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The economic impact of iron deficiency in Australia

Iron Deficiency Collaborative

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Evaluate

Evaluate was formed in September 2016, to bring fresh thinking to policy and economic questions, particularly those in the social sphere.

Our particular goal is to identify long-term solutions to ensuring the sustainability of Australia's admirable social compact, including universal access to healthcare and education, and the supply of aged care, housing and other social infrastructure.

Our approach is based on a traditional microeconomic toolkit, moderated by the knowledge that social services are accessed by people with a vast variety of experiences, needs and resources. Consequently, Evaluate has no bias towards either public or private supply of services, noting that the access and welfare needs of different Australians typically require a mix of both.

The Principals of Evaluate are experienced professionals, and we complement this with external expertise where appropriate.

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www.viforpharma.com.au

The Iron Deficiency Collaborative is designed to provide leadership and an independent structure to identify and deliver recommendations to Government and the healthcare sector on how to optimise the management of iron deficiency in Australia. The Collaborative is guided by a steering committee which includes a broad and diverse representatives from various parts of the Australian healthcare system including healthcare policy; general practice; haematology; women's health; nephrology; pathology; nursing; indigenous health; and nutrition and diet.

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Executive Summary

Iron deficiency is a significant global health issue. In Australia, 34% of women of childbearing age and nearly 5% of healthy males are iron deficient.[1]

Iron deficiency and iron deficiency anaemia are significant health conditions with the latter being the third leading cause of years lived with disability,[2] despite the fact that iron deficiency can be treated and, in some instances, prevented. Anaemia is detected in up to 40% of patients prior to surgery.[3]

In addition, in 2017-18, iron deficiency anaemia accounted for 64,348 potentially preventable hospitalisations (PPH), up from 59,383 the previous year. This is second only in the chronic category to chronic obstructive pulmonary disease (COPD) which was responsible for 77,754 PPH.[4]

Iron is a mineral nutrient that is essential in enabling the body to function normally. Iron deficiency occurs when the body does not have enough mineral iron. Causes of iron deficiency include inadequate dietary intake of iron, malabsorption, increased iron requirements (such as in pregnancy) or as a comorbidity to an underlying condition. Untreated, iron deficiency is associated with impaired development in children, adverse effects on cognitive and physical performance in adults, and poorer maternal and infant outcomes in pregnancy.

The assessment of a patient's iron status does not rely on a single marker. Ferritin is a protein that both incorporates iron and stores iron within a person's cells. Ferritin is contained in blood which means that its measurement reflects how much iron is stored within a person's body. Haemoglobin is a marker of anaemia. Ferritin and haemoglobin levels cannot be taken in isolation; these markers along with an assessment of a patient's symptoms allows for an accurate diagnosis.

Signs of anaemia and iron deficiency can vary depending on what has caused it and, where anaemia is caused by chronic disease, the symptoms of the disease may disguise the signs of anaemia or iron deficiency. This means that holistic treatment is critical, and that treatment needs to be based on blood results as well as symptoms. Symptoms can include fatigue; weakness; shortness of breath; cold feet and hands; pale skin tone; dizziness; and/or irregular heartbeats. Symptoms typically intensify as anaemia gets worse.[5]

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[1] Figures taken from Royal College of Pathologists of Australia, "Position Statement: The Use of Iron Studies, Ferritin and Other Tests of Iron Status", September 2017 and originally sourced from Australian Bureau of Statistics data, 2012, and H.E. Salvin, S.R. Pasricha, D.C. Marks& Speedy, J. "Iron deficiency in blood donors: a national cross-sectional study", *Transfusion 54*(10) 2014.
[2] T Vos et al., "Global, regional, and national incidence, prevalence, and years lived with disability for 301 acute and chronic diseases and injuries in 188 countries, 1990-201`3: a systematic analysis for the Global Burden of Disease Study 2013", *The Lancet*, 2015:386:743-800.
[3] A.J. Fowler, et al., "Meta-analysis of the association between preoperative anaemia and mortality after surgery", *British Journal of Surgery*, 2015:102:1314-1324.
[4] Australian Institute of Health and Welfare, "Potentially preventable hospitalisations in Australia by age groups and small geographic areas, 2017–18" and "Potentially preventable hospitalisations in Australia by age groups and small geographic areas, 2016–17", Last updated 14 November 2019. https://www.aihw.gov.au/reports/primary-health-care/potentially-preventable-hospitalisations/data Accessed March 2020.
[5] Mayo Clinic, "Anemia". https://www.mayoclinic.org/diseases-conditions/anemia/symptoms-causes/syc-20351360 Accessed 2 November 2019.

The Australian Red Cross Blood Service identifies numerous sub-populations at risk of iron deficiency in Australian, including:

- premature or low birth weight babies, toddlers and preschool children;
- adolescents;
- menstruating, pregnant and breastfeeding women;
- some indigenous populations;
- hospitalised and institutionalised patients, including elderly people in aged-care homes;
- refugees and recent migrants from economically poor countries;
- regular blood donors;
- endurance athletes; and
- people with restrictive diets, such as vegetarians and vegans, or malabsorption disorders, i.e., Coeliac disease.[6]

In addition, there are other groups likely to suffer from iron deficiency, such as people with chronic kidney disease.

Despite the extremely wide range of people at risk of iron deficiency, there is little focus on it in government and other health-related policies.

Given the impact of iron deficiency on children's development and on the mental and physical wellbeing of those experiencing it, this apparent oversight is concerning. This is particularly the case given the prevalence of iron deficiency in Australia and the capacity within the health system to identify, treat and manage this condition.

The analysis in this paper of the economic impact of iron deficiency on the Australian economy demonstrates that, with current GDP of $1.88 trillion, the productivity loss associated with iron deficiency in women aged 15 to 44 is $6.62 billion per annum or 0.35% of GDP.

For each the 1,809,808 women of childbearing age with iron deficiency, this represents an average opportunity cost of $2,846 per annum in terms of earnings, compounding the existing wage injustice for women of around $200 per week compared to men.

In conclusion, as the productivity and income foregone are so substantial, there is likely benefit in significant further investment in iron deficiency, particularly targeted at women of childbearing age.

[6] Australian Red Cross Blood Service, "Risk Groups and causes of iron deficiency", updated 6 February 2018. https://transfusion.com.au/transfusion_practice/anaemia_management/iron_deficiency_anaemia/risk_groups_and_causes Accessed 5 November 2019.

Certainly, the analysis in this paper indicates that an annual screening program for women aged 15 to 44 would deliver economic benefit.

Purpose

This paper is designed to analyse the economic impact of iron deficiency in Australia.

An initial review of published literature, undertaken by Evaluate early in 2020, indicated that economic losses are likely to include productivity loss due to cognitive deficits attributable to iron deficiency. While much of this research is in developing economies,[7] there is evidence both individual loss and broader effects on Gross Domestic Product (GDP) and other key economic measures. Days lost to role – whether that be in employment or other roles – were an initial measure that needs be considered in relation to productivity and potential losses due to iron deficiency.

Working from that initial literature review, Evaluate has now undertaken a more significant review of studies and materials relating to iron deficiency and refined a model to incorporate Australian data to provide a cost-benefit analysis to determine the value of potential interventions.

Productivity is not the only economic cost that needs to be considered, it is also the opportunity cost or where treatment could occur in more cost-effective setting. Iron deficiency, or iron deficiency anaemia (IDA), impacts the number of potentially preventable hospital (PPH) admissions, for which IDA accounted for 83,622 PPH bed days in 2016-17;[8] longer stays in hospital; and developmental delays in children. These, coupled with productivity losses, represent a significant economic impact in Australia.

[7] See for example, S Horton & J Ross, "The Economics of Iron Deficiency", *Food Policy*, 2003 (28).
[8] Australian Institute of Health and Wellbeing, "Potentially preventable hospitalisations in Australia by small geographic areas", 2019. https://www.aihw.gov.au/reports/primary-health-care/potentially-preventable-hospitalisations/contents/overview Accessed 4 November 2019.

The Iron Deficiency Collaborative

The creation of the Iron Deficiency Collaborative in early 2020 is designed to provide leadership and an independent structure to identify and deliver recommendations to Government and the healthcare sector on how to optimise the management of iron deficiency in Australia, with three key goals:

- Secure broader healthcare engagement to address the widespread health issue of iron deficiency, a condition that is easily identified and treated, but frequently overlooked and underestimated by patients and physicians;
- Shifting diagnosis and overall treatment from tertiary to more cost-effective healthcare settings and minimising potential preventable hospitalisations; and
- Identification of the current cost to the Australian economy, with a focus on maximising productivity gains and reducing unnecessary expenditure into the future.

The Iron Deficiency Collaborative is guided by a steering committee which includes a broad and diverse representatives from various parts of the Australian healthcare system including healthcare policy; general practice; haematology; women's health; nephrology; pathology; nursing; indigenous health; nutrition and diet; and patients.

Iron deficiency and iron deficiency anaemia (IDA) are common conditions in Australia and affect people of all ages and stages of life, with a high prevalence in women and in Indigenous communities. While iron deficiency is a common condition yet, despite being a widespread health problem, the condition is often overlooked or ignored and has serious consequences for national development.

In the 12 months leading up to the creation of the Iron Deficiency Collaborative, the Australian Government released a number of national strategies and frameworks to which iron deficiency is relevant. However, there has not been any focus on iron deficiency within those strategies. Given that, untreated, iron deficiency is associated with impaired development in children, adverse effects on cognitive and physical performance in adults, and poorer maternal and infant outcomes in pregnancy, this situation and the issues that it causes both for patients and the overall healthcare system need to be addressed.

In developing recommendations for the Australian healthcare system, the Iron Deficiency Collaborative will consider actions needed in the period to 2030 in order to deliver change and address many of the matters outlined in this paper.

This timeframe has largely been chosen due to its alignment with plans such as the *National Women's Health Strategy 2020-2030* and the *Australia's Long Term National Health Plan,* which was published in August 2019 and contains:

- The 2020 mental health vision;
- The 10-year National Preventive Health Strategy;

- The 10 year 10-year Primary Health Care Plan;
- The 10-year Medical Research Future Fund investment plan; and
- Continued improvement of private health insurance[9],

all of which have relevance to the treatment and management of iron deficiency.

[9] Department of Health, *Australia's Long Term National Health Plan to build the world's best health system,* 14 August 2019. https://www.health.gov.au/resources/publications/australias-long-term-national-health-plan Accessed 1 November 2019.

Iron Deficiency: a significant health issue

Iron deficiency is a significant global health issue. In Australia, 34% of women of childbearing age and nearly 5% of healthy males are iron deficient.[10]

Iron deficiency and iron deficiency anaemia are significant health conditions with the latter being the third leading cause of years lived with disability,[11] despite the fact that iron deficiency can be treated and, in some instances, prevented. Anaemia is detected in up to 40% of patients prior to surgery.[12]

Symptoms of iron deficiency can include fatigue; weakness; shortness of breath; cold feet and hands; pale skin tone; dizziness; and/or irregular heartbeats. Symptoms typically intensify as iron deficiency and/or anaemia gets worse.[13]

In addition, in 2017-18, there were more than 747,000 hospitalisations in Australia for the 22 conditions for which hospitalisation is considered potentially preventable. Iron deficiency anaemia is one of those conditions and falls within the "chronic" category. In 2017-18, iron deficiency anaemia accounted for 64,348 potentially preventable hospitalisations (PPH), up from 59,383 the previous year. This is second only in the chronic category to chronic obstructive pulmonary disease (COPD) which was responsible for 77,754 PPH.[14]

Iron is a mineral nutrient that is essential in enabling the body to function normally. Iron deficiency occurs when the body does not have enough mineral iron. Causes of iron deficiency include inadequate dietary intake of iron, malabsorption, increased iron requirements (such as in pregnancy) or as a comorbidity to an underlying condition. Untreated, iron deficiency is associated with impaired development in children, adverse effects on cognitive and physical performance in adults, and poorer maternal and infant outcomes in pregnancy.

Iron is also essential in for the formation of haemoglobin. Haemoglobin is a protein found in red blood cells and which takes oxygen to the various tissues in the body. Oxygen is critical for tissue to survive and iron makes both haemoglobin and blood cells red.[15] Anaemia is caused by a person experiencing a decrease in

[10] Figures taken from Royal College of Pathologists of Australia, "Position Statement: The Use of Iron Studies, Ferritin and Other Tests of Iron Status", September 2017 and originally sourced from Australian Bureau of Statistics data, 2012, and H.E. Salvin, S.R. Pasricha, D.C. Marks& Speedy, J. "Iron deficiency in blood donors: a national cross-sectional study", *Transfusion 54*(10) 2014.
[11] T Vos et al., "Global, regional, and national incidence, prevalence, and years lived with disability for 301 acute and chronic diseases and injuries in 188 countries, 1990-201`3: a systematic analysis for the Global Burden of Disease Study 2013", *The Lancet*, 2015:386:743-800.
[12] A.J. Fowler, et al., "Meta-analysis of the association between preoperative anaemia and mortality after surgery", *British Journal of Surgery*, 2015:102:1314-1324.
[13] Mayo Clinic, "Anemia". https://www.mayoclinic.org/diseases-conditions/anemia/symptoms-causes/syc-20351360 Accessed 2 November 2019.
[14] Australian Institute of Health and Welfare, "Potentially preventable hospitalisations in Australia by age groups and small geographic areas, 2017–18" and "Potentially preventable hospitalisations in Australia by age groups and small geographic areas, 2016–17", Last updated 14 November 2019. https://www.aihw.gov.au/reports/primary-health-care/potentially-preventable-hospitalisations/data Accessed March 2020.

either the number of red blood cells in their body or the amount of haemoglobin within their red blood cells. Haemoglobin helps move oxygen from a person's lung around the rest of their body and, when a person is anaemic, their heart needs to work harder in order to ensure that their muscles and organs get the oxygen required.[16]

World Health Organization guidelines currently state iron deficiency is determined by serum ferritin levels of: levels of haemoglobin point to a risk of anaemia. These levels are different, depending on a person's gender, age and whether they are pregnant. Haemoglobin at the following levels indicates risk:

- <12 µg/L for apparently healthy infants and children aged under 5 years;
- <15 µg/L for apparently healthy adolescents, adults and older people; and
- <15 µg/L for women in the first trimester of pregnancy.[17]

The appropriateness of these cut off levels being adopted for Australia is questionable but it is important to note that assessment of most patients' iron status does not however rely on a single marker.

The assessment of a patient's iron status does not rely on a single marker. Ferritin is a protein that both incorporates iron and stores iron within a person's cells. Ferritin is released and is contained in blood which means that its measurement reflects how much iron is stored within a person's body. Haemoglobin is a marker of anaemia. Ferritin and haemoglobin levels cannot be taken in isolation; these markers along with an assessment of a patient's symptoms allows for an accurate diagnosis.

Signs of anaemia and iron deficiency can vary depending on what has caused it and, where anaemia is caused by chronic disease, the symptoms of the disease may disguise the signs of anaemia or iron deficiency. This means that holistic treatment is critical and that treatment needs to be based on blood results as well as symptoms. Symptoms can include fatigue; weakness; shortness of breath; cold feet and hands; pale skin tone; dizziness; and/or irregular heartbeats. Symptoms typically intensify as anaemia gets worse.[18]

In most patients with ID first-line therapy is oral iron supplementation. Therapeutic oral iron is readily available in over-the-counter formulations, with patients requiring a minimum dose of 100mg of elemental iron per day. It is important to understand that over-the-counter supplements containing lower doses of iron are not sufficient to replenish iron stores or correct anaemia. Parenteral iron can be used if there is an intolerance to oral iron, such as gastrointestinal side effects or drug interactions, poor adherence or lack of

[16] Australian Bureau of Statistics (ABS), Australian Health Survey: Biomedical Results for Chronic Disease, 2011-12, 2013. https://www.ausstats.abs.gov.au/ausstats/subscriber.nsf/0/01ECE269AAE6E736CA257C0700114DBA/$File/AHS%20-%20Biomedical%20Results%20for%20Chronic%20Diseases.pdf Accessed 2 November 2019.
[17] World Health Organization (WHO), WHO guideline on use of ferritin concentrations to assess iron status in individuals and populations, 2020. https://www.who.int/publications/i/item/9789240000124 Accessed 16 October 2020.
[18] Mayo Clinic, "Anemia". https://www.mayoclinic.org/diseases-conditions/anemia/symptoms-causes/syc-20351360 Accessed 2 November 2019.

efficacy of oral iron, malabsorption or high iron need, for example in haemodialysis, and where replenishment is needed rapidly.

Iron deficiency and iron deficiency anaemia are diagnosed via blood tests.

Definition of iron deficiency and iron deficiency anaemia

In line with the World Health Organization guidelines, Australia's National Blood Authority (NBA) recommended that perioperative patients at risk of significant blood loss should be investigated for anaemia which they define as being haemoglobin of <130 g/L for males and <120 g/L for females.

In addition, the NBA recommends that these individuals also be investigated for iron deficiency which is identified as ferritin of <30µg/L and suboptimal iron stores for those in whom substantial blood loss is anticipated. Suboptimal iron stores are determined as ferritin <100 µg/L as are inflammatory conditions and renal disease. Investigations should include full blood count; iron studies including serum ferritin; testing for C-Reactive Protein (CRP), which is a marker of inflammation; and renal function.[19]

As such, the levels at which iron deficiency and iron deficiency anaemia are determined are largely consistent with the WHO's guidelines being adopted in Australia although a review of guidelines undertaken by the Iron Deficiency Collaborative identified a number of inconsistencies with how guidelines define iron deficiency and iron deficiency anaemia; how it is measured; and the manner(s) in which it is treated and managed.

[19] National Blood Authority (NBA), Identification, Assessment and Management A Case Study: Guidelines for Australian Health Providers, June 2014. https://www.blood.gov.au/system/files/documents/preoperative-anaemia-identification-assessment-and-management-case-study%20grey%20cover%20v4.pdf Accessed 30 October 2019.

Policy settings relevant to iron deficiency

There are a number of policy settings that relate to the diagnosis, treatment and management of iron deficiency as explored in Evaluate's earlier paper. These include:

- Guidelines for the treatment and management of iron deficiency and iron deficiency anaemia – generating greater consistency across the different guidelines and position statements, their recommendations and language utilised would ensure that patients, clinicians and other healthcare professionals received clearer messages about iron, iron deficiency and iron deficiency anaemia;
- The role of primary care providers – patients with anaemia are often first encountered and then also treated in primary care;[20]
- Pathology – pathology testing is critical in the diagnosis of iron deficiency and it is important that an appropriate pathology regime be enabled and accessed which reflects the needs of individual patients;
- Prevention – not all forms of anaemia can be prevented depending on their cause. Anaemia caused by dietary deficiency however may be prevented by adequate dietary intake and eating certain foods more regularly, such as lean meats, nuts, legumes and fresh fruit and vegetables. This is both economically and medically sound practice;
- Timely access to treatment – given the breadth of patient cohorts that experience iron deficiency, ensuring all the patients who require treatment gain access to it is a significant task and one that requires attention from primary health care as well as community, secondary and tertiary care; and
- Health literacy and education – ensuring that treating health professionals and potential patients have access to appropriate information, education and materials about iron deficiency is critical to ensuring that it is treated appropriately and in a timely manner.

The Iron Deficiency Collaborative has regard to all these areas and will be making recommendations regarding some of them. In the interim and to provide context to this paper, Evaluate outlines below some of the key Australian health policies that relate to, or should have regard to, iron deficiency and its role in the health of the Australian population.

[20] Eisenstaedt RS. The prevalence of anemia in primary care. Postgrad Med 2004;116(5 Suppl Anemia):7–11.

Health policies and iron deficiency

The Australian Red Cross Blood Service identifies numerous sub-populations at risk of iron deficiency in Australian, including:

- premature or low birth weight babies, toddlers and preschool children;
- adolescents;
- menstruating, pregnant and breastfeeding women;
- some indigenous populations;
- hospitalised and institutionalised patients, including elderly people in aged-care homes;
- refugees and recent migrants from economically poor countries;
- regular blood donors;
- endurance athletes; and
- people with restrictive diets, such as vegetarians and vegans, or malabsorption disorders, i.e., Coeliac disease.[21]

In addition, there are other groups likely to suffer from iron deficiency, such as people with chronic kidney disease, and one study finding that approximately one-third of patients scheduled for surgery suffer from anaemia. This latter is important from both an economic and health perspective given that it is is associated with prolonged hospitalisation and a higher need for allogenic blood transfusions as well as for an increased morbidity and mortality. Both anaemia and iron deficiency are also associated with fatigue and muscular weakness which can affect patient's recovery. Managing pre-operative anaemia is an essential part of patient blood management and a multimodal approach would improve patient safety,[22] outcomes and their related costs.

Despite the very wide range of people at risk of iron deficiency, there is little focus on it in government and other health-related policies.

This is despite the strong focus through documents such as the *National Women's Health Strategy 2020-2030* and the *Australia's Long Term National Health Plan,* on preventive health. Pillar three of the National Health Plan focuses on mental health and preventive health with chronic diseases being particularly singled out. This makes sense, given that just under half of all Australians are identified as having one or more

[21] Australian Red Cross Blood Service, "Risk Groups and causes of iron deficiency", updated 6 February 2018. https://transfusion.com.au/transfusion_practice/anaemia_management/iron_deficiency_anaemia/risk_groups_and_causes Accessed 5 November 2019.
[22] Patrick Meybohm, "The future of iron deficiency diagnostics – Rapid home-use point-of-care test kits", *EBioMedicine,* April 2019; 42: 28-29. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6491617/ Accessed 2 November 2019.

chronic conditions and almost one in four has more than one,[23] as does the identification of early detection as a key aspect of prevention.

That iron deficiency is not mentioned or identified in most health policy documents is disappointing though. The *National Women's Health Strategy 2020-2030* does not mention iron deficiency in any place despite the numbers of women and girls who experience this condition. The Strategy outlines five key priorities 'to drive change and improve health outcomes'. These include:

- Maternal, sexual and reproductive health;
- Healthy ageing;
- Chronic conditions and preventive health;
- Mental health; and
- Health impacts of violence against women and girls.[24]

Of these five priorities, iron deficiency is relevant to four yet is not mentioned directly at any point. Nutrition is mentioned within the document but, given its importance to health, seems to receive little focus. It is mentioned however in relation to preconception health – "promote the importance of good preconception health, particularly regarding nutrition, lifestyle and pelvic floor health, for all women who are planning a pregnancy" - and in relation to the targeted prevention, timely detection and intervention of chronic diseases affecting women and girls – "embed nutrition education and provision of health food options in all schools".

Healthy, Safe and Thriving: National Strategic Framework for Child and Youth Health does focus somewhat more on nutrition, noting in relation to its first strategic priority – equip children and young people with the foundations for a healthy life – that children and young people should be provided with "an appropriate diet".[25] At the same time, however, whilst highlighting the need for expectant mothers and children to have optimal health and the provision of optimal care throughout pregnancy, birth and the perinatal period, the need for the mother to be appropriately fed and accessing the necessary nutrients is not highlighted at all as critical to the child's wellbeing.

In contrast, the *National Women's Health Policy 2010* mentions iron deficiency in regard to maternal nutrition during pregnancy and the peri-conception period, noting that it "is a key modifier of health

[23] Department of Health, *Australia's Long Term National Health Plan to build the world's best health system,* 14 August 2019. https://www.health.gov.au/resources/publications/australias-long-term-national-health-plan Accessed 1 November 2019.
[24] Department of Health, *National Women's Health Strategy 2020-2030*, 2018. https://www1.health.gov.au/internet/main/publishing.nsf/Content/AF504671BA9786E8CA2583D6000AFAE7/$File/National%20Womens%20Health%20Strategy%202020-2030.pdf Accessed 19 September 2020.
[25] COAG Health Council, *Healthy, Safe and Thriving: National Strategic Framework for Child and Youth Health*, August 2015. http://www.coaghealthcouncil.gov.au/Portals/0/Healthy%20Safe%20and%20Thriving%20%20National%20Strategic%20Framework%20for%20Child%20and%20Youth%20Health.pdf Accessed 20 September 2020

outcomes for both mother and child in the long term".[26] It further notes that the Australian Longitudinal Study on Women's Health research demonstrated that many women do not obtain the necessary nutrients while pregnant and that the folate, fibre and iron intake of pregnant women does not meet national recommended levels.

Given the impact of iron deficiency on children's development and on the mental and physical wellbeing of those experiencing it, this apparent oversight is concerning. This is particularly the case given the prevalence of iron deficiency in Australia and the capacity within the health system to identify, treat and manage this condition. The economic impacts of this, as outlined in the next section, further underline the value of addressing this as a matter of priority and Evaluate notes that, with a variety of government policy currently under development, including the National Preventive Health Strategy, this could be done in coming months.

[26] Commonwealth of Australia, *National Women's Health Policy 2010,* 2010. https://www1.health.gov.au/internet/main/publishing.nsf/Content/3BC776B3C331D5EECA257BF0001A8D46/$File/NWHP_access_final.pdf Accessed 20 September 2020.

Economic impact

Literature

Horton & Ross's pioneering work on the economic impact of iron deficiency[27] continues to set the scene for measurement of the potential benefits of nutritional fortification. While this was focused on developing economies, the rates of impact may be transferred to developed economies such as Australia.

In particular, Horton and Ross identified the following benefits:

- The long-term benefit-cost ratio for iron fortification is 6:1;
- This ratio is based on productivity gains, and rises to 36:1 once the expected lifetime value of cognitive benefits is taken into account;
- Improvement in IQ of half a standard deviation;
- Consequently (and conservatively) a 4% difference in expected earnings;
- Increases in labour productivity of:
    - 5% for blue-collar work excluding heavy manual labour;
    - 17% for heavy manual labour due to physical limitations.[28]

While noting that, while this is based on studies of developing countries, these estimates are both: consistent with evidence from developed nations;[29] and more conservative than previous 20% estimates of productivity effects.[30] In discussion and calculations below, a 5% estimate is assumed as modal.

Critically, these benefits predominantly flow from arresting progress from general iron deficiency to actual IDA. While they do not take into account the costs of maternal mortality from IDA, this is less of a concern in Australia and similar societies.

A more recent study takes a retrospective look at the impact of iron fortification in the United States from 1943.[31] Key observations from this include:

- A 3.6% increase in earnings as an adult;[32] and

[27] S Horton & J Ross, "The economics of iron deficiency", *Food Policy*, (28) 2003.
[28] Horton & Ross, "The economics of iron deficiency", *Food Policy*, (28) 2003.
[29] Horton & Ross, "The economics of iron deficiency", *Food Policy*, (28) 2003.
[30] In H M Levin et al, "Micronutrient deficiency disorders", in DT Jamison & WH Mosley (Eds), *Disease control priorities in developing countries*, New York, Oxford University Press, 1994.
[31] Gregory Niemesh, "Ironing Out Deficiencies: Evidence from the United States on the Economic Effects of Iron Deficiency", Vanderbilt University (pre-publication), 2011 . http://web.stanford.edu/group/SITE/archive/SITE_2012/2012_segment_3/2012_Segment_3_papers/niemesh.pdf Accessed October 2020.
[32] Niemesh, "Ironing Out Deficiencies" 2011, p.24.

- A benefit-cost ratio of (at least) 14:1, which is within Horton & Ross's estimates.[33]

It is important to note that in each of these studies, there was no prior diagnosis of iron deficiency. Rather, these are benefits of whole of population dietary fortification. The impact of this is inevitably greater on those with poor diets or who are living in poverty. These circumstances may be more prevalent in developing nations, or in mid-century America, and needs to be taken into account. Similarly, one of the difficulties in parsing these sort of data lies in feedback loops and intersecting effects. For example, in the Niemesh study, there is a strong association of iron fortification with increased years of schooling. However, this may have other policy and cultural drivers, and it in turn intersects with cognitive effects in adult life to deliver aggregate wage outcomes.

Nonetheless, a longitudinal study of US teens comparing those with early iron deficiency to those with normal infant iron intake showed significant differences in cognitive and behavioural capabilities.[34] Most importantly, this shows the difference between prevention and even successful intervention.

A further illustration of the challenges of extrapolating data from one culture or era to another is seen in WHO estimates of mortality risk attributable to poor nutrition. For example, whereas the risk of death from iron deficiency in Europe is 0.02% compared to 0.36% for Southeast Asia, the relative risk of mortality from obesity is 1.11% against 0.25%.[35]

This has significance for the scale of available gains. While studies in impoverished countries with high levels of multi-factor malnutrition show a cost per disability-adjusted life (DALY) year as low as USD100 or even USD10, this is based on avoidance of mortality.[36] This occurs in environments where there is no countervailing health system to intervene and correct nutrition. The effect of prophylactic nutritional fortification is consequently much greater than would be expected in Australia.

That said, even if the cost per DALY were substantially greater, it is unimaginable that it would approach the modal Australian threshold of $50,000, and the cost of later intervention would inevitably be higher than the price of prophylaxis.

Two special cases are also worth considering. The first is perinatal iron deficiency. In their extensive review of literature on lifecycle health and economic effects, Prinz et al cite the impact of micronutrient deficiency at the foetal stage on later life achievement. Using data from the experience of Ethiopian Jews migrating to Israel, they found that better nutrition (including iodine, iron and folic acid) in the first trimester of pregnancy leads to a 12% greater likelihood of finishing secondary school.[37]

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[33] Niemesh, "Ironing Out Deficiencies" 2011.
[34] Betsy Lozoff et al, "Poorer Behavioral and Developmental Outcome More Than 10 Years After Treatment for Iron Deficiency in Infancy", *Paediatrics*, (105:4), April 2000.
[35] Susan Horton, "The Economics of Nutritional Interventions", in Richard D Semba & Martin W Bloem (Eds), *Nutrition and Health in Developing Countries*, New Jersey, Humana Press, 2008, p.860.
[36] Laura E Caulfield et al, "Stunting, Wasting and Micronutrient Deficiency Disorders", in Dean T Jamieson et al, "Disease Priorities in Developing Countries", New York, Oxford University Press, 2006, p.560.
[37] Daniel Prinz et al, "Health and Economic Activity Over The Lifecycle: Literature Review", National Bureau of Economic Research Working Paper 24865, Cambridge MA, July 2018, p.26.

While this is not strictly pertinent to the urban Australian experience, it may be a useful cue to particular interventions for refugees, other migrants and Aboriginal and Torres Strait Islander Australians.

Finally, on the literature survey, the benefits of iron supplementation as part of a regime of patient blood management in hospitals is clear. A recent European survey of published literature finds that a regime including iron supplementation, cell salvage and transexamic acid reduced transfusion rates by 39%; length of hospital stay by 0.45 days; and complication rates by 20%.[38] This is economically beneficial, as benefits exceed costs, and as 30% of surgical patients suffer from preoperative anaemia associated with iron deficiency[39], it is a significant element. These data support the Red Cross's observation that iron deficiency anaemia – particularly perioperatively – is responsible for demanding some $600 million in incremental blood products each year, excluding the costs of transfusion and complications.[40]

Calculations

As this paper seeks to address the economics of iron deficiency as distinct from IDA, it faces a number of data challenges. Not least of these is the ambiguity between the two diagnoses and a lack of evidence on the expected rate of progress from one to the other. For example, one study found:

> "… the prevalence of anemia among individuals with only one abnormal index of iron metabolism (low serum ferritin concentration, low serum iron concentration, low iron-binding capacity, or elevated erythrocyte protoporphyrin levels) was 11 percent, only slightly higher than the 8 percent in the entire population. In contrast, anemia was found in 28 percent of individuals with two abnormal values and 63 percent of those with three abnormal values."[41]

The solution to this is to diagnose iron deficiency where two of the three markers are present, but this then changes the rate of overlap with IDA.

The observed Australian prevalence of inadequate iron intake from diet is, respectively:

- 6.2% for youths 2-18;
- 2.5% of those 19 and over; and
- 3.3% of the overall population.[42]

[38] Patrick Meybohn et al, "Health economics of Patient Blood Management: a cost-benefit analysis based on a meta-analysis", *Vox Sanguinis*, (115), 2020, p.183.
[39] Meybohn et al, "Health economics of Patient Blood Management", 2020, pp.184-5.
[40] https://transfusion.com.au/transfusion_practice/anaemia_management/iron_deficiency_anaemia Accessed October 2020.
[41] Robert Earl & Catherine Wotecki (Eds), Committee on the Prevention, Detection, and Management of Iron Deficiency Anemia Among U.S. Children and Women of Childbearing Age, Institute of Medicine, "Iron Deficiency Anemia: Recommended Guidelines for the Prevention, Detection, and Management Among U.S. Children and Women of Childbearing Age", pp.60-61.
[42] Australian Bureau of Statistics, "Australian Health Survey: Usual Nutrient Intakes", March 2015. https://www.abs.gov.au/statistics/health/health-conditions-and-risks/australian-health-survey-usual-nutrient-intakes/latest-release#data-download Accessed October 2020.

This is a snapshot at a given moment and there is strong evidence that inadequate iron intake itself is poorly correlated with observed iron deficiency, particularly in women, where heavy menstruation is a more likely cause. Nonetheless, it emphasises the need for nutritional encouragement.

Using the international data from literature discussed above, several calculations are suggested. These are intended to illustrate the potential scale of what is avoidable or what might be gained for a more programmatic and consistent approach to iron deficiency.

These data are focused specifically on the population of women of childbearing age as they have the highest prevalence of iron deficiency. While there are outliers, this group defined as women aged 15-44.[43]

First, labour productivity is considered. If a static approach is taken looking at prevailing rates of iron deficiency, then the opportunity cost of iron deficiency might be expressed as:

$$GDP_{foregone} = GDP * \left(\frac{105}{100} - 1\right) * population\ with\ iron\ deficiency$$

Key data for the $population\ with\ iron\ deficiency$ are:

- Women aged 15-44 are 20.63% of the overall Australian population;[44]
- The overall Australian population currently is 25,713,245;[45]
- Biomedical testing of Australian women shows that 34.12% of those aged 16-44 have an iron concentration of <30 µG/L;[46]
- Australian GDP is $1.882 trillion;[47]
- The Australian workforce is 12,583,400;[48]
- Women comprise 46.78% of the workforce;[49] and

[43] The ABS uses 15 or 16 as a limiting age in different datasets and this is a minor source of error in the following calculations.
[44] ABS, "3101.0 - Australian Demographic Statistics, Jun 2019", 19 December 2019. https://www.abs.gov.au/ausstats/abs@.nsf/0/1CD2B1952AFC5E7ACA257298000F2E76?OpenDocument Accessed October 2020.
[45] ABS Population Clock https://www.abs.gov.au/ausstats/abs%40.nsf/94713ad445ff1425ca25682000192af2/1647509ef7e25faaca2568a900154b63?OpenDocument Morning of 21 October 2020.
[46] ABS, "Australian Health Survey: Biomedical Results for Nutrients", 11 December 2013, specifically Table 7: Nutrient biomarkers for women aged 16-44 years by ranges https://www.abs.gov.au/statistics/health/health-conditions-and-risks/australian-health-survey-biomedical-results-nutrients/latest-release Accessed October 2020.
[47] https://www.abs.gov.au/statistics/economy/key-indicators Accessed November 2020.
[48] https://www.abs.gov.au/statistics/labour/employment-and-unemployment/labour-force-australia/latest-release Accessed October 2020.
[49] ABS, "6202.0 - Labour Force, Australia, Jan 2019", 21 February 2019. https://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/6202.0Jan%202019?OpenDocument Accessed October 2020.

- The average weekly earnings for women is $1,515.00.[50]

Based on these data, the impact on the economy can be calculated in several ways, including:

1. The observed prevalence of iron deficiency only in women aged 15-44 is responsible for an annual productivity loss of $6.62 billion, or 0.35% of GDP;

2. For the 1,809,808 women of childbearing age with iron deficiency, or 7.04% of the population, this represents an individual productivity loss of $3,660.20 each; and

3. Using a 3.6% reduction in earnings, this represents variously:

    a. An individual loss for these women at the mean of $54.54 per week, which is

    an annual mean individual loss of $2,845.82. This only compounds the prevalent wage injustice for women, at an average weekly rate of -$200, compared to men.

Another way of looking at the economic impact of iron deficiency is in terms of its contribution to overall Australian burden of disease. Here, the Australian Institute of Health and Welfare estimates that:

- Iron deficiency accounts for 0.3% of all disease and injury burden in Australia (including 100% of any burden attributable to IDA);[51]
- The total burden of disease and injury in 2011 was calculated at 201 DALY per 1,000 people;[52]
- This makes the total annual burden, due to iron deficiency across the entire population, of some $379,389,510;
- It should be noted that this will be heavily concentrated amongst women of child-bearing age as:
    - Iron deficiency accounts for 1.0% of the total burden on disease or four times its average number of DALYs for women under 24; and
    - 1.1% of the total burden or 6.5 times its average number of DALYs for women aged 25-44.[53]

While these figures are – due to data limitations – somewhat incomplete, they support some conclusions as follows:

[50] ABS, "Average Weekly Earnings, Australia", May 2020, calculated as weighted female weekly wage according to sector using ABS, "Employment and Earnings, Public Sector, Australia", 12 November, 2019 https://www.abs.gov.au/statistics/labour/earnings-and-work-hours/average-weekly-earnings-australia/latest-release#:~:text=Seasonally%20adjusted%20estimates,the%20same%20time%20last%20year and also https://www.abs.gov.au/statistics/labour/employment-and-unemployment/employment-and-earnings-public-sector-australia/latest-release Both accessed October 2020.
[51] AIHW, "Australian Burden of Disease Study: impact and causes of illness and death in Australia 2011", 10 May 2016.
[52] AIHW, "Australian Burden of Disease Study, 2016.
[53] AIHW, "Australian Burden of Disease Study, 2016.

1. There is significant economic activity foregone due to iron deficiency in Australia, predominantly amongst women of childbearing age; and

2. Given the typically low cost of nutritional fortification and supplementation, and the expectation that any guidelines would have a measure of targeting, it is highly probable that further investment in addressing iron deficiency – particularly in young people – will show benefits which exceed costs.

These numbers will be further supplemented by subjective gains in terms of quality of life as well as the avoidance – at some rate – of IDA and other costly health conditions associated with iron deficiency.

From this, the economic analysis supports further investigation with a view to more aggressively addressing iron deficiency in Australia.

While it would be ideal to undertake a complete cost-benefit analysis for further investment in prevention, diagnosis and treatment, this is difficult. However, some simple proposals may be made including:

- A complete screening program of women aged 15-44 for iron deficiency on an annual basis:
    - Using Medicare item number 66596 at a cost of $32.55;
    - Accompanied by a short GP visit for referral using Medicare item number 23 at a cost of $38.75;
    - Would cost a little over $378 million, or 5.71% of the corresponding GDP loss;[54] and
- Any treatment for someone already diagnosed would need to cost in excess of their expected average GDP loss of $3,660.20 to not be cost-effective.[55]

In conclusion, as the productivity and income foregone are so substantial, there is likely benefit in significant further investment in iron deficiency, particularly targeted at women of childbearing age. Certainly, this analysis indicates that an annual screening program for women aged 15 to 44 would deliver economic benefit.

[54] Direct costs only.
[55] Public cost. Evaluate would use the marginally-higher income foregone for a private cost.