The economic benefits of health information exchange interoperability for Australia

Peter Sprivulis, Jan Walker, Douglas Johnston, Eric Pan, Julia Adler-Milstein, Blackford Middleton and David W Bates

Abstract

Objective: To estimate costs and benefits for Australia of implementing health information exchange interoperability among health care providers and other health care stakeholders.

Design: A cost–benefit model considering four levels of interoperability (Level 1, paper based; Level 2, machine transportable; Level 3, machine readable; and Level 4, machine interpretable) was developed for Government-funded health services, then validated by expert review.

Results: Roll-out costs for Level 3 and Level 4 interoperability were projected to be $21.5 billion and $14.2 billion, respectively, and steady-state costs, $1470 million and $933 million per annum, respectively. Level 3 interoperability would achieve steady-state savings of $1820 million, and Level 4 interoperability, $2990 million, comprising transactions of: laboratory $1180 million (39%); other providers, $893 million (30%); imaging centre, $680 million (23%); pharmacy, $213 million (7%) and public health, $27 million (1%). Net steady-state Level 4 benefits are projected to be $2050 million: $1710 million more than Level 3 benefits of $348 million, reflecting reduced interface costs for Level 4 interoperability due to standardisation of the semantic content of Level 4 messages.

Conclusions: Benefits to both providers and society will accrue from the implementation of interoperability. Standards are needed for the semantic content of clinical messages, in addition to message exchange standards, for the full benefits of interoperability to be realised. An Australian Government policy position supporting such standards is recommended.

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What is known about the topic?

Health information exchange interoperability is seen as essential for efficient, effective and safe health care delivery.

What does this paper add?

This paper presents a cost–benefit model for paper-based, machine transportable, machine readable and machine interpretable interoperability. This analysis suggests savings of over two billion dollars annually from implementation of health information exchange interoperability for transactions in which Australian governments have a financial interest. The principal sources of savings are reduced costs associated with handling of laboratory and imaging reports and in the communication of clinical information between providers.

What are the implications for practitioners?

The authors suggest that the greatest risk to achieving value from interoperability is not the cost of implementation, but whether or not rigorous standards for Level 4 interoperability are developed and implemented across Australia.

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INFORMATION SYSTEM INTEROPERABILITY is the ability of information systems to exchange information and to use the information that has been exchanged.[1] Australia is pursuing health informa-

1 Definitions of four levels of sophistication and standardisation of health information exchange interoperability[5]

Level	Interoperability	Definition	Example
Level 1	Non-electronic data	Minimal use of information technology to share information	Mail, telephone
Level 2	Machine transportable data	Transmission of non-standardised information via basic information technology; information within the document cannot be electronically manipulated	Fax or exchange of documents in other image formats such as scanned documents transmitted as portable document format files
Level 3	Machine organisable data	Transmission of structured messages containing non-standardised data; requires interfaces to translate data from the sending organisation's vocabulary to the receiving organisation's vocabulary	E-mail of free text, exchange of files in incompatible/proprietary file formats
Level 4	Machine interpretable data	Transmission of structured messages containing standardised and coded data; systems exchange information using the same formats and vocabularies	Automated exchange of coded results from external laboratories into an electronic medical record, automated exchange of the patients "active problem" lists between providers

tion exchange interoperability via the development work of Health*Connect* and, more recently, through the work of the National E-Health Transition Authority (NEHTA).[2] In February 2004, the firm DMR Consulting reported to the Australian Government the "indicative benefits" expected from national e-health investment. Benefits expected total $396 million per annum, principally from reduced adverse drug events ($231 million), improved diabetes management ($140 million), improved medication management ($55 million) and reduced emergency services demand ($6.7 million), noting some overlap between these individual benefits.[2]

Similar improvements in care quality are expected from national health information system initiatives in both Canada and the United Kingdom.[2-4] However, financial benefits from improved efficiency of information exchange between health care stakeholders are also expected.[3,4]

In the United States, the Center for Information Technology Leadership (CITL) modelled the financial benefits attributable to improved efficiency of health information exchange arising from interoperability. The Center estimated a net annual benefit of US$78 billion from "fully standardised" interoperability for the US.[5,6] Development of a similar Australian model may assist the business case for national e-health investment and inform national health policy to ensure that the maximum yield is realised from national e-health investment.

This study estimated the costs and benefits associated with improved efficiency of information exchange associated with interoperability for Australia, with a particular emphasis on differences in the costs and benefits associated with varying levels of interoperability standards.

Methods

An Australian model of interoperability benefits was developed by adapting the US CITL model.[5,6] Analytica® modelling software (Lumina Decision Systems, Los Gatos, Calif, USA) was used to develop the model as an influence diagram.[7]

Data sources

Information for the US model was obtained via literature reviews, interviews and expert panel estimates.[5,6] The expert panel included experts in

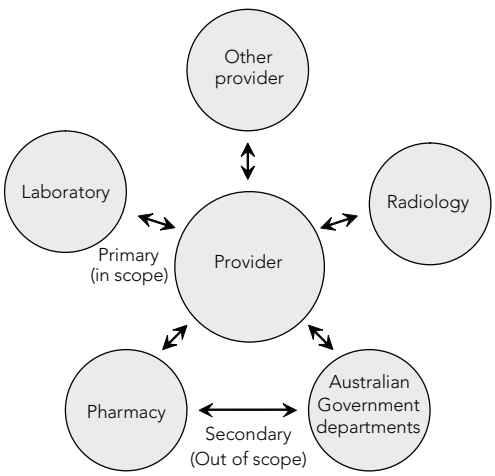
health informatics, economics, data sharing, public health and policy. The panel identified data sources and estimated data points when published data were unavailable.[5,6]

The primary information sources for the Australian adaptation were Australian Bureau of Statistics, Australian Institute of Health and Welfare, and Health Insurance Commission reports for 2002–2003.[8-13] Other sources included studies conducted in Australia or other English-speaking countries. When published information was unavailable, CITL expert panel estimates were used. In addition, ten Australian experts in health care information reviewed the model assumptions, calculations, findings and contentious model variable values. Where there was disagreement with CITL's expert panel, the median Australian experts' values were used.

Conceptual framework for model development

Four levels of sophistication and standardisation of interoperability were modelled in order to assess the impact of different interoperability standards upon the costs and benefits of implementing interoperability (Box 1).[5] The costs and benefits associated with information exchange between providers, defined as registered medical practitioners undertaking direct patient care, and information exchange between providers and key health care stakeholders were modelled. The relationship between providers and stakeholders is illustrated in Box 2. The costs and benefits of improved interoperability between non-provider stakeholders (eg, laboratory to pharmacist) were not modelled. The costs associated with information transfer were allocated to the sender. Both providers and stakeholders were assumed to be operating within a national health information exchange environment using peer-to-peer information exchange (ie, directly between providers and stakeholders) rather than a centralised hub and spoke model of information exchange where information passes between providers and stakeholders via a central hub.

2 Provider–stakeholder relationships included in the modelling of the financial benefits of health care information exchange interoperability



Scope of the Australian model

To simplify analysis, the Australian model was limited to transactions in which the Australian federal or state governments had a financial interest. All state government public medical services, including public hospital services, and private outpatient services attracting federal government rebates, such as Australian Health Insurance Commission Medicare rebates, Pharmaceutical Benefits Scheme rebates and federal Department of Veterans' Affairs rebates were included. Fully private medical and pharmaceutical services and third party paid services, such as workers compensation insurance, and clinical services provided by non-medical clinical providers (eg, allied health) were not modelled.

Projection of costs

Interfaces are computer programs that enable information systems to communicate with one another. Costs were projected for stakeholders' interfaces with providers assuming again a peer-to-peer model of data exchange.

Level 3 interoperability interface development costs were estimated to be $50 000 per interface for hospitals, laboratories, imaging centres, phar-

3 Benefits associated with Level 4 interoperability between outpatient providers and independent laboratories

Item		Amount	Source
A	Total Health Insurance Commission (HIC) laboratory test expenditure	$1 211 916 811	HIC[13]
B	Total HIC rebated laboratory tests per year	55 343 850	HIC[13]
C	Provider administrative cost incurred per test	$19.25	Pan et al[6]
D	Average HIC expenditure per laboratory test	$21.90	(A ÷ B)
E	Avoidable redundancy in testing, estimate one	20%	Brailer et al[15]
F	Avoidable redundancy in testing, estimate two	8.6%	Bates et al[16]
G	Average avoidable redundancy in testing (average of E and F)	14.3%	Mean (E,F)
H	Proportion of redundant tests avoidable at Level 4 interoperability	95%	Pan et al[6]
I	Tests avoided at Level 4 interoperability	13.6%	(G × H)
J	Tests avoided per year	7 518 000	(B × I)
K	HIC expenditure saved per year from avoided tests	$164 629 000	(C × J)
L	Remaining tests per year	47 826 000	(B –J)
M	Proportion of laboratory tests administrative costs that could be avoided at Level 4 interoperability	95%	Pan et al[6]
N	Avoided administrative costs at Level 4 interoperability	$874 618 000	(C × L × M)
O	Total savings	$1 039 247 000	(K + N)

macies, and government public health departments, and $20 000 per interface for provider practices. Level 3 interoperability requires a unique interface to each *individual* external organisation. Between eight and 20 interfaces were assumed for the purposes of the model. Level 4 interoperability requires one interface to each *type* of external organisation; totalling four per provider, assuming that providers develop a generic ordering, reporting and digital attachment (eg, pathology slide image or radiology image) interface for laboratory and imaging centre transactions. For both Level 3 and Level 4, each external organisation was assumed to require one interface to communicate with providers.

Despite widespread electronic record use in Australia, these systems do not support interoperability, therefore it was assumed that providers would install new electronic health record systems to achieve Level 3 and Level 4 interoperability with stakeholders, similar to the US model.[12] Birkmeyer's cost estimates for hospital providers and earlier CITL estimates for the cost of implementing advanced outpatient information systems were used to estimate information system costs.[6,14] Acquisition costs included initial licences, hardware, implementation and training, internal interfaces and provider assistance. Annual maintenance costs of 17.5% of the acquisition costs were assumed for ongoing licence fees, system upgrades and hardware replacement costs.[5,6]

The allocation of Level 4 interoperability costs separately to interfaces and system replacement, in order to allow comparison with Level 3, is somewhat arbitrary, because achievement of Level 4 interoperability is most likely to be achieved by the development of integrated information services (a single product), based on web services standards rather than separate interfaces and provider systems (the two distinct products required for Level 3 interoperability).

Projection of benefits

Projections at each level were based upon 100% attainment of the particular interoperability level. Box 3 provides an example of the projection of benefits associated with Level 4 interoperability

4 Ten-year roll-out costs and annual costs of health care information exchange and interoperability (interoperability)

	Roll-out cost ($ millions)		Annual cost ($ millions)	
Cost item	**Level 3**	**Level 4**	**Level 3**	**Level 4**
Clinician office system cost	5 702	5 702	341	341
Public hospital system cost	1 710	1 710	100	100
Provider interface cost	13 523	6 098	986	445
Stakeholder interface cost	648	648	47	47
Total	**21 583**	**14 158**	**1 474**	**933**

between outpatient providers and independent laboratories.

National roll-out scenario

A 10-year national implementation scenario was used to project benefits and costs over time. It was assumed that 20% of organisations would install systems in each of the first 5 years, incurring all acquisition and start-up costs in year 1 and incurring maintenance costs in years 1 through 10. Each organisation is assumed to accrue 50% of potential benefits in year 1, then benefits would increase by 10% each year. The model did not attempt to account for inflation, discounting or changes in utilisation due to changes in the Australian population. Dollar amounts are expressed in 2002–2003 Australian dollars.

Results

Costs of interoperability

Level 2 interoperability was assumed to be cost free because faxing is widely available. The costs associated with Level 3 and Level 4 interoperability are presented in Box 4.

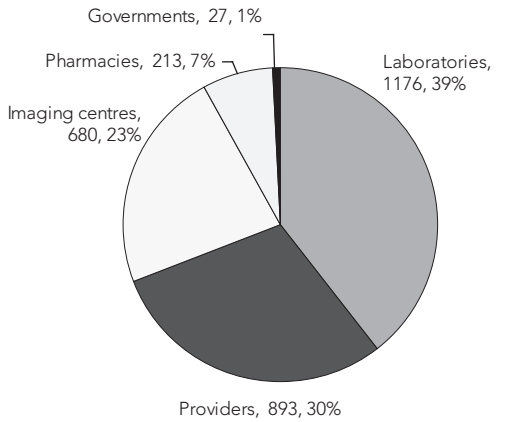
Benefits of interoperability

Interoperability between office-based clinicians and laboratories would result in reduced duplication of laboratory tests and reduce costs associated with paper-based ordering and reporting of results.[5] The model indicates that the benefits from reduced test duplication and reduced paper systems would produce a total annual benefit of $272 million at Level 2, $740 million at Level 3 and $1180 million at Level 4.

Interoperability between office-based clinicians and imaging centres would result in reduced duplication of imaging examinations and would reduce costs associated with paper and film-based processes. The model projected annual savings from avoided tests and improved efficiencies of $177 million at Level 2, $385 million at Level 3 and $680 million at Level 4.

Interoperability between outpatient providers and pharmacies would reduce the processing costs for prescriptions for pharmacists; Level 2,

5 Savings by provider relationship from health information exchange interoperability at Level 4 steady state (AU$ millions)



6 Net value of health care information exchange and interoperability (interoperability)

Interoperability level	Implementation, cumulative years 1–10 ($ millions)	Steady state, annual starting year 11 ($ millions)
Level 2		
Benefit	4 480	690
Cost	–	–
Net value	4 480	690
Level 3	–	–
Benefit	11 840	1 820
Cost	21 580	1 470
Net value	–9 740	350
Level 4	–	–
Benefit	19 420	2 990
Cost	14 160	930
Net value	5 260	2 060

$60 million; Level 3, $127 million and Level 4 interoperability, $213 million.

The Australian government would benefit by $356 million annually from reduced laboratory and imaging item rebates payable for duplicated tests that would be avoided at Level 4 interoperability.

Provider-to-provider interoperability would reduce the costs of handling requests for clinical information and referrals between providers.[17] The model projects a total annual benefit from reducing time spent copying chart information and seeking missing clinical information during consultations, as well as from improved efficiency of referral processes, of $176 million at Level 2, $385 million at Level 3 and $893 million at Level 4.

Provider connectivity to Australian government public health departments would make statutory reporting of notifiable diseases and birth, death and immunisation notifications more efficient and complete, potentially saving providers $5 million at Level 2, $17 million at Level 3 and $27 million at Level 4.

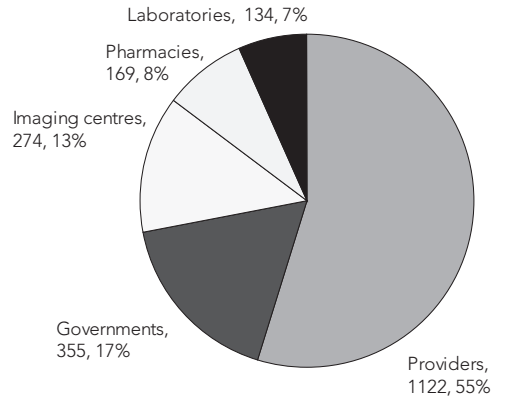
The proportions of benefits attributable to each type of transaction at Level 4 interoperability steady state are presented in Box 5.

A practice level example illustrates the projections. A medium sized office practice, defined in our analysis as one with two to five providers (eg, four general practitioners) would invest $330 000 in clinical systems and interfaces to achieve Level 4 interoperability. Beginning in Year 2, the practice would spend $37 000 per year to maintain those systems. Benefits would increase over time as more of the practice's care partners achieved Level 4 interoperability. At steady state the practice would accrue annual benefits of $270 000 annually from transactions with other providers ($117 000), laboratories ($123 000), imaging centres ($28 000) and governments ($4000). The net steady-state saving of $230 000 is 37% of the estimated total administrative costs for a five-provider practice and is comparable to the administrative savings realised by fully integrated information systems implementations in other clinical settings.[18]

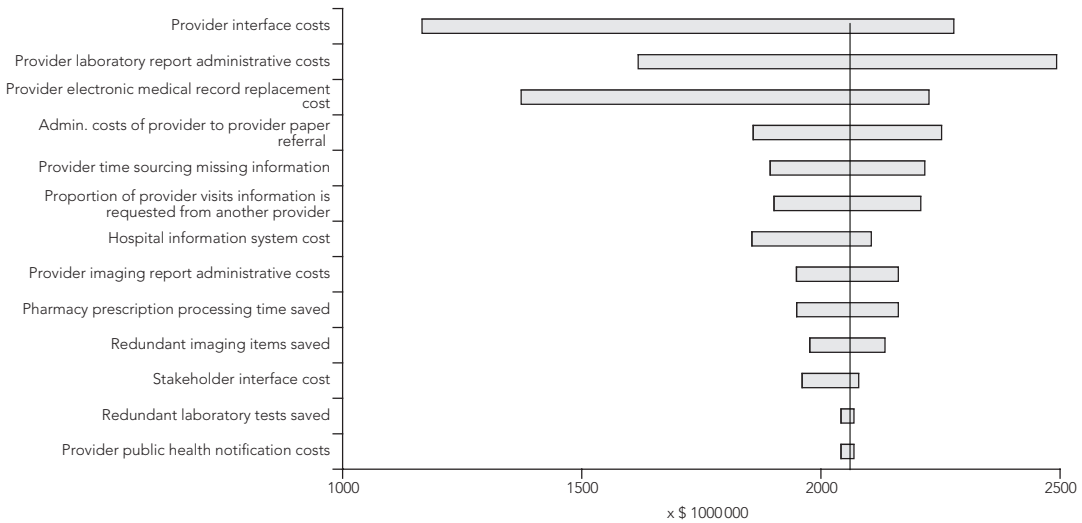
Net value of interoperability

The net value of three Levels of interoperability, obtained by subtracting the projected costs from projected savings, is presented in Box 6 and the distribution of these benefits is presented in Box 7. Providers gain the greatest net benefit from Level 4 interoperability at steady state $1120

7 Distribution of net annual benefit by stakeholder of health information exchange interoperability at Level 4 steady state (AU$ millions)



8 Health care information exchange interoperability (interoperability) sensitivity analysis



million (55%) of a total annual net value to all stakeholders of $2050 million.

Sensitivity analysis

The sensitivity of the net value of interoperability was evaluated by varying critical model inputs from 50% to 150% (Box 8) except for provider and stakeholder information system and interface costs which were varied from 50% to 200% given the unexpected pitfalls that may accompany large information system installations. Of the factors tested, net benefits are most sensitive to the provider interface and electronic medical record replacement costs. Doubling these costs decreases annual Level 4 net value to $1160 million and $1370 million respectively. Halving these information system costs raises annual net value to $2280 million and $2230 million, respectively.

Discussion

This study suggests that the total net savings from the national implementation of health information exchange interoperability for transactions in which Australian governments have a financial interest, could net over two billion dollars in savings annually.[11] The principal sources of savings are reduced costs associated with handling of laboratory and imaging reports and in the communication of clinical information between providers. The largest component of the costs associated with implementation falls upon providers with a fairly even split between the replacement costs of their existing electronic medical records and the costs of building interfaces. These costs are significantly lower for Level 4 interoperability, where standards for the semantic content of messages are assumed to be available, compared with Level 3, where such standards are absent.

In keeping with the principal benefits and costs of implementing Level 4 interoperability, model estimates of net value were shown to be most sensitive to varying information system and interface costs for providers and the administrative costs associated with handling laboratory reports. However, varying any benefits parameter by 50% resulted in a less than 25% variation in the overall estimate of the net benefit of Level 4 interoperability.

Although the model did not quantify many additional important costs and benefits, the projections obtained using this model suggest a significant positive net value from the implemen-

tation of interoperability for all stakeholders. In addition, implementation of interoperable systems would be expected to result in more timely, accurate and complete clinical information sharing and utilisation. Direct quality and safety benefits for patients are expected to result from this improved information availability.[2] Clearly, there are risks associated with the costs of information systems and interface implementation.[2-4] However, even the lowest estimate of net benefit provides a strong business case for investment in Level 4 interoperability even without incorporating the quality improvement benefits described by DMR Consulting.[2,19,20] Thus, we believe this represents a lower bound of the benefit. Both Level 2 and Level 3 communication offer positive financial returns, although they are small in comparison with the value of Level 4 interoperability.

Level 3 interoperability requires a large investment in interfaces to translate the wide range of electronic nomenclatures used by different stakeholders in a given geographic area but would eventually accumulate benefits that outweigh the costs. However, this local investment in custom interfaces may lock in local solutions and divert resources from the development of a national approach. Level 3 investment may therefore delay conversion to national standards and would result in later conversion costs.

The value of standards

It is apparent that the greatest risk to achieving value from interoperability is not the cost of implementation, but whether or not rigorous standards for Level 4 interoperability are developed and implemented across Australia. For this to occur, federal and state governments must work closely with stakeholders to develop standards for electronic data exchange (Level 3 interoperability), and particularly standards for the semantic content of clinical messages (Level 4 interoperability), so that provider and stakeholder information systems can understand and use the exchanged information rather than just store it. Since this is a public good, substantial public investment can be justified. The difference in the projected net annual value between Levels 3 and 4 of $1700 million may be considered the annual return on investment in national standards for interoperability of Australian health care information systems. Although no estimate has been made of the cost of developing such standards, it is likely that this cost would be two orders of magnitude less than the net benefit.

The governments of Canada, the US and the United Kingdom have adopted policies supporting standards for Level 4 as opposed to Level 3 interoperability.[3,4,19] Ideally, the Australian Level 4 standards should be developed in collaboration with near neighbours, such as New Zealand, Indonesia and Singapore, and other nations currently pursuing health care interoperability initiatives such as Canada, the UK and the US.

Limitations

While this analysis incorporates the best available evidence, it relied upon expert estimates for a number of model variables. No attempt has been made to model internal organisational effects of interoperability, such as changes in hospital workflow due to the removal of paper systems. However, evidence suggests that substantial benefits can accrue if implementation is properly managed.[18,21]

The model did not account for lost revenues from avoided tests or other changes in utilisation. Given the expected growth in health care services in Australia over the next 10 years, individual stakeholders are considered more likely to experience slower growth in services rather than an absolute reduction in demand for services. In addition, the projected benefits might not be realised as actual dollar savings for the Australian government, but could be translated into alternative or enhanced service delivery for the nation.

This model used a peer-to-peer model of information exchange with a national framework. Most Australian experts consulted believed substantial reductions in costs of interface development and maintenance could be realised by the implementation of regional hub and spoke models of information exchange. To achieve the projected benefits, essentially all Australian providers would need to participate in the network. How-

ever, Australian experts considered it unlikely that Australian providers, and particularly general practitioners, would be willing to undertake the substantial investment to upgrade their information systems to achieve interoperability in the absence of significant Australian Government incentives.

Conclusion

The implementation of interoperability in Australia should yield substantial benefits for patients, providers, and the Australian Government, as well as other stakeholders. Rigorous standards are needed for the semantic content of clinical messages, in addition to standards for message exchange, for the full benefits of interoperability to be realised. Ideally, these standards should be developed in collaboration with other countries pursuing national health care interoperability initiatives. Important policy considerations are how to develop Level 4 standards and how to provide incentives to Australian providers and health care stakeholders to adopt them.

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Competing interests

The authors declare that they have no competing interests.

References

1 Institute of Electrical and Electronics Engineers. The Authoritative Dictionary of IEEE Standards Terms. 7th ed. New York: IEEE, Inc.; 2001.

2 DMR Consulting. HealthConnect Indicative Benefits Report. Canberra: Commonwealth Department of Health and Aging; 2004.

3 Canada Health Infoway. Building momentum: 2003/2004 business plan. Ottawa: Canada Health, 2003.

4 National Programme for Information Technology. NPfIT Programme business justification. London: National Health Service; 2003.

5 Walker J, Pan E, Johnston D, et al. The value of health care information exchange and interoperability. *Health Aff (Millwood)* 2005; Suppl Web Exclusives: W5-10-W5-18.

6 Pan E, Johnston D, Walker J, et al. The value of healthcare information exchange and interoperability. Boston: Center for Information Technology Leadership, 2004.

7 Lumina Decision Systems Inc. Analytica 3.0.1. Modelling software. Los Gatos, California, 2004.

8 Australian Bureau of Statistics. Population projections, Australia, 2002–2101. Canberra: ABS, 2003. (ABS cat. No. 3222.0.)

9 Australian Institute of Health and Welfare. Medical labour force 2002. Canberra: AIHW, 2004. (AIHW Cat No. HWL 30.)

10 Australian Institute of Health and Welfare. Australian hospital statistics 2002–03. Health Services Series No. 22. Canberra: AIHW, 2004. (AIHW Cat. No. HSE 32.)

11 Australian Institute of Health and Welfare. Australia's health 2004. Australia's Health No. 9. Canberra: AIHW, 2004. (AIHW Cat. No. AUS 44.)

12 Britt H, Miller G, Knox S, et al. General practice activity in Australia 2003–04. General Practice Series No. 16. Canberra: Australian Institute of Health and Welfare, 2004. (AIHW Cat. No. GEP 16.)

13 Australian Government Health Insurance Commission. Annual Report 2003–2004. Canberra: HIC, 2004.

14 Birkmeyer C, Lee J, Bates D, Birkmeyer J. Will electronic order entry reduce health care costs? *Eff Clin Pract* 2002; 5: 67-74.

15 Brailer D, Augustinos N, Evans L, Karp S. Moving toward electronic health information exchange: interim report on the Santa Barbara County data exchange. Oakland: California HealthCare Foundation, 2003.

16 Bates D, Boyle D, Rittenberg E, et al. What proportion of common diagnostic tests appear redundant? *Am J Med* 1998; 104: 361–8.

17 Smith P, Araya-Guerra R, Bublitz C, et al. Missing clinical information during primary care visits. *JAMA* 2005; 293: 565-71.

18 Bedel V, Zdanowicz M. PACS strategy for imaging centers. *Radiol Manage* 2004; 26: 24-9.

19 Brailer D. Interoperability: the key to the future health care system. *Health Aff (Millwood)* 2005; Suppl Web Exclusives: W5-19-W5-21.

20 James B. E-health: steps on the road to interoperability. *Health Aff (Millwood)* 2005; Suppl Web Exclusives: W5-26-W5-30.

21 Asch S, McGlynn E, Hogan M, et al. Comparison of quality of care for patients in the Veterans Health Administration and patients in a national sample. *Ann Intern Med* 2004; 141: 938-45.

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