Abstract

Nosocomial infections are a major worldwide cause of death and disability, according to estimates reported by the World Health Organization [1]. Up to 15% of hospitalized patients suffer from infections associated with healthcare [2]. In addition, in the EPIC (European Prevalence of Infection in Intensive Care) study [3], Vincent and coworkers reported that the prevalence of NI in 1417 European intensive care units was 20.6% in 1992. Several studies focusing on the impact of NIs on healthcare revealed that they are responsible for increased in mortality, morbidity, and length of hospital and intensive care unit stays [4,5].

NIs appear be an unavoidable toll that we must pay while we attempt to manage patients aggressively using the latest technologies, including invasive devices. However, at least a third of NIs are preventable through infection control programs, as suggested by the SENIC (Study on the Efficacy of Nosocomial Infection Control) study from the US Centers for Disease Control and Prevention [6]. Because there is ample evidence of the effectiveness of infection control programs [6-8], an understanding of such programs and their incorporation into everyday clinical practice is mandatory.

The need for education and constant updating of infection control measures may now be achieved with the use of modern technology, including the internet and world wide web. However, navigation of the world wide web to gain valuable information from reliable sources is recognized not to be easy [9]. Thus, we endeavored to identify various electronic sources on matters of prevention and control of NIs, and to compile a list of major websites as a guide for interested healthcare professionals.

Method

Popular internet search engines, including Google, Yahoo and AltaVista, were used to identify websites that provide information regarding the control of NIs. Broad search terms such as 'infection control' were used to identify a large number of relevant websites. The first 100 hits on each search engine were further reviewed. A number of the identified sites provided links to other sites, which are also included in this review.

PubMed and Current Contents were also extensively searched by using the following search strategy: 'infection control' AND 'world wide web'.

To be included in our list, a website had to be developed by a government, academic institution, or a national or international healthcare professionals' association, as a guarantee of accuracy and overall validity of the information provided; personal sites or those maintained by commercial entities.
Table 1

| Website title (country)                                                                 | Web site address                                         | Title of web page presenting information                  |
|----------------------------------------------------------------------------------------|----------------------------------------------------------|----------------------------------------------------------|
| National Library of Medicine (USA)                                                     | http://www.nlm.nih.gov                                    | MedlinePlus: Infection control                           |
| Faculty of Medicine: University Catholic of Louvain (Belgium)                          | http://www.uclouvain.be/md.html                           | Infection control                                        |
| Infection control today magazine (USA)                                                 | http://www.infectioncontroltoday.com                      | Infection control programs                               |
| Association for Professionals in Infection Control and Epidemiology (USA)               | http://www.apic.org/AM/Template.cfm?Section=Home         | Infectious disease centre. Practice guidance             |
| Infection Control Nurses Association (UK)                                              | http://www.icna.co.uk/                                   | Public downloads                                          |
| Yale-New Haven Medical Center (USA)                                                    | http://www.med.yale.edu                                  | Yale-New Haven hospital infection control manual        |
| Australian Government.                                                                 |                                                          |                                                          |
| Department of Health and Ageing (Australia)                                            | http://www.health.gov.au                                 | Infection control guidelines. Navigation page            |
| National Institute for Health and Clinical Excellence (UK)                             | http://www.nice.org.uk/page.aspx?o=home                  | Infection control                                        |
| Centers for Disease Control and Prevention (USA)                                       | www.cdc.gov                                              | Infection control in health care settings                |
| National Health Service (NHS) plus - Health at work (UK)                               | http://www.nhsplus.nhs.uk/default.asp                     | NHS stuff. Infection control                             |
| Royal College of nursing (UK)                                                          | http://www.rcn.org.uk                                    | Good practice in infection prevention and control        |
| American Dental Association (USA)                                                      | http://www.ada.org/index.asp                              | Oral health topics. Infection control                    |
| World Health Organization                                                              | http://www.who.int/en/                                   | Hospital hygiene and infection control                   |
| Public Health Agency of Canada (Canada)                                                | http://www.phac-aspc.gc.ca/new.e.html                    | Guidelines on infection control                          |
| NSW Health (Australia)                                                                 | http://www.health.nsw.gov.au/                            | Infection control policy                                  |
| Infection Control Department (USA)                                                     | http://infectioncontrol.ucsfmedicalcenter.org/           | Infection control policy. Standard and transmission based precautions |
| Victorian Government Health information (Australia)                                    | http://www.health.vic.gov.au/                            | Guidelines and regulations                               |
| Health protection agency (UK)                                                          | http://www.hpa.org.uk                                    | Centre for infections                                    |
| St. Joseph’s Health Care, London (UK)                                                  | http://www.sjhc.london.on.ca                             | Infection prevention and control                         |
| UK National Audit Office (UK)                                                          | http://www.nao.org.uk                                    | The management and control of hospital acquired infection in acute NHS trusts in England |
| Queensland Health (Australia)                                                          | http://www.health.qld.gov.au                             | Infection control                                        |
| College of Nurses of Ontario (Canada)                                                 | http://www.cno.org                                      | Infection prevention and control standards for adult care homes |
| Scottish Government, Scottish Executive (Scotland)                                     | http://www.scottland.gov.uk/Home                         | Infection control and postexposure protocols             |
| HIV Dent (USA)                                                                         | http://www.hivdent.org                                   | Infection control                                        |
| National University of Ireland, Galway (Ireland)                                       | http://www.ruagalway.ie                                  | Infection control philosophy                             |
| Infection control services, University College, London hospitals (UK)                  | http://www.infectioncontrolservices.co.uk/Default.htm    | Infection control in endoscopy                           |
| Gastroenterological Society of Australia (Australia)                                   | http://www.gesa.org.au/index.htm                         | Strengthening and co-ordinating health protection in Scotland |
| Health protection Scotland                                                             |                                                          | Control of infection: how to avoid damaging yourself and your patient |
| Imperial College of London (UK)                                                        | http://www3.imperial.ac.uk                               | HMC epidemiology/infection control                       |
| Harborview Medical Centre (HMC; USA)                                                   | http://www.uwmedicine.org/Facilities/Harborview/         | Infection control nurses of Connecticut                  |
| Infection control nurses of Connecticut (USA)                                          | http://www.infectioncontrolct.org/                       | Communicable diseases, epidemiology and immunization     |
| King County Government, Seattle, Washington (USA)                                      | http://www.metrokc.gov                                   | Resources on the internet on infection control           |
| The University of North Carolina at Chapel Hill (USA)                                  | http://www.unc.edu                                       | Infection control resource                               |
| Infection Control Resource (USA)                                                       | http://www.infectioncontrolresource.org/                 | Principles of infection control                          |
| William Fleming high school, VA (USA)                                                  | http://www.roanoke.k12.va.us/schools/Fleming/lawson/gpage/weblens.htm | Acute and communicable disease prevention                |
| Oregon Government (USA)                                                                | http://www.oregon.gov/                                  | Links and resources                                      |
| Community and Hospital Infection Control Association (Canada)                         | http://www.chica.org/                                   | Severe acute respiratory syndrome (SARS)                 |
| Centers for Disease Control and Prevention (USA)                                       |                                                          | Infection control in the correctional setting            |
| New York State (USA)                                                                   | http://www.ny.gov/                                      | Infection control manual                                 |
| The Body: The Complete HIV/AIDS Resource (USA)                                         | http://www.thebody.com/index.html                        | Department of Infection Control and Prevention           |
| University of Virginia Health System (USA)                                             | http://www.healthsystem.virginia.edu/                    | Infection control guidelines                             |
| Vanderbilt Medical Center (USA)                                                        | http://www.mc.vanderbilt.edu/                            | Florida’s health                                          |
| British Columbian Centre for Disease Control (Canada)                                  | http://bcdc.org/divisionphp/?item=11                    | The medical algorithms project. Infection control        |
| Florida Department of Health (USA)                                                     | http://www.doh.state.fl.us                              | Infection control                                        |
| Institute of algorithmic medicine (USA)                                                | http://www.medical.org/visitor/login.aspx               | Patient safety and health systems management. Infection control |
| The Chinese University of Hong Kong (China)                                            | http://sic.cuhk.edu.hk/                                 | Hospital epidemiology and infection control              |
| European Society of Intensive Care Medicine (Europe)                                   | http://www.cobacitrice.org                              | Infection control - a problem for patient safety         |
| Johns Hopkins Medicine (USA)                                                           | http://www.hopkinsmedicine.org/index.html                |                                                          |
| Medical-Journals.com (UK)                                                              | http://www.medical-journals.com/                         |                                                          |
| Website direct address                                                                 | Comments                                                                 |
|--------------------------------------------------------------------------------------|--------------------------------------------------------------------------|
| http://www.nlm.nih.gov/medlineplus/infectioncontrol.html                             | Provides infection control guidelines                                      |
| http://www.md.ucl.ac.be/didac/hosp/infco.htm                                          | A database of many articles with abstracts, published since 1 January 1994 |
| http://www.infectioncontroltoday.com/category.asp?sectionID=403                       | Provides articles concerning infection control                             |
| http://www.apic.org/AM/Template.cfm?Section=Guidelines&Template=TaggedPage/TaggedPageDisplay.cfm&TPLID=66&ContentID=519 | Provides infection control guidelines.                                    |
| http://www.icca.co.uk/publicdownloads/index.asp                                       | Mainly for members of the association                                       |
| http://www.med.yale.edu/ynhti/infection/                                              | Good collection of preventive measures for infection control               |
| http://www.health.gov.au/internet/wcms/Publishing.nsf/content/icg_guidelines-index.htm | Infection control guidelines for the prevention of transmission of infectious diseases in the health care setting |
| http://www.nice.org.uk/page.aspx?o=CG002                                              | Provides a set of measures to avoid infection that should be followed by anyone giving or receiving care at home or at a health centre |
| http://www.cdc.gov/nicidod/dhisp/index.html                                           | Guidelines for keeping patients and health care workers in health care settings protected from infectious diseases |
| http://www.nhsplus.nhs.uk/nhsstaff/infection.asp                                      | Limited information                                                         |
| http://www.ron.ucl.ac.uk/resources/mrsa/healthcarestaff/infectioncontrol/index.php   | Guidance for nursing stuff. Information on infection control and prevention |
| http://www.ada.org/public/topics/infection_control_faqs.asp#3                          | Brief answers on dental health                                              |
| http://www.who.int/water_sanitation_health/medicalwaste/148to158.pdf                 | Information on epidemiology and prevention of hospital infections           |
| http://www.phac-aspc.gc.ca/cdp_e.html#infection                                      | Contains guidelines on infection control                                     |
| http://www.health.nsw.gov.au/policies/PD/2005/pd/PD2005_247.pdf                     | Policy directive of the Australian Department of Health. Contains guidelines on hospital infection control |
| http://infectioncontrol.ucsfmedicalcenter.org/STD__Trans_Precautions_final.pdf       | Contains guidelines on hospital infection control                           |
| http://www.health.vic.gov.au/ideas/regulations/index.htm                             | Infectious disease regulation and guidelines                                |
| http://www.hpa.org.uk/infections/default.htm                                         | Carries out a broad spectrum of work related to prevention of infectious diseases |
| http://www.nao.org.uk/publications/nao_reports/9900230.pdf                           | Contains information on infection control                                   |
| http://www.health.qld.gov.au/infectioncontrol/guidelines.html                        | General information on infection control and costs of hospital acquired infections |
| http://www.cno.org/docs/prac/41002_infection.pdf                                      | Queensland government infection control guidelines                          |
| http://www.scotland.gov.uk/Publications/2005/03/19927/42764#11                       | Guidelines for nurses                                                      |
| http://www.hivdirect.org/infcnt/office.htm                                           | Provides infection control standards for adult care homes                   |
| http://www.nuigalway.ie/bac/control_of_infection.htm                                 | Dental office issues                                                       |
| http://www.infectioncontrolservices.co.uk/intro1.htm                                | General information on infection control                                    |
| http://www.who.int/water_sanitation_health/medicalwaste/148to158.pdf                 | Contains information on infection control                                   |
| http://www.gesa.org.au/members_guidelines/endoscopy_inf/                              | Practice guidelines for endoscopic procedures                               |
| http://www.hps.scot.nhs.uk/schief.asp                                                | Contains infection control procedures                                       |
| http://www3.imperial.ac.uk/OCHEALTH/formedicalstudents/controlofinfection/           | Basic principles of infection control                                       |
| http://depts.washington.edu/ictrain/cmanual/                                          | Information for health care providers                                       |
| http://www.infectioncontrolct.org/                                                  | Contains useful information and helpful links on infection control          |
| http://www.metrokc.gov/health/providers/epidemiology/index.htm                       | Information about infection control                                         |
| http://www.unc.edu/depts/spice/resource.html                                         | Contains articles on prevention strategies for infection control practitioners and professional nurses |
| http://www.infectioncontrolresource.org/                                             | An internet lesson to introduce health occupation students to infection control and prevention |
| http://www.roanoke.k12.va.us/schools/Fleming/lawson/jgpage/infect.htm                 | General disease control and antimicrobial resistance                        |
| http://www.ohio.edu/DHS/ph/acd/ldh/infectcontrol.shtml#genl                          | Information on hand hygiene, bioterrorism and disasters. Needs subscription for further information |
| http://www.chica.org/links_overview.html                                             | Only for SARS. Limited information                                          |
| http://www.cdc.gov/nicidod/sars/ic-closecontacts.htm                                 | Guidelines on infection control                                            |
| http://www.health.state.ny.us/nysdoh/infection/infectioncontrol.html                 | Information on HIV prevention                                               |
| http://www.mcr.vanderbilt.edu/root/vumc.php?nicoinfectioncontrol&doc=4616            | Contains infection control procedures                                       |
| http://www.hps.scot.nhs.uk/schief.asp                                                | Isolation guidelines, infection control policies                           |
| http://www.doh.state.fl.us/DiseaseCtrl/epi/icg/icg.pdf#search=%22%22infection%20control%22%20in%20guidelines%22 | Contains infection control guidelines and many links.                        |
| http://www.medicaljournal.org/infect.htm                                             | Main focus is on pandemic influenza and avian flu                          |
| http://www.naoh.org.uk/publications/nao_reports/9900230.pdf                          | Information on control of the majority of nosocomial infections. Requires registration |
| http://www.hpa.org.uk/infectioncontrol/guidelines.html                               | Focus on SARS                                                               |
| http://www.cdc.gov/nicidod/dhisp/index.html                                           | Contains practice guidelines on prevention of nosocomial infections          |
| http://www.health.gov.au/internet/wcms/Publishing.nsf/content/icg_guidelines-index.htm | Information on infectious diseases and their prevention                      |
| http://www.chica.org/links_overview.html                                             | An article on nosocomial infections                                         |
were excluded. In addition, we selected only those sites that were written in English (alternative language options, if present, were mentioned, but absence of information in English was considered an exclusion criterion for the purposes of this article) and that offer free access (specifically, no paid registration is required to gain access to the full content of the site; sites requiring free registration for access were not excluded).

Results

A great many websites were initially identified using the specified search engines. In detail, the term 'infection control' yielded about 26,800,000 hits in Google, about 45,100,000 in Yahoo, and about 26,000,000 in Alta Vista. Of these we selected 44 websites; five additional sites, known to us, that were not captured through the initial internet search were added to the final list. Searches of the PubMed and Current Contents databases did not identify any additional websites.

In Table 1 we present the websites we selected based on the selection criteria outlined above. In all, our list contains 49 websites that provide information on infection control. Twenty-one of these sites were developed by governments, 15 by academic institutions, and 13 by health care professionals' associations. It is noteworthy that some interesting websites on the issue of infection control are derived from nurses' associations. The majority of the retrieved sites provide general information on infection control practices, whereas others focus on one particular infection, such as human immunodeficiency virus infection or severe acute respiratory syndrome.

We accessed each of the web addresses listed in Table 1 both to confirm accessibility and to verify that they contain accurate information on matters of infection control. Other characteristics of these resources, such as extent of content, subspecialty focus, and inclusion of specific guidelines, are summarized in the right-most column of the table.

Discussion

We attempted to provide health care professionals with a timely and succinct list of world wide web resources that contain valuable information on the prevention and control of NIs. Because websites containing information that is both accurate and accessible are considered to be the best [10], we aimed to include in our list only those websites with these features.

Our search was conducted to identify websites reporting on methods and techniques that are needed to prevent cross-contamination and to control potential sources of pathogens that could be transmitted from patient to patient or from health care professional to patient. Specifically, the listed websites include updated information on isolation, standard precautions (hand hygiene, wearing of gloves, mask and gowns, manipulation of sharp objects, and proper use of patient care equipment) and transmission-based precautions.

In addition to such measures, control of use of antimicrobial agents is a major component of hospital infection control, because antimicrobial abuse is known to enhance the development of resistant strains [11]. It was beyond the scope of this work to identify websites providing recommendations on the control of antimicrobial use. However, a good knowledge of local epidemiologic patterns and resistance profiles of prevailing pathogens is crucial to selecting appropriate antimicrobial treatment. Therefore, our research team recently reported on a collection of world wide web resources that include updated information on antimicrobial resistance patterns of clinical isolates from patients from various parts of the world [12].

One of the sites included in our list [13], developed by US Centers for Disease Control and Prevention Hospital Control Practice Advisory Committee, is worthy of particular mention because it features guidelines for the protection of health care professionals from infectious agents as well as management of postexposure care. The prevention strategies we found in this website include immunization for vaccine preventable diseases (tetanus, hepatitis B, and influenza) and isolation precautions to prevent exposure to infectious agents. Specific recommendations regarding management of health care workers who have suffered significant exposure to human immunodeficiency virus, hepatitis B and C viruses, *Neisseria meningitidis*, and *Mycobacterium tuberculosis* are also provided in this site.

We considered free access to be a prerequisite for websites to be included in our list, because the rationale of this work and of the world wide web in general is to provide information to all who are interested. In addition, need for free distribution of medical literature is widely supported, and open access journals are expected to enjoy greater increases in impact factor than are their subscription counterparts [14]. However, given that appropriate educational resources are often costly, we acknowledge that the exclusion of websites requiring paid registration might have directed our list of websites toward lower quality resources.

Although we endeavored, through our gathering strategy, to review most websites that provide information on infection control, we also recognize that some sites that offer valuable information on this issue might have been omitted. In addition, there are other potentially relevant sites that we omitted because they did not fulfill the inclusion criteria. The selection criteria were primarily aimed at avoiding the creation of an extended and impractical list, which would be of limited use to a health care worker with time constraints.

Conclusion

We provide the reader with an organized and practical list of available internet resources that contain free and accurate information on prevention and control of NIs. Given the well documented impact of such infections on morbidity and
mortality, as well as the effectiveness of infection control programs, we believe that this work may help to limit NIs through broader distribution of knowledge on infection control measures.

Competing interests
The authors declare that they have no competing interests.

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