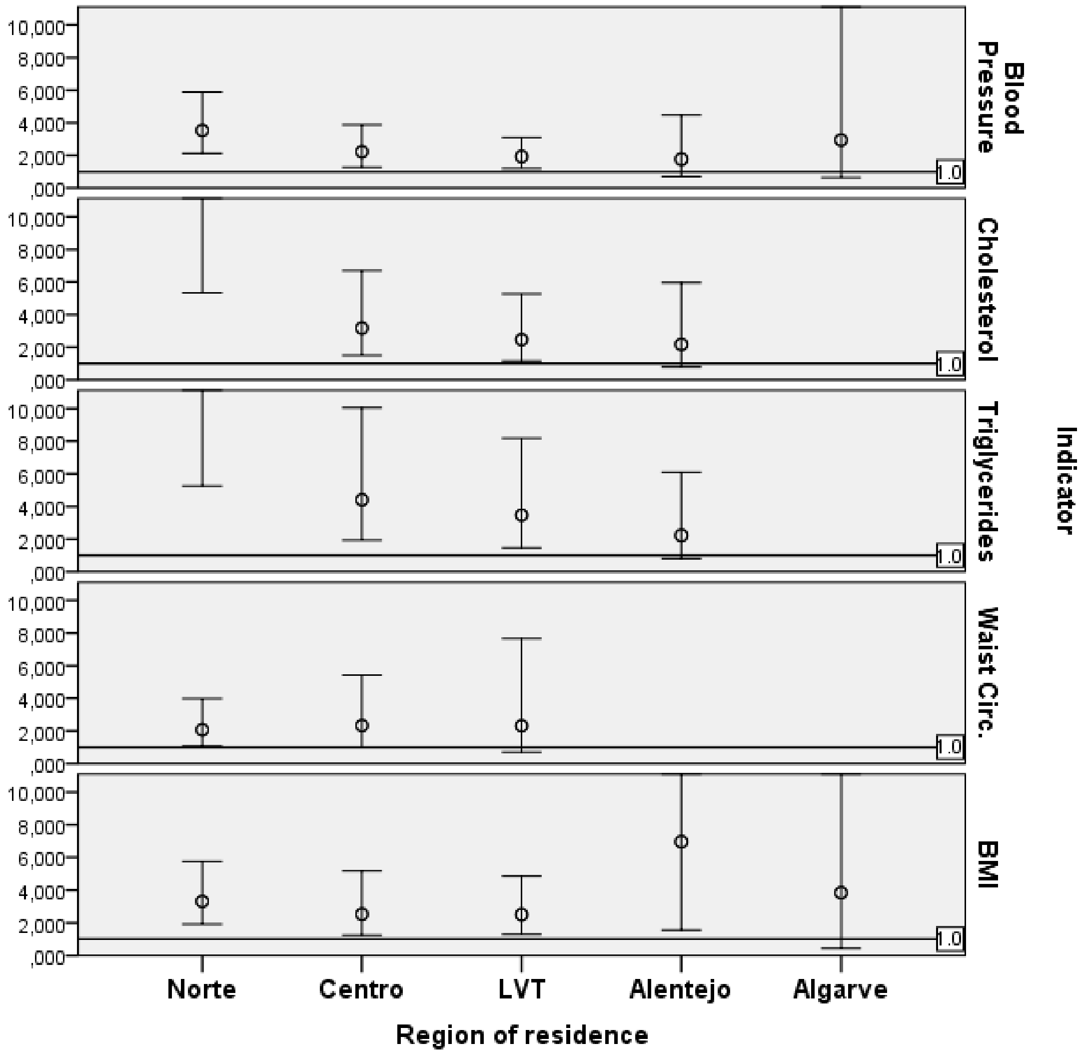
Table 22. Odds ratios for Outcome by Registration of Waist Circumference - overall crude, adjusted and stratified by region

	Outcome (deceased or not at Dec 31 2013) by								
	Waist circumference registered or not			Waist circumference registered or not after controlling for Sex, Age, Sex*Age			Waist circumference registered or not after controlling for Sex, Age, Sex*Age and for 4 Admission Severity indicators		
	OR	CI 95%	p-value	OR	CI 95%	p-value	OR	CI 95%	p-value
Overall Model	2.308	[1.479;3.601]	p<0.001	2.167	[1.376;3.413]	0.001	2.315	[1.464;3.66]	p<0.001
Overall Model also adjusted by Region	2.426	[1.546;3.805]	p<0.001	2.359	[1.488;3.739]	p<0.001	2.468	[1.551;3.926]	p<0.001
Stratifying by Region									
Norte	2.187	[1.168;4.093]	0.014	2.072	[1.088;3.946]	0.027	2.067	[1.076;3.972]	0.029
Centro	1.834	[0.817;4.113]	0.141	1.965	[0.856;4.511]	0.111	2.327	[0.998;5.422]	0.050
LVT	2.485	[0.772;8.002]	0.127	2.280	[0.694;7.492]	0.174	2.313	[0.698;7.667]	0.170
Alentejo	-	-	-	-	-	-	-	-	-
Algarve	-	-	-	-	-	-	-	-	-

Table 23. Odds ratios for Outcome by Registration of BMI - overall crude, adjusted and stratified by region?

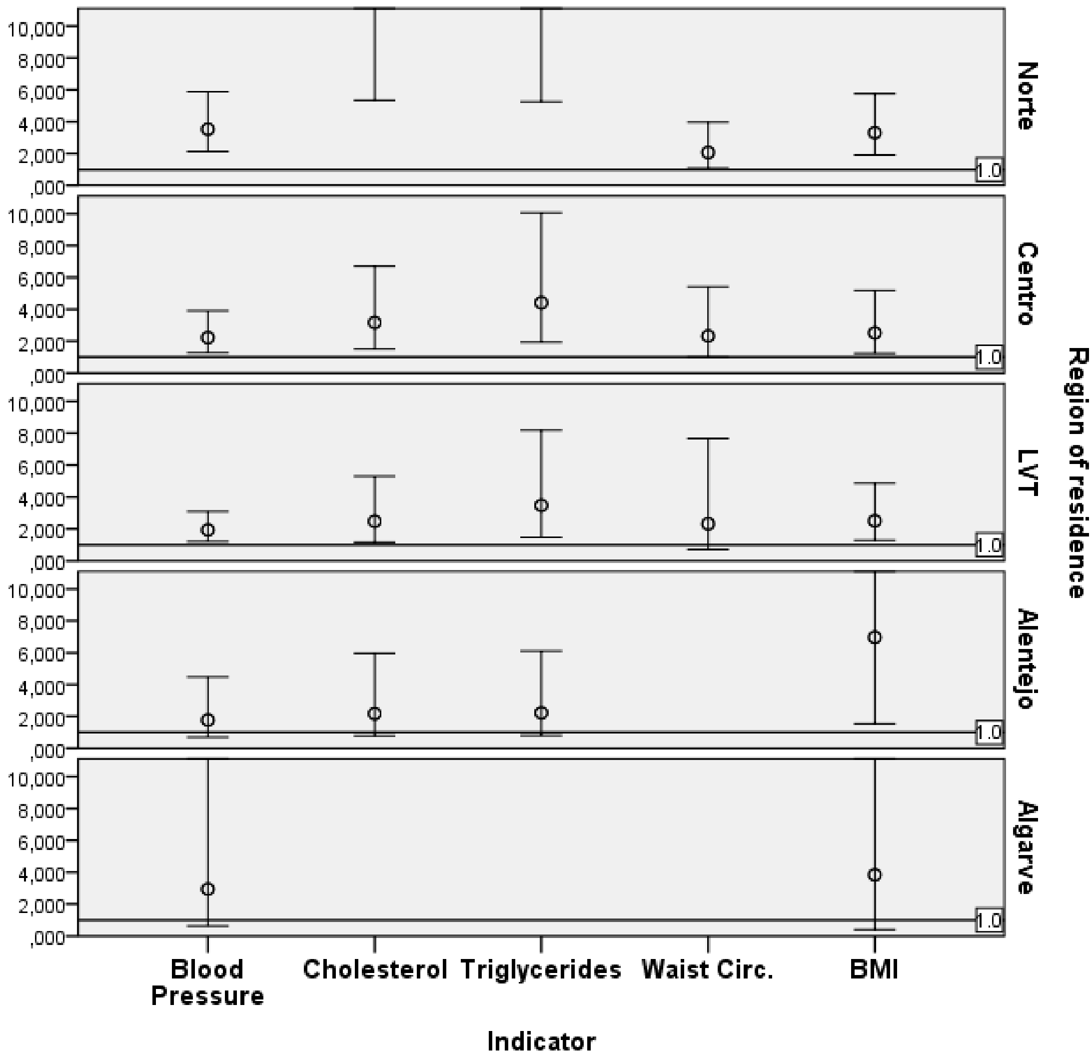
	Outcome (deceased or not at Dec 31 2013) by								
	BMI registered or not			BMI registered or not after controlling for Sex, Age, Sex*Age			BMI registered or not after controlling for Sex, Age, Sex*Age and for 4 Admission Severity indicators		
	OR	CI 95%	p-value	OR	CI 95%	p-value	OR	CI 95%	p-value
Overall Model	3.126	[2.24;4.362]	p<0.001	2.806	[1.995;3.947]	p<0.001	2.909	[2.061;4.105]	p<0.001
Overall Model also adjusted by Region	3.240	[2.314;4.537]	p<0.001	3.029	[2.142;4.284]	p<0.001	3.067	[2.162;4.349]	p<0.001
Stratifying by Region									
Norte	3.285	[1.94;5.563]	p<0.001	3.287	[1.904;5.672]	p<0.001	3.305	[1.9;5.749]	p<0.001
Centro	2.540	[1.268;5.087]	0.009	2.288	[1.122;4.665]	0.023	2.523	[1.227;5.187]	0.012
LVT	3.080	[1.618;5.862]	0.001	2.652	[1.369;5.135]	0.004	2.498	[1.282;4.867]	0.007
Alentejo	6.836	[1.58;29.572]	0.010	6.817	[1.547;30.028]	0.011	6.968	[1.551;31.306]	0.011
Algarve	4.267	[0.54;33.692]	0.169	3.474	[0.388;31.137]	0.266	3.835	[0.415;35.422]	0.236

Figure 9. 95% Confidence Intervals for Adjusted OR for mortality by registration of each health indicator stratified by region, visualized by health indicator registered [1,2,3]



(1) After controlling for Sex, Age, Sex*Age and Hospital Admission Severity Indicators
(2) Stratified Models by Region
(3) Not Applicable for Waist Circumference in Alentejo and Algarve and for Triglycerides and Cholesterol in Algarve

Figure 10. 95% Confidence Intervals for Adjusted Odds ratios for mortality by registration of each health indicator stratified by region, visualized by region (1,2,3)



(1) After controlling for Sex, Age, Sex*Age and Hospital Admission Severity Indicators
(2) Stratified Models by Region
(3) Not Applicable for Waist Circumference in Alentejo and Algarve and for Triglycerides and Cholesterol in Algarve

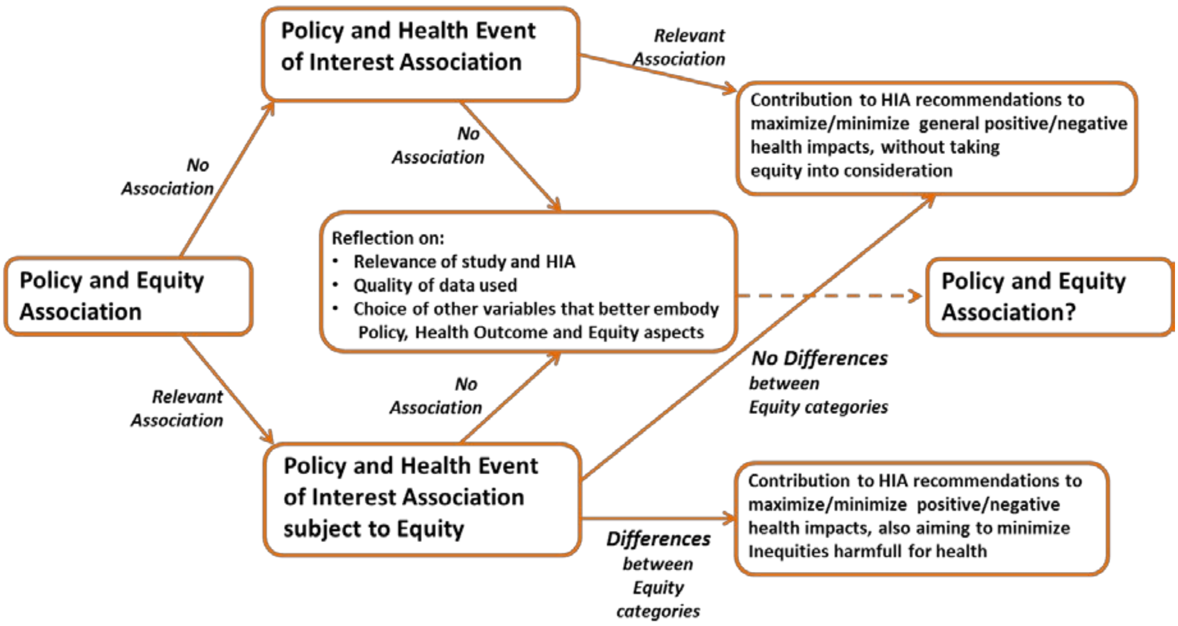
Table 24. Summary of Adjusted OR for Mortality by Registered Indicators, stratified by Region

	Adjusted OR for Registered Indicator				
Region of residence	**Blood pressure**	**Cholesterol**	**Triglycerides**	**Waist circumference**	**BMI**
Norte	3.533	13.504	13.277	2.067	3.305
Centro	2.227	3.173	4.409	2.327	2.523
LVT	1.932	2.471	3.467	2.313	2.498
Alentejo	1.773	2.175	2.221		6.968
Algarve	2.945				3.835

Color Code	OR adjusted
	>=4.000
	[2.000 - 4.000[
	[1.5 - 2.000[
	[1.0 - 1.5[
	<1.0

Conceptual Path Policy / Equity / Health Event of Interest

Figure 11. Conceptual Path Policy / Equity / Health Event of Interest



Appendix 7: Main Scientific Publications published by the author and activities, relevant to this research

MAIN PUBLICATIONS AS FIRST AUTHOR

Paper published:

Bacelar-Nicolau, L., T. Rodrigues, E. Fernandes, M.F. Lobo, C. Nisa, V. Azzone, A. Teixeira-Pinto, Costa-Pereira, A., Normand, S.-L., Pereira Miguel, J. "Picturing Inequities for Health Impact Assessment: Linked Electronic Records, Mortality and Regional Disparities in Portugal." Impact Assessment and Project Appraisal; VOL.36, NO.1, 90-104; 2018.
https: //doi.org/10.1080/14615517.2017.1364016

Book chapter accepted for publication:

2017 – **Bacelar-Nicolau L.**, Heitor M.J., Pereira Miguel J., *Guia de Metodologias de Avaliação de Políticas Públicas*, 16. Avaliação de Impacte na Saúde. Eds. Feijó A, Ferrão J, Monteiro S, Pinto Paixão J, Lisboa: Imprensa da Universidade de Lisboa [in press]

Papers submitted or to be submitted for publication proximately:

Bacelar-Nicolau L, Lobo M, Nisa C, Fernandes E, Azzone V, Teixeira-Pinto A, Costa-Pereira A, Normand SL, Pereira Miguel J. *Aiding systematic reviews with multivariate data analysis: profiling Health Impact Assessment guides and journal publications.* Submitted to Environmental Impact Assessment Review, based on Chapter 2 PhD thesis findings – Dec 2017

Bacelar-Nicolau L, Lobo M, Nisa C, Fernandes E, Azzone V, Teixeira-Pinto A, Costa-Pereira A, Normand SL, Pereira Miguel J. *Screening National Health Programs for Health Impact Assessment: setting health priorities with cluster analysis* – target journal TBD, based on SubChapter 3.2 PhD thesis findings

Bacelar-Nicolau L, Lobo M, Nisa C, Fernandes E, Azzone V, Teixeira-Pinto A, Costa-Pereira A, Normand SL, Pereira Miguel J. *Screening Policies in Health Impact Assessment: easier decision making through cluster analysis* – target journal TBD, based on SubChapter 3.1 PhD thesis findings

Bacelar-Nicolau L, Alves I., Pereira Miguel J. *WHO, OECD, Eurostat: please agree on mortality standardized rates?* – Commentary to be submitted to BMJ Global Health

Abstracts published in International Peer-reviewed Scientific Journals:

2016 - **Bacelar-Nicolau L**, Rodrigues T, Fernandes E, Lobo MF, Nisa C, Azzone V, Teixeira-Pinto A, Rocha-Gonçalves FN, Azevedo LF, Freitas A, Normand S-LT, Costa-Pereira A, Pereira-Miguel J, "Helping Decision-Makers Visualize Inequities In Health Impact Assessment: Linked Electronic Records, Mortality And Regional Disparities In Portugal", Value in Health. 2016. Vol. 19, Issue 7, PHS109 – DOI: http://dx.doi.org/10.1016/j.jval.2016.09.1591

2015 - **Bacelar-Nicolau L**, Pereira Miguel J, Saporta G, "Screening Policies for Health Impact Assessment: cluster analysis for easier decision making", Eur J Public Health, Vol. 25 (suppl 3), 133-134 - DOI: http://dx.doi.org/10.1093/eurpub/ckv171.014

2015 - **Bacelar-Nicolau L**, Pereira-Miguel J, Saporta G, "Screening Policies in Health Impact Assessment: easier decision making through cluster analysis", Eur J Epidemiol, Vol. 30, Issue 8 (suppl.), 852 – Abstract P238, Healthy Living: The European Congress of Epidemiology 2015, Maastricht, Netherlands, Bols E., Smits L., Weijenberg M. (Eds.) - DOI: 10.1007/s10654-015-0072-z http://link.springer.com/article/10.1007%2Fs10654-015-0072-z

Papers and Abstracts in Conferences and Congresses Proceedings

2016 - **Bacelar-Nicolau L**, Rodrigues T, Fernandes E, Lobo MF, Nisa C, Azzone V, Teixeira-Pinto A, Rocha-Gonçalves FN, Azevedo LF, Freitas A, Normand S-LT, Costa-Pereira A, Pereira-Miguel J, "Helping Decision-Makers Visualize Inequities In Health Impact Assessment: Linked Electronic Records, Mortality And Regional Disparities In Portugal", Value in Health. 2016. Vol. 19, Issue 7, PHS109 – DOI: http://dx.doi.org/10.1016/j.jval.2016.09.1591

2015 - **Bacelar-Nicolau L**, Pereira Miguel J, Saporta G, "Screening Policies for Health Impact Assessment: cluster analysis for easier decision making", Eur J Public Health, Vol. 25 (suppl 3), 133-134 - DOI: http://dx.doi.org/10.1093/eurpub/ckv171.014

2015 - **Bacelar-Nicolau L**, Pereira-Miguel J, Saporta G, "Screening Policies in Health Impact Assessment: easier decision making through cluster analysis", Eur J Epidemiol, Vol. 30, Issue 8 (suppl.), 852 – Abstract P238, Healthy Living: The European Congress of Epidemiology 2015, Maastricht, Netherlands, Bols E., Smits L., Weijenberg M. (Eds.) - DOI: 10.1007/s10654-015-0072-z http://link.springer.com/article/10.1007%2Fs10654-015-0072-z

Oral Invited Presentations

2016 - **Bacelar-Nicolau L**, Rodrigues T, Fernandes E, Lobo MF, Nisa C, Azzone V, Teixeira-Pinto A, Rocha-Gonçalves FN, Azevedo LF, Freitas A, Normand S-LT, Costa-Pereira A, Pereira-Miguel J, "Helping Decision-Makers Visualize Inequities In Health Impact Assessment: Linked Electronic Records, Mortality And Regional Disparities In Portugal", I Workshop do Capítulo ISPOR Portugal, 16 November 2016, Lisbon, Portugal

2016 – **Bacelar-Nicolau L.** Health Impact Assessment: Quantifying and Modeling to Better

Decide, Conservatoire National des Arts et Métiers, July 1, 2016, Paris, France

Other Oral Presentations

2015 - **Bacelar-Nicolau L**, Pereira-Miguel J, Saporta G, "Screening Policies for Health Impact Assessment: cluster analysis for easier decision making", European Public Health Conference, October 2015, Milan, Italy. [Oral Pitch Presentation]

2009 - **Bacelar-Nicolau L**, Craveiro I, Pereira Miguel J, Saporta G, "HIA of Social Welfare Payment for Inclusion Policy: Tools to Improve Health Gaps, Promote Equity" HIA09 On the Move- 10th Conference on Health Impact Assessment (Rotterdam, Holanda)

2009 - **Bacelar-Nicolau L**, Craveiro I, Pereira Miguel J, Saporta G, "Health Impact Assessment of a Social Welfare Payment for Inclusion Policy: A Tool to Improve Health Gaps and Promote Equity?" 2nd Joint European Public Health Conference 2009 (Lozd, Poland)

Poster Presentations

2016 - **Bacelar-Nicolau L**, Rodrigues T, Fernandes E, Lobo MF, Nisa C, Azzone V, Teixeira-Pinto A, Rocha-Gonçalves FN, Azevedo LF, Freitas A, Normand S-LT, Costa-Pereira A, Pereira-Miguel J, "Helping Decision-Makers Visualize Inequities In Health Impact Assessment: Linked Electronic Records, Mortality And Regional Disparities In Portugal", ISPOR 19th Annual European Congress, October 29-November 2 2016, Vienna, Austria

2015 - **Bacelar-Nicolau L**, Pereira-Miguel J, Saporta G, Screening Policies in Health Impact Assessment: easier decision making through cluster analysis, European Congress of Epidemiology, June 25-27, 2015, Maastricht, The Netherlands

OTHER CO-AUTHORED PUBLICATIONS RELEVANT TO THIS RESEARCH, EITHER FOR THEME OR METHODOLOGIES USED BY THE AUTHOR

Book

2017 – Cooke A., Coggins T., Virgolino A., Carreiras J., **Bacelar-Nicolau L.**, Heitor M.J. *Mental Health and Wellbeing Impact Assessment: Final Report EEA grants Healthy Employment Project. The impact of a community-based intervention on the mental wellbeing of professionals working with unemployed individuals.* Lisboa. [http://empregosaudavel.org/en/publicacoes/]

Book Chapter

2015 - **Bacelar-Nicolau, L.**, Barbosa, P., Sakellarides, C., *Economic crisis, health systems and health in Europe – Country experience*, Part II: Country profiles of health system responses to the crisis - Portugal, Pages 460-465, Edit. Thomson S, Figueras J, Evetovits T, Jowett M, Mladovsky P, Maresso A, Cylus J, Karanikolos M and Kluge H, Maidenhead: Open University Press on behalf of the European Observatory on Health Systems and Policies and World Health Organization Regional Office for Europe. http://www.euro.who.int/en/about-us/partners/observatory/publications/studies/economic-crisis,-health-systems-and-health-in-europe-country-experience

Master Thesis Supervision

2017 - Dias, M., "Health Impact Assessment of the Sustainable Enlargement of ADSE/Avaliação de Impacte em Saúde sobre o Alargamento Sustentável da ADSE", Master's Thesis – Mestrado Integrado em Medicina, Faculdade de Medicina, Universidade de Lisboa, Lisboa, Portugal

Papers in peer-reviewed International Journals

2017 – Lobo MF, Azzone V, Azevedo LF, Melica B, Freitas A, **Bacelar-Nicolau L**, Rocha-Gonçalves FN, Nisa C, Teixeira-Pinto A, Pereira-Miguel J, Resnic FS, Costa-Pereira A, Normand SL, "A Comparison of In-Hospital Acute Myocardial Infarction Management Between Portugal and the United States: 2000 – 2010", International Journal for Quality in Health Care, Vol.29, Issue 5, 669-678. [https://doi.org/10.1093/intqhc/mzx092]

2015 - Ouakinin S, Eusébio S, Torrado M, Silva H, Nabais I, Gonçalves G, **Bacelar-Nicolau L**, "Stress reactivity, distress and attachment in newly diagnosed breast cancer patients", Health Psychology and Behavioral Medicine, Vol. 3, No.1, 424-438 - DOI: http://dx.doi.org/10.1080/21642850.2015.1121491
[http://www.tandfonline.com/doi/full/10.1080/21642850.2015.1121491]

2015 - Oliveira L, Gomes C, **Bacelar-Nicolau L**, Ferreira L, Ferreira R, "Environment in pediatric wards: sound, light and temperature", Sleep Medicine, Vol. 16, Issue 9, 1041–1048 - DOI: http://dx.doi.org/10.1016/j.sleep.2015.03.015 [http://www.sleep-journal.com/article/S1389-9457(15)00707-8/abstract] - Award Jaime Salazar de Sousa 2015, attributed by ACSM-Associação das Crianças de Santa Maria and the Pediatric Department of the Centro Hospitalar Lisboa Norte/Hospital de Santa Maria for the 2015 most relevant paper published in an international journal

2014 - Bacelar-Nicolau, H., Costa Nicolau, F., Sousa, Á., **Bacelar-Nicolau, L.**, "Clustering of variables with a three-way approach for health sciences", TPM-Testing, Psychometrics, Methodology in Applied Psychology, Vol. 21, No. 4, December 2014 – 435-447 – Special Issue – doi: 10.4473/TPM21.4.5 – Cises. http://www.tpmap.org/2014-vol-21-no-4-december/

Papers in Peer-reviewed National Journals with referees

2017 – Lobo MF, Azzone V, Resnic FS, Melica B, Teixeira-Pinto A, Azevedo LF, Freitas A, Nisa C, **Bacelar-Nicolau L**, Rocha-Gonçalves FN, Pereira-Miguel J, Costa-Pereira A, Normand SL, "The Atlantic Divide in Coronary Heart Disease: Epidemiology and patient care in US and Portugal", Portuguese Journal of Cardiology/Revista Portuguesa de Cardiologia, Vol. 36(9), Pag. 583-593, Lisboa, Portugal http://dx.doi.org/10.1016/j.repc.2016.09.02

2010 – Bacelar-Nicolau, H., Sousa, A., **Bacelar-Nicolau, L.** & Marques, M.S., "Do univariado ao multivariado: A escala de elementos tangíveis, suas relações com outras escalas e mais além", Revista Portuguesa de Filosofia, Vol. 1, Pág. 383-405, Lisboa, Portugal http://www.jstor.org/stable/41354798?seq=1#page_scan_tab_contents

Papers and Abstracts in Conferences and Congresses Proceedings

2016 - Nisa CF, Lobo MF, Resnic F, Freitas A, Azevedo LF, Azzone V, **Bacelar-Nicolau L**, Teixeira-Pinto A, Normand SL, Costa-Pereira A. "Treating coronary heart disease in diabetic patients: A systematic review of systematic reviews", Rev Port Cardiol. 2016. 35 (Espec Congr): 60-61 - http://www.elsevier.pt/pt/revistas/revista-portuguesa-cardiologia-334/pdf/X0870255116527330/S300/

2015 - Lobo MF, Azzone V, Melica B, **Bacelar-Nicolau L**, Nisa C, Freitas A, Azevedo LF, Rocha-Gonçalves FN, Resnic FS, Teixeira-Pinto A, Pereira-Miguel J, Normand S-LT, Costa-Pereira A, "The Atlantic Divide In Coronary Heart Disease: Health Technologies Use in the US and Portugal", Value in Health. 2015. Vol. 18, Issue 7, A402 - DOI: http://dx.doi.org/10.1016/j.jval.2015.09.930

2014 - Bacelar-Nicolau, H., Nicolau, F.C., Sousa, Á., & **Bacelar-Nicolau, L.**, "On cluster analysis of complex and heterogeneous data", Proceedings of the 3rd Stochastic Modeling Techniques and Data Analysis International Conference (SMTDA2014), C. H. Skiadas (Eds.), 2014 ISAST, 99-108. http://www.smtda.net/images/1_A-F_SMTDA2014_Proceedings_NEW.pdf

2010 - Bacelar-Nicolau, H.; Nicolau, F. C.; Sousa, A.; **Bacelar-Nicolau, L.**,. "Clustering Complex Heterogeneous Data Using a Probabilistic Approach", Proc. of Stochastic Modeling Techniques and Data Analysis International Conference (SMTDA2010), Chania, Crete, Greece, 8-11 June 2010, 85-93. http://www.smtda.net/smtda2010proceedings.html

Oral Invited Presentations

2016 – Lobo, M., Fernandes, E., Nisa, C., **Bacelar-Nicolau, L.**, "Main results and lessons to be learned from the CUTEheart project", 2nd CUTEheart Workshop on Health Technology Assessment in Cardiovascular Disease, in Congresso Português de Cardiologia, 23 April 2016, Vilamoura, Portugal

2015 - **Bacelar-Nicolau, L.**, "Economia da Saúde: como garantir um bom retorno no investimento em saúde", X Simpósio de Liderança e Gestão de Saúde, 20 February 2015, Covilhã, Portugal

Other Oral Presentations

2016 – Fernandes E, **Bacelar-Nicolau L**, Lobo MF, Nisa C, Teixeira-Pinto A, Normand SL, Azzone A, Costa-Pereira A., Pereira Miguel J, "Comparison of statistical models for predicting 30-day readmission after acute myocardial infarction in Portugal". I Workshop in Biostatistics, December 7-9 2016, Maringá, PR, Brazil.

2014 - Bacelar-Nicolau H, Nicolau F.C., Sousa Á., **Bacelar-Nicolau L.**, "On cluster analysis of complex and heterogeneous data", SMTDA2014 - 3rd Stochastic Modeling Techniques and Data Analysis International Conference, 11-14 June 2014, p.1. (Lisbon, Portugal)

Poster Presentations

2016 - Nisa C, Azevedo LF, Resnic FS, Lobo MF, Freitas A, Azzone A, **Bacelar-Nicolau L**, Teixeira-Pinto A, Normand SL, Costa-Pereira A. Treating coronary heart disease in diabetic Patients: A systematic review of systematic reviews, 2nd CUTEheart Workshop – Health Technologies Assessment / Portuguese Congress of Cardiology, April 2016, Vilamoura, Portugal

2015 - Lobo MF, Azzone V, Melica B, **Bacelar-Nicolau L**, Nisa C, Freitas A, Azevedo LF, Rocha-Gonçalves FN, Resnic FS, Teixeira-Pinto A, Pereira-Miguel J, Normand ST, Costa-Pereira A. The Atlantic Divide in Coronary Heart Disease: Health technologies use in the US and Portugal, ISPOR 18th Annual European Congress, November 2015, Milan, Italy

2008 - **Bacelar-Nicolau L**, Pereira Miguel J, Saporta G, "The Added Value of Multivariate Statistical Data Analysis in Policy HIA – A Quantitative Way of Profiling Subjects" HIA08 Health Impact Assessment and Sustainable Well-being- 9th Conference on Health Impact Assessment (Liverpool, UK)

OTHER ASSOCIATED RELEVANT RESEARCH ACTVITIES

Focal point for Faculdade de Medicina of Universidade de Lisboa regarding the CUTEHeart Project (Comparative use of technologies for coronary heart disease - HMSP-ICT/0013/2011), an international partnership between the Harvard Medical School and the Faculties of Medicine from the Universities of Lisboa and Porto in Portugal, funded by the Harvard Medical School – Portugal Program in Translational Research and Information, which included the organization of the first workshop "Health Services Research: From data to practice" on December 11 2014 and and 2nd Workshop on "Health Technology Assessment in Cardiovascular Disease", in Congresso

Português de Cardiologia on April 23 2016 [http://cuteheart.med.up.pt] (2014-2016)

Advisor for Mental Wellbeing Impact Assessment regarding the Healthy Employment Project (2015-2017): an international partnership including Portugal, Norway and Iceland, for the promotion of mental health and wellbeing of the unemployed active population and the professionals that give them support [http://www.empregosaudavel.org/en/]

WHO Country Expert para “Health policy responses to the financial crisis in Europe” (first study published in 2012, updated in 2014): http://www.euro.who.int/en/what-we-do/data-and-evidence/health-evidence-network-hen/publications/2012/health-policy-responses-to-the-financial-crisis-in-europe

High Commissioner for Health (Alto Comissariado da Saúde - ACS) Advisor (2011): Member of the National Health Plan 2011-2016 Group, Responsible for Evaluating the National Health Programs

WHO Temporary Adviser (2009): High-level Meeting: “Health in Times if Global Economic Crisis: Implications for the WHO European Region”, Oslo, 1-2Abril 2009

Leonor BACELAR-NICOLAU

Health Impact Assessment: Quantifying and Modeling to Better Decide

Résumé :
L'Évaluation d'Impact sur la Santé (EIS) est un instrument de support à la décision, pour juger une politique quant aux effets potentiels sur la santé et leur distribution (équité). C'est encore souvent une approche qualitative.

L'objectif principal est de montrer l'utilité de méthodologies statistiques quantitatives multivariées pour enrichir la pratique d'EIS, améliorant la compréhension des résultats par des professionnels non-statisticiens.

Les futures réformes des systèmes de santé déplacent le centre d'évaluation des services de santé des fournisseurs aux citoyens (besoins, préférences, équité d'accès aux gains de santé), exploitant *big data* associant information de soins aux données sociales, économiques et de déterminants de santé. Des méthodologies statistiques et d'évaluation innovantes sont nécessaires à cette transformation.

Les méthodes de *data mining* et *data science*, souvent complexes, peuvent gérer des résultats graphiques compréhensibles pour amplifier l'usage d'EIS, qui deviendrait ainsi un outil précieux d'évaluation de politiques publiques pour amener les citoyens au centre de la prise de décision. **Mots-Clés :** Évaluation d'Impact sur la Santé; Équité; Analyse de Données Multivariées; Modélisation; Prise de décision

Abstract :
Health Impact Assessment (HIA) is a decision-making support tool to judge a policy as to its potential effects and its distribution on a population's health (equity). It's still very often a qualitative approach.

The main aim here is to show the usefulness of applying quantified multivariate statistical methodologies to enrich HIA practice, while making the decision-making process easier, by issuing understandable outputs even for non-statisticians.

The future of healthcare reforms shifts the center of evaluation of health systems from providers to people's individual needs and preferences, reducing health inequities in access and health outcomes, using big data linking information from providers to social and economic health determinants. Innovative statistical and assessment methodologies are needed to make this transformation.

Data mining and data science methods, however complex, may lead to graphical outputs simple to understand by decision makers. HIA is thus a valuable tool to assure public policies are indeed evaluated while considering health determinants and equity and bringing citizens to the center of the decision-making process. **Keywords:** Health Impact Assessment; Equity; Multivariate Data Analysis; Modeling; Decision-Making

Resumo:
A Avaliação de Impacte na Saúde (AIS) é um instrumento de suporte à decisão para julgar política quanto aos seus efeitos potenciais e à sua distribuição na saúde de uma população (equidade). É geralmente ainda uma abordagem qualitativa.

O principal objetivo é mostrar a utilidade das metodologias estatísticas quantitativas e multivariadas para enriquecer a prática de AIS, melhorando a compreensão dos resultados por profissionais não-estatísticos.

As futuras reformas dos sistemas de saúde deslocam o centro da avaliação dos serviços de saúde dos prestadores para as necessidades e preferências dos cidadãos, reduzindo iniquidades no acesso à saúde e ganhos em saúde, usando *big data* que associam informação de prestadores a dados sociais e económicos de determinantes de saúde. São necessárias metodologias estatísticas e de avaliação inovadoras para esta transformação.

Métodos de *data mining* e *data science*, mesmo complexos, podem gerar resultados gráficos compreensíveis para os decisores. A AIS é assim uma ferramenta valiosa para avaliar políticas públicas considerando determinantes de saúde, equidade e trazendo os cidadãos para o centro da tomada de decisão. **Palavras-chave:** Avaliação de Impacte na Saúde; Equidade; Análise de Dados Multivariada; Modelização; Tomada de decisão