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Training the biomedical informatics workforce in Latin America: results of a needs assessment

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ABSTRACT

Objective: To report the results of a needs assessment of research and training in Medical Informatics (MI) and Bioinformatics (BI) in Latin America.

Methods and results: This assessment was conducted by QUIPU: The Andean Global Health Informatics Research and Training Center. After sending email invitations to MI—BI related professionals from Latin America, 142 surveys were received from 11 Latin American countries. The following were the top four ranked MI-related courses that a training programme should include: introduction to biomedical informatics; data representation and databases; mobile health; and courses that address issues of security, confidentiality and privacy. Several new courses and topics for research were suggested by survey participants. The information collected is guiding the development of curricula and a research agenda for the MI and BI QUIPU multidisciplinary programme for the Andean Region and Latin America.

ARTICLE SUMMARY

Article focus

- The objective of this paper is to report the results of the first needs assessment of research and training in Medical Informatics (MI) and Bioinformatics (BI) in Latin America.

Key messages

- Top ranked courses in biomedical informatics included: mobile health, issues on security, confidentiality and privacy, public and clinical informatics and electronic health records.
- The information collected in this needs assessment is guiding the development of curricula and a research agenda for training and research in the Andean region through the Peruvian NIH funded centre QUIPU. 'Quipu' is a Quechua word that describes an ancient system used throughout the Andes by the Incas to record and distribute information.

Strengths and limitations of this study

- The online survey included participants from 11 Latin American countries.
- It is the first needs assessment in Latin America addressing issues of training and research in biomedical informatics.
- The sample was, however, purposive.

INTRODUCTION

The WHO has recognised the use of information and communication technologies (ICT) as a core competency of the 21st century healthcare workforce to support patient care.[1] Thus, professionals well-trained in the use of ICT are highly needed.[2] Training programmes in Biomedical Informatics have emerged over the last 40 years, especially in developed countries.[3 4] In Latin America, a few countries have developed initiatives and programmes in Biomedical and/or Health Informatics (ie, Brazil,[5 6] Cuba,[7] Peru,[8 9] Colombia[10]), Medical Informatics (ie, Argentina,[11] Peru[12]), and Bioinformatics (ie, Brazil,[13 14] Peru[12]). These programmes have encompassed short courses, certificate programmes, Master's programmes and even sub-specialty programmes (ie, Argentina).[15]

Several assessments have characterised the needs for research and training in Biomedical Informatics. These assessments have been conducted mainly in the USA, Europe and Australia.[16–19] To our knowledge, no assessments have been published with data from Latin America.

The objective of this paper is to report the results of a needs assessment in Biomedical Informatics in Latin America. This needs assessment was conducted as part of one of the activities of QUIPU: The Andean Global Health Informatics Research and Training Center (http://www.andeanquipu.org). 'Quipu' is a Quechua word that describes an ancient system used throughout the Andes by the Incas to record and distribute information. The Center is funded by the Fogarty International Center (FIC)/National Institutes of Health (NIH),[20] and

administered by Universidad Peruana Cayetano Heredia (UPCH) in collaboration with the US Naval Medical Research Unit Six in Peru (NAMRU-6), the Universidad del Cauca in Colombia and the University of Washington in Seattle (USA).[21]

METHODS

Online survey of Medical Informatics and Bioinformatics

We conducted a needs assessment of biomedical informatics training and research. We broadly classified this field into Medical Informatics (MI) and Bioinformatics (BI). For the purposes of this study, we considered the field of MI in a very broad sense, including Clinical Informatics and Public Health Informatics. We designed an online survey using LimeSurvey (http://www.limesurvey.org), an Open Source application successfully used in previous studies conducted by our group.[22] The survey questions were based on those used in previous electronic and paper surveys, as well as questions suggested by local and international experts in MI and BI.

The survey was divided into four sections: (1) demographics, (2) type and level of experience in MI or BI, (3) needs regarding training in MI–BI in the Latin American region, and (4) research needs. Participants were asked to rate a list of existing courses on a scale of 1 to 5 (1=unimportant to 5=very important), including courses that should be common to both disciplines (MI and BI). They were also asked to suggest additional courses that were not included in the questionnaire. In the last section of the survey, which included open ended questions, respondents were asked to list three priority areas in Biomedical Informatics research that they consider important for their country.

We piloted the survey for correct language, optimal workflow and accurate interpretation of question meaning with 15 selected health professionals before launching the needs assessment. Pilot users were not invited to respond in the final version of the survey.

Survey distribution

In partnership with the International Medical Informatics Association for Latin America and the Caribbean (IMIA-LAC), we sent targeted email invitations to 330 selected MI–BI related professionals from Latin America, 190 attendees of our previous informatics courses,[12 23 24] and four mailing lists related to health informatics, namely the IMIA-LAC mailing list (imia-lac@googlegroups.com), a Latin American Telemedicine mailing list (telemedicina-imtavh@googlegroups.com), a Peruvian Medical Informatics mailing list (apim@yahoogroups.com) and a Colombian eHealth mailing list (esalud-colombia@afrodita.unicauca.edu.co).

The MI–BI related professionals were nominated by national and international collaborators of the QUIPU programme, and the attendees of previous Biomedical Informatics courses were identified from a contact database. Emails were sent individually and included information about the objectives of the survey, the organisations involved, the confidentiality of the information, and a link that redirected participants to the survey. The survey was available online for 70 days.

This study was approved by the Human Ethics Committee of the Universidad Peruana Cayetano Heredia and the US Naval Medical Research Unit Six, Peru.

Statistical analysis

Demographic data and rankings from the questionnaire were analysed using SPSS V.11.0.

RESULTS

Participant characteristics

We received 142 surveys; 64% (91) of the respondents were male, 58% of participants were 40 years old or younger, and 49% had a Master's or PhD degree. Overall, 47% of the respondents reported that they were working in Peru, 38% in another Latin American country, 10% outside Latin America (Belgium, Spain, France, Ireland and the USA), and 6% did not report their country of work. A total of 11 Latin American countries were represented in the survey. Latin American participants were from Colombia (24), Ecuador (6), Chile (5), Venezuela (5), Argentina (4), Brazil (4), Mexico (1), Uruguay (3), Honduras (1) and Guatemala (1). More than half (55.6%) of the participants were based at a university; 46.5% participated in teaching activities and 62% conducted research.

Most of the respondents (66%) identified their area of expertise as related to MI and 16.9% as related to BI. Table 1 summarises the demographic characteristics of study participants and areas of self-reported expertise.

Regarding their self-reported experience with software and programming, 90 (63%) reported using specialised software such as SPSS and STATA (used for statistical analysis), or Blast (Basic Local Alignment Search Tool used for aligning primary biological sequence information of proteins or DNA sequences). Sixty participants (42.3%) were capable of using/programming in JAVA and/or PHP, and/or administering general informatics services; 56 (39.4%) reported experience with telemedicine or electronic medical records.

Training needs for Medical Informatics and Bioinformatics

Participants ranked a list of 25 courses in Medical Informatics and five courses in Bioinformatics. The top three ranked courses in Medical Informatics were: Introduction to Biomedical Informatics, Data Representation and Databases, and Mobile Health. The top three ranked courses in Bioinformatics were: Sequence Analysis, Gene and Sequence Annotation, and Molecular Modelling (table 2).

Participants also suggested common courses for both Medical Informatics and Bioinformatics disciplines. The common courses suggested by more than 50% of the participants were: Introduction to Biomedical

Table 1 Demographic characteristics of participants who answered the needs assessment survey on research and training in Biomedical Informatics in Latin America (N=142)

Variable	N (%)
Age (years)	
<30	34 (23.9)
31–40	48 (33.8)
41–50	34 (23.9)
51–60	19 (13.4)
>60	7 (4.9)
Educational level	
Doctorate	21 (14.8)
Master's degree	48 (33.8)
Bachelor's degree	62 (43.7)
Not reported	11 (7.7)
Country	
Peru	66 (46.5)
Colombia	24 (16.9)
Other Latin American country	30 (21.1)
Outside Latin America	14 (9.9)
Not reported	8 (5.6)
Place of work*	
University	79 (55.6)
Governmental organisation	25 (17.6)
Non-governmental organisation	13 (9.2)
Enterprise	16 (11.3)
Health centre	27 (19.0)
Research centre	10 (7.0)
Main activities*	
Research	88 (62.0)
Teaching	66 (46.5)
Administration	50 (35.2)
Areas of the most relevant self-reported expertise	
Bioinformatics; sequence analysis	15 (10.6)
Bioinformatics; molecular modelling	9 (6.3)
Medical imaging	11 (7.7)
Public health informatics	24 (16.9)
Health informatics	44 (31.0)
Telemedicine	15 (10.6)
Other	24 (16.9)

*Participants were able to choose more than one option.

Table 2 Ranking of Medical Informatics and Bioinformatics courses (N=142)

	Mean score*
Medical Informatics courses	
Introduction to Biomedical Informatics	4.41
Data Representation and Databases	4.29
Mobile Health	4.26
Security, Confidentiality and Privacy	4.25
Project Management	4.20
Clinical Informatics	4.18
Public Health Informatics	4.18
Health Information Systems Evaluation	4.14
Design/Interaction in Biomedical Informatics	4.10
Electronic Health Records	4.10
Biostatistics	4.08
Rural Telemedicine	4.03
Information Retrieval in Databases	4.01
Health Informatics Policy	3.92
Imaging Pattern Recognition	3.89
Communication and Leadership in Biomedical Informatics	3.87
Knowledge Representation in Biomedical Informatics	3.87
Electronic Learning Systems	3.87
Epidemiology	3.80
Health Information System Architectures	3.76
Global Public Health	3.75
Foundations in Biology, Biophysics and Informatics	3.72
Interoperability and Standards	3.69
Geographic Information Systems	3.56
Software Engineering	3.50
Bioinformatics courses	
Sequence Analysis	4.21
Gene and Sequence Annotation	4.15
Molecular Modelling	4.07
Phylogenomics and Molecular Evolution	3.90
Computational Chemistry	3.96

*Ranking from 1 to 5.

Informatics (80.3%), Information Retrieval in Databases (61.3%), Biostatistics (61.3%), Foundations in Biology, Biophysics and Informatics (58.5%), Data Representation and Databases (57.7%), Clinical Informatics (51.4%), and Epidemiology (50.0%).

Several new courses in Medical Informatics were suggested by participants. These included: Administration and Management in Informatics; Artificial Intelligence; Auditing in Informatics; Business Models in Informatics; Body Networks: Design of Health Personal Systems; Change Management in Informatics; Competency Development; Decision Making in Informatics; Evidence-based Medicine in Informatics; Expert Systems; History of Medical Informatics; Imaging Systems; Introduction to Biomedical Engineering; Intercultural and Global Health Informatics; Low-cost Cluster Design and Implementation; Methodology of Knowledge Generation; Operational Research in Informatics; Open Source Tools in Informatics; Qualitative Research; Semantic Web; Standards in Informatics; and Telemedicine and Tele-education.

New courses in Bioinformatics suggested by participants were: Bioinformatics Algorithms, Clusters and Grid Computing; Biological Systems; Comparative Genomics; Computational Evolutionary Biology; Data Mining; Database Management and Information Retrieval; Gene Expression Analysis; Genetic Therapy; Drug Design; Molecular Docking; Functional Genomics;

Low-cost Cluster Design and Implementation; Management and Administration in Bioinformatics; Nanotechnology; New Applications in Bioinformatics; Pattern Recognition and Sequence Analysis; Population Genomics; Proteomics; Perl Programming in Bioinformatics; and Project Management.

Research priorities suggested

Participants were asked in an open ended question to list three priority areas in Biomedical Informatics research that they think are needed in their country. The top ten topics recognised as research priorities were: Evaluation of Health Information Systems; Policy in Health Informatics; Interoperability and Standards; Evidence-based Decision Making in Informatics; Rural Telemedicine; Mobile Health; Electronic Health Records; Sequence Analysis and Gene Finding; Tele-education; and Cost-effectiveness analysis in Biomedical Informatics.

DISCUSSION

Participants in this survey represented a diverse array of individuals from several Latin American countries, with different disciplines related to MI and BI, and with a variety of interests in training and research. The results have allowed us to recognise topics of preference for diverse courses and research areas in Biomedical Informatics.

A course covering basic concepts in Biomedical Informatics was ranked as a top priority by participants. In addition, topics related to security, confidentiality and privacy, as well as emerging areas in Biomedical Informatics, such as Mobile Health, were suggested as priority courses. Given the wide distribution and availability of cell-phones and mobile devices, Mobile Health is showing promising impact as an emerging area of interest, especially in developing countries.[25 26]

Security and privacy concerns are becoming increasingly important in modern health information systems.[27] These concerns call for dedicated support infrastructures due to the sensitivity of personal information and its corresponding personal and social impact, especially considering the increase in network-based or network-aware health information systems. International initiatives in this direction include security standards, that is, security standards provided by the International Organization for Standardization (ISO).[28]

In general, there is a need for an agreed on framework for curriculum development in Biomedical Informatics. Kampov-Polevoi *et al* recently developed a Course-Based Informatics Programme Categorisation (CBIPC) scheme based on the descriptions of 636 courses offered by 73 Public Health, Nursing, Health, Medical and Bioinformatics programmes in the USA. This scheme was used to classify coursework and to compare programmes across these different Biomedical and Health Informatics disciplines. Using this scheme, the authors found that there is substantial variability in programme content by informatics discipline; some programmes are characterised by fewer different course types, and by the common presence of certain courses (eg, Public Health, Bioinformatics, and Nursing Informatics). In contrast, other programmes such as Medical and Health Informatics offer greater curricular diversity. Additionally, there is similarity across several programmes in that a number of course topics—including programming, database systems and statistics, as well as courses dealing with legal, ethical and social issues—are present in the majority of these programmes.[29]

Recently, Chang *et al* published a study focused on identifying the nursing informatics competencies required for nurses in Taiwan.[30] They used a modified web-based Delphi method for two expert groups in nursing—educators and administrators—and identified 318 nursing informatics competencies selected by consensus for both item importance and appropriate level of nursing practice.[30] Although our study was not intended to identify competencies, the study by Chang *et al* found that nursing informatics competencies required for nursing professionals in Taiwan are similar to those required for US nursing professionals.

Stead *et al* have recently provided a framework and reported a set of core informatics competencies for health professionals of the future according to the Accreditation Council for Graduate Medical Education core competencies. These included patient care, medical knowledge, practice-based learning and improvement, interpersonal skills and communication, professionalism and system-based practice.[31] Future studies that evaluate competencies in Latin America are needed to explore the similarities and differences with other countries.[32]

Participants suggested several research topics which could be integrated as part of the research agenda in Biomedical Informatics. These topics were closely related to the courses suggested for the development of a curriculum in Biomedical Informatics. Research areas such as Health Information Systems, Policy in Biomedical Informatics, and Interoperability and Standards are of crucial importance in our globalised world. Others, such as Rural Telemedicine and Tele-education, reflect the importance of conducting research that improves the health and education of remote and often neglected areas in Latin America.

Given the limited resources in the Latin American region, the creation of networks of universities with experience in Biomedical Informatics training and research should be promoted. The recently created QUIPU network ('Red QUIPU') is a promising group that aims to discuss regional curricula, look for funding that could be shared by member countries that are part of the network, share faculty and content with the members of the network (eg, via e-learning), and promote collaborations in Biomedical Informatics research and training.[21]

Our study has some limitations. First, our sample was purposive and not intended to represent all Biomedical

Informatics-related professionals in Latin America. Second, since the survey was conducted over the internet, our sampling is likely to be biased in terms of educational background and age. Another limitation is that we did not provide a definition of Medical Informatics and/or Bioinformatics. These definitions vary immensely from country to country and from group to group, so respondents self-identified themselves to MI or BI according to their own understanding of the fields. One of the strengths of this paper is that a total of 11 Latin American countries are represented by this survey, which is considered significant for an online survey in Latin America.

In summary, defining the needs for Biomedical Informatics professionals is an ongoing process that needs to be evaluated systematically. Currently, there is no consensus around these needs, which highlights the importance to further characterise the competencies for a biomedical informatics programme. Future assessments should characterise the needs of persons who wish to enter the field in order to have a broader curricular and research perspective. The information collected in this assessment is guiding the development of the curricula and research agenda for training and research in the Andean Region through the QUIPU Center.

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Correction notice The "To cite: …" information and running footer in this article have been updated with the correct volume number (volume 1).

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Competing interests One author of this manuscript is an employee of the US Government. This work was prepared as part of his duties. Title 17 U.S.C. § 105 provides that 'Copyright protection under this title is not available for any work of the United States Government.' Title 17 U.S.C. § 101 defines a US Government work as a work prepared by a military service member or employee of the US Government as part of that person's official duties.

Ethics approval This study was approved by the Human Ethics Committee of the Universidad Peruana Cayetano Heredia and the US Naval Medical Research Unit Six, Peru.

Contributors MB, WC and PG conceived, designed and implemented the study, analysed the data and drafted the manuscript; MZ, CC, JC, AL and DL conceived and designed the study, collaborated on the interpretation of data and drafted the manuscript. All authors approved the final version of the manuscript.

Provenance and peer review Not commissioned; externally peer reviewed.

Data sharing statement No additional data available.

REFERENCES

1. World Health Organization. *Preparing a Health Care Workforce for the 21st Century: The Challenge of Chronic Conditions*. Geneva: WHO, 2005. http://www.who.int/entity/chp/knowledge/publications/workforce_report.pdf (accessed 19 Nov 2010).
2. World Health Organization. *Health Technologies: The Backbone of Health Services*. Geneva: WHO, 2007. http://www.who.int/eht/en/Backbone.pdf (accessed 20 Nov 2010).
3. Patton GA, Gardner RM. Medical informatics education: the University of Utah experience. *J Am Med Inform Assoc* 1999;6:457–65.
4. AMIA. *Academic & Training Programs*. American Medical Informatics Association, 2010. http://www.amia.org (accessed 13 Aug 2010).
5. Marin HF, Massad E, Marques EP, *et al*. Training health informatics professionals in Brazil: rationale for the development of a new certificate program. *AMIA Annu Symp Proc* 2005:1042.
6. Marin HF, Massad E, Marques EP, *et al*. A certificate program in health informatics: Brazil/USA experience. *Stud Health Technol Inform* 2006;122:800.
7. Couturejuzon L, Ruben M, Gonzalez N. Impacto institucional y social de la Maestría Informática en Salud Instituto Superior de Ciencias Médicas de La Habana.1997-2002. [Social and institutional impact of the Master in Health Informatics] [Spanish]. *Rev Cubana Informática Médica* 2005;5. http://www.cecam.sld.cu/pages/rcim/revista_9/articulos_htm/impactoinstituc.htm (accessed 19 Nov 2010).
8. Curioso WH, Fuller S, Garcia PJ, *et al*. Ten years of international collaboration in biomedical informatics and beyond: the AMAUTA program in Peru. *J Am Med Inform Assoc* 2010;17:477–80.
9. Curioso WH, Kimball AM, Garcia PJ, *et al*. Training biomedical and health informatics professionals in Peru: towards the development of the first graduate diploma program in the country. *AMIA Annu Symp Proc* 2007:921.
10. Rendon A, Martinez A, Dulcey MF, *et al*. Rural telemedicine infrastructure and services in the Department of Cauca, Colombia. *Telemed J E Health* 2005;11:451–9.
11. Otero P, Hersh W, Luna D, *et al*. A medical informatics distance-learning course for Latin America. Translation, implementation and evaluation. *Methods Inf Med* 2010;49:310–15.
12. Curioso WH, Hansen JR, Centurion-Lara A, *et al*. Evaluation of a joint Bioinformatics and Medical Informatics international course in Peru. *BMC Med Educ* 2008;8:1.
13. Marques EP, Marin HF, Massad E, *et al*. Training in health informatics in Brazil. *Stud Health Technol Inform* 2002;90:757–60.
14. Marin HF, Massad E, Marques EP, *et al*. International training in health informatics: a Brazilian experience. *Stud Health Technol Inform* 2004;107:898–902.
15. Quiros FG, Luna D, Otero P, *et al*. Experience in the development of an in-house health information system and the training needs of the human resources at the hospital Italiano de Buenos Aires. Antoine Geissbuhler and Casimir Kulikowski, eds. *IMIA Yearbook of Medical Informatics*. Stuttgart, Germany: Schattauer, 2009.
16. Staggers N, Gassert CA, Skiba DJ. Health professionals' views of informatics education: findings from the AMIA 1999 spring conference. *J Am Med Inform Assoc* 2000;7:550–8.
17. Murphy J, Stramer K, Clamp S, *et al*. Health informatics education for clinicians and managers—what's holding up progress? *Int J Med Inform* 2004;73:205–13.
18. Garde S, Harrison D, Hovenga E. Skill needs for nurses in their role as health informatics professionals: a survey in the context of global health informatics education. *Int J Med Inform* 2005;74:899–907.
19. Mantas J, Ammenwerth E, Demiris G, *et al*. Recommendations of the International Medical Informatics Association (IMIA) on Education in Biomedical and Health Informatics. First Revision. *Methods Inf Med* 2010;49:105–20.
20. FIC/NIH. *Informatics Training for Global Health*. http://www.fic.nih.gov/programs/training_grants/itgh/ (accessed 10 Jul 2010).
21. Curioso WH, Garcia PJ, Castillo GM, *et al*. Red QUIPU. Reforzando las Capacidades en Investigación en Informática para la Salud Global en la Región Andina a través de la Colaboración Internacional. [Strengthening Global Health Informatics Research within the Andean Region through International Collaboration] [Spanish]. *Rev Peru Med Exp Salud Publica* 2010;27:449–57. http://www.ins.gob.pe/insvirtual/images/artrevista/pdf/rpmesp2010.v27.n3.a20.pdf (accessed 19 Nov 2010).
22. Blas MM, Alva IE, Carcamo CP, *et al*. Effect of an online video-based intervention to increase HIV testing in men who have sex with men in Peru. *PLoS One* 2010;5:e10448.
23. Karras BT, Kimball AM, Gonzales V, *et al*. Informatics for Peru in the new millennium. *Stud Health Technol Inform* 2001;84:1033–7.
24. Blas MM, Curioso WH, Alva IE, *et al*. Evaluación de un Curso Internacional y Multidisciplinario de Informática Biomédica en el Perú. *Paper presented at: INFOLAC 2008*. Buenos Aires, Argentina: AAIM, 2008.
25. Blaya JA, Fraser HS, Holt B. E-health technologies show promise in developing countries. *Health Aff (Millwood)* 2010;29:244–51.
26. Aylward DK, Leão B, Curioso WH, *et al*. Can you heal me now? Potential (and pitfalls) of mHealth. *Americas Quarterly* 2010;4:88–95.
27. Blobel B. Architectural approach to eHealth for enabling paradigm changes in health. *Methods Inf Med* 2010;49:123–34.
28. ISO/TC215 WGS. Health informatics. *International Organization for Standadization*. Technical Committee 215. 2010. http://www.iso.org (accessed 20 Nov 2010).

29. Kampov-Polevoi J, Hemminger BM. A curricula-based comparison of biomedical and health informatics programs in the USA. *J Am Med Inform Assoc* 2011;18:195–202.
30. Chang J, Poynton M, Gassert C, *et al*. Nursing informatics competencies required of nurses in Taiwan. *Int J Med Inform* 2010;80:332–40.
31. Stead WW, Searle JR, Fessler HE, *et al*. Biomedical informatics: changing what physicians need to know and how they learn. *Acad Med* 2011;86:429–34.
32. Hart MD. A Delphi study to determine baseline informatics competencies for nurse managers. *Comput Inform Nurs* 2010;28:364–70.

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4,5
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	5,6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5-7
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	5-7
Bias	9	Describe any efforts to address potential sources of bias	6,7
Study size	10	Explain how the study size was arrived at	NA
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	5,6
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7
		(*b*) Describe any methods used to examine subgroups and interactions	NA
		(*c*) Explain how missing data were addressed	NA
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	NA
		(*e*) Describe any sensitivity analyses	NA
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	7
		(b) Give reasons for non-participation at each stage	NA
		(c) Consider use of a flow diagram	NA
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	7-10
		(b) Indicate number of participants with missing data for each variable of interest	7
Outcome data	15*	Report numbers of outcome events or summary measures	7-13
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	NA
		(*b*) Report category boundaries when continuous variables were categorized	NA
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	NA
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	NA
Discussion			
Key results	18	Summarise key results with reference to study objectives	14-17
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	16,17
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	17
Generalisability	21	Discuss the generalisability (external validity) of the study results	16
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	18

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.