Fractured from Fracking: Examining the Health and Wellbeing Implications of Unconventional Natural Gas Development in Rural Communities

vorgelegt von

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Abbreviations

APLNG	Australia Pacific LNG Limited
ARIA	Accessibility/ Remoteness Index of Australia
CAS	Complex adaptive systems
CASP	Critical Appraisal Skills Programme
CM	Community Member
CSG	Coal seam gas
CSR	Corporate social responsibility
DIDO	Drive in drive out
FGD	Focus group discussion
FIFO	Fly in fly out
GP	General Practitioner
GRI	Global Reporting Initiative
HIA	Health Impact Assessment
HIC	High income country
HNA	Health Needs Assessment
I	Interviewer
ICMM	International Council on Mining and Metals
IDI	In-depth interview
KII	Key informant interview
LGAs	Local government areas
LMIC	Low and middle income country
LNG	Liquefied natural gas
MTM	Mountain-top mining
NSW	New South Wales
SDoH	Social determinants of health
STIs	Sexually transmitted infections
UNG	Unconventional natural gas

Summary

Background

Coal seam gas (CSG) is an unconventional natural gas (UNG) that is extracted from wells via coal seams, and reserves are found in Australia, the USA and the UK. Other UNG include shale and tight gas, which are sourced from different geological formations and utilise similar processes to CSG mining, and are extracted in Canada, Europe, Asia, the Middle East and Australia. In recent decades, UNG extraction has grown exponentially, with hydraulic fracturing or 'fracking'[1] occurring across regional and rural landscapes and in close proximity to communities. Whilst major development projects can facilitate employment and other opportunities in surrounding communities through population growth and increased demand for services, there is evidence that negative impacts on health and wellbeing can outweigh any benefits.

Commonly referred to as the 'resource curse', when the costs of extraction and exporting natural resources outweigh the economic benefits, the expansion of CSG activity has often been met with trepidation from local communities and the broader public. There was uncertainty around the impacts and consequences of rapid development, particularly in the USA and Australia, stemming from a lack of prior experience, mixed messages in the media, perceived lack of governmental support, and little empirical evidence. Presented with the opportunity to address the gap in the literature, this research explores the broader implications of mining activity on surrounding communities, with a focus on CSG and the social determinants of health and wellbeing.

The level of community interaction throughout a project lifecycle is greater in CSG mine settings compared to traditional mining methods (like coal, for example) because of their proximity to communities, and so there is a greater expectation of the mining company to monitor and mitigate impacts on the communities in which they operate. There is emerging evidence that the extractives industry may play a more diverse role in regional communities than previously expected, but the pathways in which they do this in the health sector are not clear. Integral to the provision of health services in regional areas is the integration of services and partnerships – it is common for stakeholders external to the health sector, like transport, police or environmental departments to be involved in the planning and availability of health services. There is a dearth of scientific evidence of the ways in which the extractives industry interacts with the health system in the communities in which they operate; what the costs and benefits of this interaction might

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[1] Definition of 'fracking'*: the process of injecting liquid at high pressure into subterranean rocks, boreholes, etc. so as to force open existing fissures and extract oil or gas*

be and how the relationship might be optimized to enable long-lasting health improvements.

This is particularly important in mining communities, where health outcomes could fluctuate with the various stages of mining activity, and more so in communities where mining activity is soon to cease, leading to uncertainty and economic downturn.

Objectives

This research was conducted in order to inform the regional and rural health sector, extractives industry, and communities who are undergoing a period of uncertainty with little peer reviewed evidence to provide objective direction. The research aims to: respond to the demand in understanding broader public health and wellbeing outcomes of mining beyond direct, physical and biological outcomes; contribute to the growing evidence base around CSG development and potential community-level impacts; and to comment on the interaction between stakeholders in the health system and the extractives industry at a local level.

Methods

This thesis has been organised in to three parts to meet the stated objectives:

1. Two systematic reviews to synthesise the evidence for broader, indirect health and wellbeing implications at community level associated with mining activity in low, middle and high income countries in order to provide a comprehensive account of how communities may be affected by mining;
2. Synthesis of qualitative data collected via a Health Needs Assessment (HNA) in Queensland, Australia to explore the determinants of health and wellbeing in communities living in proximity to CSG developments in order to strengthen understanding of how community and health services can prepare for fluctuations that might come with a mining boom or bust; and
3. Critically review regional health systems and the interaction between the extractives industry and key stakeholders at a local level in order to compile a set of recommendations that optimise health outcomes for local communities.

Results

Systematically Reviewing the Evidence

Sixteen publications were included in the systematic review of high-income countries, and included studies that took place in the USA, Australia and Canada. Products mined included coal and mountain-top mining. There was evidence that mining activity can affect the social, physical and economic environment in which communities live, and these factors can in turn have adverse effects on health and wellbeing if not adequately measured and mitigated. Specific examples of self-reported health implications included

increased risk of chronic disease and poor overall health, relationship breakdown, lack of social connectedness, and decreased access to health services.

Twelve publications were included in the systematic review of low and middle-income countries, and included studies that took place in Ghana, Namibia, South Africa Tanzania, India, Brazil, Guatemala and French Guiana. Products mined included gold and silver, iron ore and platinum. Mining was perceived to influence health behaviours, employment conditions, livelihoods and socio-political factors, which were linked to poorer health outcomes. Family relationships, mental health and community cohesion were negatively associated with mining activity. High-risk health behaviours, population growth and changes in vector ecology from environmental modification was associated with increased infectious disease prevalence.

Assessing Health Needs in a Mining Community
The HNA was implemented in four towns in regional Queensland situated in proximity to CSG development. Eleven focus group discussions, nine in-depth interviews, and forty-five key informant interviews (KIIs) with health and community service providers and community members were conducted. Framework analysis was conducted following a recurrent theme that emerged from the qualitative data around health and wellbeing implications of the CSG industry. CSG mining was deemed a rapid development in the otherwise predominantly agricultural, rural communities. With this rapid development came fluctuations in the local economy, population, social structure and environmental conditions. There were perceived direct and indirect effects of CSG activity at an individual and community level, including impacts on alcohol and drug use; family relationships; social capital and mental health; and social connectedness, civic engagement and trust.

Understanding Local Health Systems
Before examining the interaction between the health system and mining sector, it was important to describe the rural health system and its complementary parts. Systems theory underpinned analysis of qualitative data from KIIs to assist in describing the characteristics of the health system and unique influences on its functionality. Results showed that communities are closely interconnected with the health system, and that the rural health systems in the case study were defined by geography, climate and economic fluctuations. Understanding unique system pressures is important for recognising the impact that policy decisions may have on rural health. Decentralisation of decision making, greater flexibility and predictability of programs will assist in health system strengthening in rural areas.

Defining Relationships Between the Health and Mining Sector

Another key theme emerged from the HNA: the mining sector played a diverse role in health and community service planning and delivery. Key informant transcripts were analysed again using phenomenology theory. Of these, 23 mentioned the presence of CSG or mining activity at least once during the interview without any specific reference to the extractives industry. Mining activity was perceived to influence the ability of service providers to meet demand, recruit and retain staff, and effectively plan and maintain programs. The level of interaction between mining companies with service providers and regulatory bodies varied and was commented on extensively. Several key informants identified pathways for the mining sector to engage with services more effectively, which included strengthening multi-sectoral engagement and enabling transparent, public consultation and evidence-based funding initiatives.

Conclusion

Unconventional natural gas extraction and the implications of mining activity on nearby communities is a subject of major concern internationally. Through the application of core public health theories and methodologies, including the Social Determinants of Health model, complex adaptive systems theory and health needs assessments; this thesis has significantly contributed to the discourse and demonstrated a significant association between mining activity and health.

This thesis sought to strengthen the evidence base of the association between the extractives industry and the social determinants of health of surrounding communities, with a focus on the potential impacts of CSG developments. The hypothesis that there may be broader, direct and indirect impacts on health and wellbeing at an individual or community-level was tested and proven. The secondary aim was to examine the relationship of stakeholders in the local health system with the mining sector, with the intention to develop recommendations that improve measurement, monitoring and response to potential impacts of mining in surrounding communities.

This research established that there are both common and unique health and wellbeing issues experienced by communities living in proximity to mining internationally. Our understanding of the ways in which CSG mining activity can influence the social determinants of health has been significantly strengthened. This thesis argues the importance of first examining how local health systems operate in order to maximise engagement with the mining sector - a potentially significant funding source – and sustain health services. There are pathways and opportunities for the mining sector to contribute to community development, and this requires engagement with the community and local service providers. This also highlights key characteristics of communities that might influence the magnitude of perceived CSG mining impacts,

which serve to inform development of indicators and tools to strengthen measurement and response.

It is beyond the scope of this thesis to present a comprehensive framework with standardised approach for monitoring broader health and wellbeing implications of UNG development, as this relies on first establishing multidisciplinary approach and considering the regulatory frameworks that shape corporate social responsibility and mining investments. However, this thesis presented a set of key recommendations and criteria that should be considered in the design of a standardised monitoring framework. Formalising, publicising and regulating this process is the next step along the road to mending and preventing fractured communities from the potential impacts of mining.

Zusammenfassung

Hintergrund

Kohleflözgas (CSG) ist ein unkonventionelles Erdgas (UNG), das über Kohleflöze aus Bohrlöchern gefördert wird. Reserven befinden sich in Australien, den USA und Großbritannien. Andere UNG umfassen Schiefer und Gas, die aus verschiedenen geologischen Formationen stammen und ähnliche Verfahren wie der CSG-Abbau nutzen, und die in Kanada, Europa, Asien, dem Nahen Osten und Australien gefördert werden. In den letzten Jahrzehnten hat die UNG-Förderung exponentiell zugenommen, wobei hydraulisches Fracking in regionalen und ländlichen Gebieten und in unmittelbarer Nachbarschaft zu Gemeinden stattgefunden hat. Während grössere Entwicklungsprojekte durch Bevölkerungswachstum und erhöhte Nachfrage nach Dienstleistungen Beschäftigung und andere positive wirtschaftliche Folgen in den umliegenden Gemeinden ermöglichen können, gibt es Hinweise darauf, dass negative Auswirkungen auf Gesundheit und Wohlbefinden diese Vorteile überwiegen können.

In Situationen in denen die Kosten für die Gewinnung und den Export natürlicher Ressourcen die wirtschaftlichen Vorteile überwiegen, der sogenannte "Ressourcenfluch", stieß die Ausweitung der CSG-Aktivitäten auf örtliche Gemeinden und die breite Öffentlichkeit. Die Auswirkungen und Folgen dieser rasanten Entwicklung, insbesondere in den USA und in Australien, waren nicht ausreichend bekannt. Dies lag zum einen an der mangelnden Vorerfahrung, zum anderen an gemischten Botschaften in den Medien, mangelnder staatlicher Unterstützung und wenig empirischen Beweisen über negative Auswirkungen dieser neuen Verfahren. Das vorliegende Forschungsprojekt bot die Gelegenheit, eine Lücke in der wissenschaftlichen Literatur zu schließen, und untersucht die umfassenderen Auswirkungen der Bergbautätigkeit auf die umliegenden Gemeinden, wobei der Schwerpunkt auf CSG und den sozialen Determinanten von Gesundheit und Wohlbefinden liegt.

Die Interaktion der Gesellschaft während des gesamten Projektlebenszyklus ist in CSG-Minen-Umgebungen im Vergleich zu herkömmlichen Bergbaumethoden (wie z. B. Kohle) aufgrund ihrer Nähe zu den Gemeinden größer. Daher besteht eine höhere Erwartung des Bergwerks, die Auswirkungen auf die Gemeinden in denen sie tätig sind zu überwachen und zu mindern. Es gibt Anzeichen dafür, dass die Bergbauindustrie in den regionalen Gemeinden eine vielfältigere Rolle spielen könnte als bisher erwartet, aber die Wege, auf denen sie dies im Gesundheitssektor tun, sind noch unklar. Für die Bereitstellung von Gesundheitsdiensten in regionalen Gebieten ist die Integration von Diensten und Partnerschaften von grundlegender Bedeutung. Es ist üblich, dass Gesundheitswesen-externe Akteure wie Verkehr, Polizei oder Umweltabteilungen an der Planung und Verfügbarkeit von Gesundheitsdiensten beteiligt sind. Es gibt kaum wissenschaftliche Belege dafür, wie die Bergbauindustrie mit dem Gesundheitssystem

in den Gemeinden, in denen sie tätig sind, interagiert. Wie können Kosten und Nutzen dieser Interaktion aussehen und wie können diese Beziehungen optimiert werden, um dauerhafte Verbesserungen der Gesundheit der lokalen Bevölkerung zu ermöglichen.

Dies ist besonders wichtig in Bergbaugemeinden, in denen die Gesundheitsergebnisse mit den verschiedenen Stadien der Bergbaubetriebsaktivität schwanken könnten, insbesondere in Gemeinden, in denen die Bergbaubetriebstätigkeit bald eingestellt wird, was zu Unsicherheit und einem wirtschaftlichen Abschwung führt.

Ziele

Dieses Forschungsprojekt wurde durchgeführt, um den regionalen und ländlichen Gesundheitssektor, die Bergbauindustrie und Gemeinden zu informieren, die sich gegenwärtig in einer Phase der Unsicherheit befinden. Das Projekt zielt darauf ab, auf die Forderung nach einem besseren Verständnis der Auswirkungen des Bergbaus auf die öffentliche Gesundheit und das Wohlergehen über direkte, physische und biologische Ergebnisse zu reagieren; zur wachsenden Beweisgrundlage für die CSG-Entwicklung und potenziellen Auswirkungen auf Gemeinschaftsebene beizutragen; und auf lokaler Ebene die Interaktion zwischen den Akteuren des Gesundheitssystems und der Bergbauindustrie zu charakterisieren und beschreiben

Methoden

Diese Arbeit wurde in drei Teile gegliedert, um die angegebenen Ziele zu erreichen:

1. Zwei systematische Übersichtsarbeiten, um die Nachweise für umfassendere, indirekte Auswirkungen auf die Gesundheit und das Wohlergehen auf Gemeindeebene in Verbindung mit Bergbautätigkeiten in Ländern mit niedrigem, mittlerem und hohem Einkommen zusammenzufassen, mit dem Ziel einen umfassenden Bericht darüber zu liefern, wie Gemeinden durch den Bergbau beeinflusst werden können;

2. Eine Synthese von qualitativen Daten, die im Rahmen eines Gesundheitsberichts (Health Needs Assessment (HNA)) in Queensland, Australien, gesammelt wurden, um die Determinanten von Gesundheit und Wohlbefinden in Gemeinden, die sich in der Nähe von CSG-Entwicklungen befinden, zu erforschen und dadurch das Verständnis dafür zu verbessern, wie sich Gemeinde- und Gesundheitsdienste auf Schwankungen vorbereiten können die mit einem Bergbauboom oder -schwund einhergehen; und

3. Eine kritische Überprüfung der regionalen Gesundheitssysteme und der Interaktion zwischen der Bergbauindustrie und den wichtigsten Interessengruppen auf lokaler Ebene, um eine Reihe von Empfehlungen zu erarbeiten, die die Gesundheitsergebnisse für die lokale Bevölkerung optimieren.

Ergebnisse

16 Publikationen wurden in die systematische Übersicht in Ländern mit hohem Einkommen aufgenommen, darunter Studien, die in den USA, Australien und Kanada durchgeführt wurden. Diese stammten überwiegend aus dem Kohlebergbau. Es gibt Belege dafür, dass die Bergbautätigkeit das soziale, physische und wirtschaftliche Umfeld der betroffenen Gemeinden beeinflussen kann. Diese Faktoren können wiederum negative Auswirkungen auf die Gesundheit und das Wohlbefinden haben, wenn sie nicht angemessen gemessen und abgeschwächt werden. Spezifische Beispiele für selbst berichtete Auswirkungen auf die Gesundheit waren ein erhöhtes Risiko für chronische Krankheiten und schlechte allgemeine Gesundheit, ein Zusammenbruch der Beziehungen, ein Mangel an sozialer Verbundenheit und ein verminderter Zugang zu Gesundheitsdiensten.

Zwölf Publikationen wurden in die systematische Übersicht über Länder mit niedrigem und mittlerem Einkommen einbezogen, darunter Studien, die in Ghana, Namibia, Südafrika, Tansania, Indien, Brasilien, Guatemala und Französisch-Guayana durchgeführt wurden. Zu den gewonnenen Bergbauprodukten gehörten Gold und Silber, Eisenerz und Platin. Es schien, dass Bergbau das Gesundheitsverhalten, die Beschäftigungsbedingungen, den Lebensunterhalt und sozio-politische Faktoren beeinflusst, die mit einem schlechteren Gesundheitsergebnis zusammenhängen. Familienbeziehungen, psychische Gesundheit und sozialer Zusammenhalt waren negativ mit der Bergbautätigkeit verbunden. Gesundheitsgefahren mit hohem Risiko, Bevölkerungswachstum und Veränderungen in der Vektorökologie aufgrund von Umweltveränderungen waren mit einer erhöhten Prävalenz von Infektionskrankheiten verbunden.

Der Gesundheitsbericht wurde in vier Städten im ländlichen Queensland in der Nähe der CSG-Bergbau durchgeführt. Es wurden elf Fokusgruppendiskussionen, neun ausführliche Interviews und fünfundvierzig wichtige Informanteninterviews (KIIs) mit Gesundheits- und Gemeindedienstleistern und Gemeindemitgliedern durchgeführt. Die Rahmenanalyse wurde nach einem wiederkehrenden Thema durchgeführt, das sich aus den qualitativen Daten zu den Auswirkungen auf die Gesundheit und das Wohlbefinden der CSG-Industrie ergab. Der CSG-Bergbau wurde in den sonst überwiegend landwirtschaftlich geprägten ländlichen Gemeinden als eine rasche Entwicklung betrachtet. Mit dieser rasanten Entwicklung kam es zu Schwankungen in der lokalen Wirtschaft, der Bevölkerung, der Sozialstruktur und den Umweltbedingungen. Es gab direkte und indirekte Auswirkungen der CSG-Aktivität auf Einzel- und Gemeinschaftsebene, einschließlich der Auswirkungen auf Alkohol- und Drogenkonsum. Familienbeziehungen; soziales Kapital und psychische Gesundheit; und soziale Verbundenheit, bürgerliches Engagement und Vertrauen.

Bevor die Wechselwirkung zwischen dem Gesundheitssystem und dem Bergbausektor untersucht wurde, war es wichtig, das ländliche Gesundheitssystem und seine ergänzenden Teile zu beschreiben. Die Systemtheorie untermauerte die Analyse qualitativer Daten aus KII, um die Charakteristika des Gesundheitssystems und die einzigartigen Einflüsse auf seine Funktionalität zu beschreiben. Die Ergebnisse zeigten, dass die Gemeinden eng mit dem Gesundheitssystem verbunden sind und dass die ländlichen Gesundheitssysteme in der Fallstudie durch Geografie, Klima und wirtschaftliche Schwankungen definiert wurden. Das Verständnis des einzigartigen Systemdrucks ist wichtig, um die Auswirkungen politischer Entscheidungen auf die Gesundheit in ländlichen Gebieten zu erkennen. Die Dezentralisierung der Entscheidungsfindung, größere Flexibilität und Vorhersehbarkeit der Programme werden zur Stärkung des Gesundheitssystems in ländlichen Gebieten beitragen.

Ein weiteres Schlüsselthema wurde aus dem HNA herausgearbeitet: Der Bergbausektor spielte eine vielfältige Rolle bei der Planung und Bereitstellung von Gesundheits- und Sozialdiensten. Wichtige Informantentranskripte wurden erneut mit der Theorie der Phänomenologie analysiert. Von diesen erwähnten 23 das Vorhandensein von CSG- oder Bergbautätigkeit während des Interviews mindestens einmal ohne besonderen Hinweis auf die Bergbauindustrie. Es wurde angenommen, dass Bergbautätigkeit die Fähigkeit der Dienstanbieter beeinflusst, die Nachfrage zu befriedigen, Personal einzustellen und zu binden sowie Programme effektiv zu planen und zu verwalten. Die Wechselwirkungen zwischen Bergbaugesellschaften mit Dienstleistern und Aufsichtsbehörden waren unterschiedlich und wurden ausführlich kommentiert. Mehrere wichtige Informanten identifizierten Wege, wie der Bergbausektor effektiver mit Dienstleistungen zusammenarbeiten könnte. Dazu gehörten die Stärkung des sektorübergreifenden Engagements und die Ermöglichung transparenter, öffentlicher Konsultationen und faktengestützter Finanzierungsinitiativen.

Fazit

Die unkonventionelle Erdgasförderung und die Auswirkungen der Bergbautätigkeit auf die umliegenden Gemeinden sind international ein großes Problem. Durch die Anwendung der wichtigsten Theorien und Methoden des öffentlichen Gesundheitswesens, einschließlich des Modells für soziale Determinanten von Gesundheit, der Theorie komplexer adaptiver Systeme und der Bewertung der Gesundheitsbedürfnisse; Diese Arbeit hat wesentlich zum Diskurs beigetragen und signifikante Zusammenhänge zwischen Bergbautätigkeit und Gesundheit in betroffenen Gemeinden gezeigt.

Diese Dissertation versuchte die Evidenzbasis der Verbindung zwischen der Bergbauindustrie und den sozialen Determinanten der Gesundheit der umliegenden Gemeinden zu stärken, wobei die potenziellen Auswirkungen der CSG-Entwicklungen im Mittelpunkt standen. Die Hypothese, dass umfassendere, direkte und indirekte

Auswirkungen auf Gesundheit und Wohlbefinden auf Einzel- oder Gemeinschaftsebene bestehen können, wurde getestet und nachgewiesen. Das sekundäre Ziel bestand darin, die Beziehung der Stakeholder untereinander zu untersuchen und zu beschreiben.

1. Introduction

1.1 Background

Coal seam gas (CSG) is an unconventional natural gas (UNG) that is extracted from wells via coal seams, and reserves are found in Australia, the USA and the UK. Other UNG include shale and tight gas, which are sourced from different geological formations and utilise similar processes to CSG mining, and are extracted in Canada, Europe, Asia, the Middle East and Australia. UNG is a vital resource for industrial processes and used domestically for electricity generation and heating homes. (1) The lifecycle of CSG starts with exploration, through to construction and production, and finishes with decommissioning of wells. (2) The exploratory phase includes drilling across several locations to identify if gas can be produced profitably. (3) The construction phase involves considerable infrastructure and manpower to drill and frack[2] wells, and has become the focus of much concern and debate in the local communities within which it occurs. At the local level, the commonly termed mining 'boom' reflects the construction phase (approximately 0.5 – 2 years), and the mining 'bust' reflects the production phase when the physical presence of mining personnel and infrastructure reduces in the community (approximately 20 years). (3)

Major development projects can facilitate employment and other opportunities in the affected communities through population growth and increased demand for services. However there is evidence of impacts to social, economic and environmental externalities than can outweigh the benefits. Commonly referred to as the 'resource curse', when the costs of extraction and exporting natural resources outweigh the economic benefits, the recent expansion of CSG activity was often met with trepidation from local communities and the broader international public. (4) There was uncertainty around the impacts and consequences of rapid UNG development particularly in the USA and Australia, stemming from a lack of prior experience, mixed messages in the media, perceived lack of governmental support, and little empirical evidence. (5) The academic community noted an absence of evidence of the impacts of UNG development, which did not necessarily correlate with evidence of absence.

Through recent exploration of the extractives industry and health outcomes, a shift has occurred from assessing direct environmental impacts, such as dust exposure as a risk factor for respiratory disease, towards measuring the indirect, or social determinants of health (SDoH) and wellbeing as a consequence of living in proximity to large-scale

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[2] Definition of 'fracking'*: the process of injecting liquid at high pressure into subterranean rocks, boreholes, etc. so as to force open existing fissures and extract oil or gas*

extractive mining activity. (6-10) Determinants of health include the economic, physical and social conditions that influence health status and are often measured at a population level (Figure 2). (11) There is evidence that changes in these determinants, brought about by the influx and temporary nature of UNG activity, can have positive and negative impacts on health and wellbeing outcomes in host communities. (12-14)
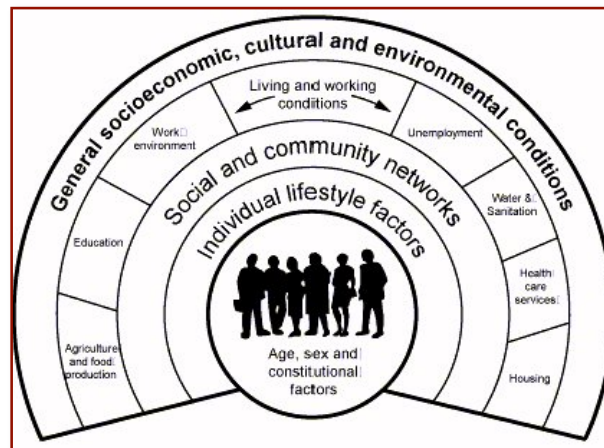
Figure 1: The Social Determinants of Health model

The extractives industry is a major contributor to Australia s economy, particularly in regional and rural areas of Queensland and Western Australia, where iron ore, gold, coal and CSG amongst other commodities are extracted from the ground in proximity to regional and rural communities. CSG exploration and extraction for the domestic market commenced in the late 1970 s in regional and rural towns in Queensland, and commercial production started in 2006. (15) Picking up on its success, large oil and gas companies entered in to the resource rich areas of Bowen and Surat Basin. Four large companies carried out extensive exploration, built export facilities and industrial plants, and extracted CSG, which was converted into liquefied natural gas (LNG) and sold in domestic and international markets in addition to domestic distribution, occurring at a rapid and unprecedented rate. (16)

CSG development in regional Queensland was described as rapid due to increased international demand, spatial expansion and extensive resourcing that occurred with the number of wells drilled per year increasing from 200 in 2005-2006 to around 1,600 in 2013-2014. Without much prior experience or understanding of how the local communities would be affected, the crossover of activity with traditional community practices increased, with wells being drilled on active farms and grazing properties. (17) Such intensive expansion often generates temporary economic opportunities, community development and cultural diversity, and the reception with which these changes are received at a local level vary. (18, 19) The rapid expansion of CSG development across Australia has been contentious with regular opposition from

community groups, particularly landholders and farmers, concerned health professionals, and international communities undergoing similar UNG development. (20)

The International Council for Mining and Metals (ICMM) has 27 international mining companies and more than 30 national and regional mining associations as members, and formally state that signatories must adhere to the 10 Principles. Principle One stipulates that companies must *'pursue continual improvements in social performance and contribute to the social, economic and institutional development of host countries and communities'.* (21) Presenting as a win-win situation, the mining sector invests in development initiatives and gains a *social license to operate* and citizens benefit from services they need. (22) Such initiatives might include infrastructure improvements, support to local business development, and provision of educational programs or improvements to healthcare services. (23) ICMM mandates that members engage at the earliest stage with likely affected parties to discuss and respond to issues and conflicts; ensure that appropriate systems are in place for continual interaction with affected parties; contribute to community development from exploration to closure; and encourage partnerships. There is however, no mention of UNG or any UNG mining companies listed as members with the ICMM. (24) The level of community interaction throughout a project lifecycle is greater in UNG mine settings compared to traditional mining methods such as coal because of their proximity to communities, and so there is greater expectation of the mining company by the public to monitor and mitigate impacts on the communities in which they operate.

The spotlight on UNG mining highlights the need to investigate health and wellbeing needs of communities as they experience economic, environmental and social change as a consequence of living in proximity to mining activities. (25) Canada and Australia are leading the research in this area, but there is a dearth of peer reviewed, empirical literature that explores how determinants of health in CSG settings impact communities, and the interaction between the mining sector and local stakeholders in addressing challenges. There are complexities to unpacking the cumulative impacts of CSG mining, measuring health and wellbeing outcomes, and examining the relationship between the mining sector and host communities. (26, 27)

Integral to the provision of health services in regional areas is the integration of services and partnerships – it is common for stakeholders external to the health sector, like transport, police or environmental departments to be involved in health service planning and delivery. In regional mining communities, there is emerging evidence that the mining sector may play a larger role in regional communities than previously expected, but the pathways in which they do this in the health sector are not clear. (28) There is a dearth of scientific evidence of the ways in which the mining sector interacts with the health system in the communities in which they operate; what the costs and benefits of this interaction might be and how the relationship might be optimized to enable long-

lasting health improvements. This is particularly important in mining communities whose needs fluctuate with the various stages of mining activity, and particularly in communities where mining activity is soon to cease, leading to uncertainty and economic downturn.

1.2 Aim and Objectives

The extractives industry will continue to expand across continents and activity will continue to coexist alongside communities. There is an opportunity to learn quickly from UNG developments in leading countries in order to mitigate potential social, health and economic impacts. Following the establishment of this topic as an opportunity for research, systematic investigation of the current situation is crucial to understand contextual factors and test the hypothesis that there are broader public health implications of UNG mining activity. There is also an opportunity to build on innovative methods to measure and monitor health impacts, beyond the traditional health impact or environmental impact assessments commonly commissioned by mining companies prior to implementation. Provided that CSG developments frequently occur in regional and remote settings, often within constrained health systems, there is an opportunity to explore how mining companies interact with stakeholders to support sustainable developments in the health sector and maximise opportunities for health.

The objectives of this research is to:

1. Systematically review the global evidence for public health and wellbeing outcomes in communities living in proximity to mining activity utilising a social determinants of health framework;
2. Explore the association between CSG development and public health outcomes via a case study in Queensland, Australia; and
3. Explore the interaction between the CSG industry and health and community sector, and opportunities to optimise outcomes through a case study in Queensland, Australia.

1.3 Scope of Thesis

Dominant evidence following an in-depth literature review reflected direct, environmental health impacts of living in proximity to mining activity. There was some evidence of broader determinants of health in mine settings, including changes to the social, physical and economic environment that had implications for health and wellbeing. A systematic review was conducted utilising narrative synthesis to critically analyse the available evidence on broader health and wellbeing outcomes at individual and community level. This was done for both high-income countries and low-income countries to provide the context from which the methods for Objective 2 were developed. Empirical evidence for the association between health and wellbeing outcomes and CSG mining activity was collected through a case study in regional

Queensland. A Health Needs Assessment was carried out with community members of four regional towns to determine health and wellbeing needs and understand the drivers of change. Key informant interviews were also carried out with health and community service providers to determine community needs, and explore barriers and facilitators to planning and managing services. The pathways in which the CSG industry interacted with the local health system was analysed, and opportunities to strengthen sustainable improvements at community level were explored.

1.4 Thesis Structure

This thesis was structured in to three main parts: the first part reflects the systematic reviews of the peer-reviewed literature on health and wellbeing in the mining context. The second part comprises of findings from the case study in regional Queensland relating to the association between health and wellbeing and CSG development. The third part reviews regional health systems and provides an analysis of the pathways in which the mining sector interacts with health and service providers at the local level. The discussion section synthesises evidence generated in the thesis and provides recommendations to strengthen measurement of and response to community health and wellbeing needs, with consideration of the social determinants of health.

The contents of Chapter 2, 3 and 4 was already published, whilst the contents of Chapter 5 and 6 were prepared for submission to a peer-reviewed journal.
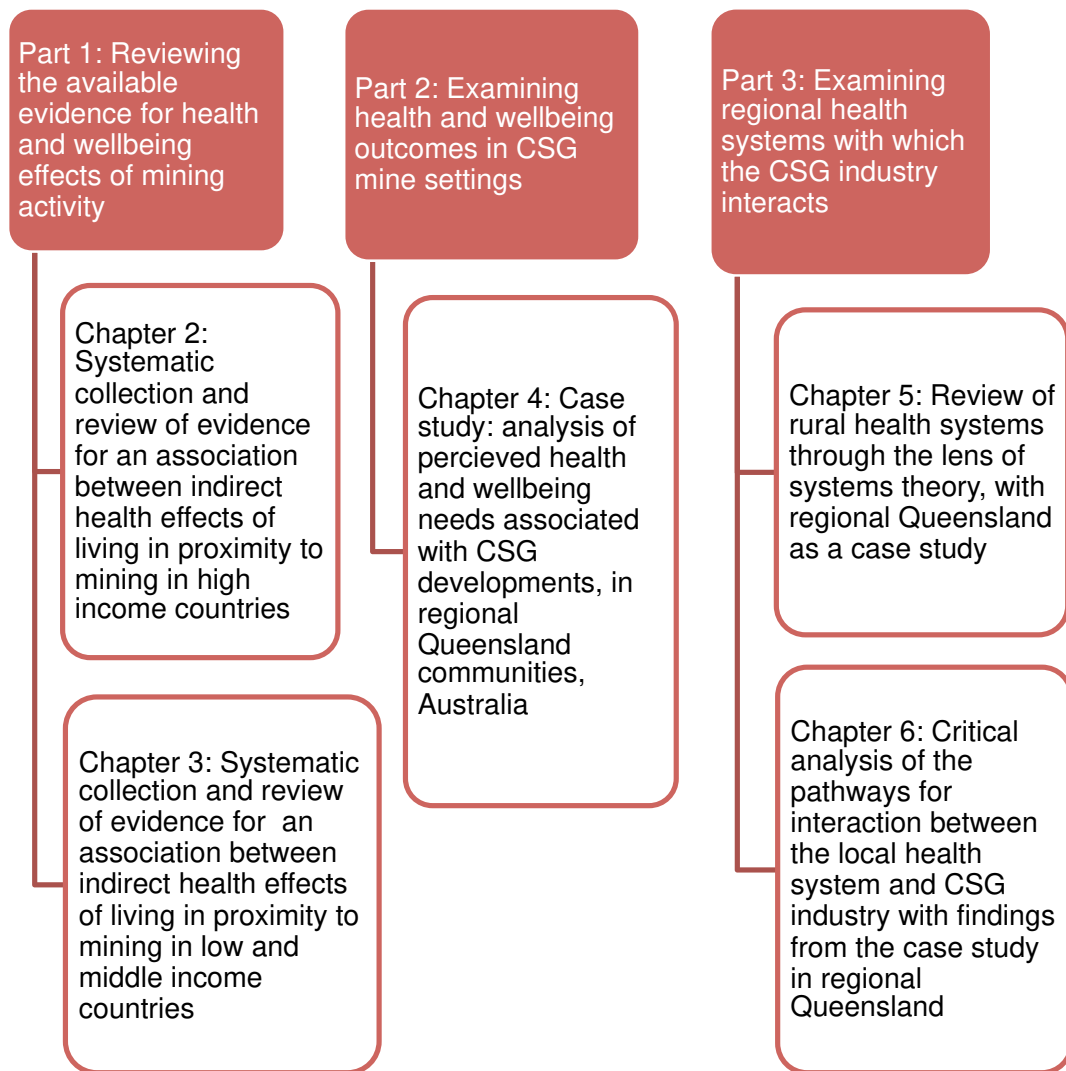
Figure 2. Schematic of thesis structure

1.5 Methodological Background

The chapters in this thesis take the reader from a wide lens of exploring international trends in health and wellbeing and mining activity, to a specific case study of CSG mining in regional Queensland, and reverts to the broader context with a synthesis of evidence and discussion of relevance to other resource rich settings where UNG is being mined. The research in this thesis has direct implications for the CSG industry in regional Queensland and more broadly in Australia. The research also sought to generate a broader understanding of the potential impacts of mining activity on individual and community health and the pathways in which the mining industry can interact with the health system to optimise health outcomes.

1.5.1 Part One

The first systematic review involved a comprehensive search for peer-reviewed articles that considered health and wellbeing outcomes as they related to mining activity in the local community. Subjects had to be residents of the community and living in proximity to mining activity; the country of interest was high in-come; individual or community-level health or wellbeing outcomes were reported; articles were peer-reviewed and used primary or secondary data. To avoid duplication with other published reviews, this systematic review excluded studies that investigated direct effects of environmental factors on health outcomes. Information from each article was systematically extracted using a standardised form and a combination of two pre-validated checklists were used to conduct quality assessments of the articles. Data extraction and quality assessment was conducted by the lead and co-author. A narrative synthesis was carried out on the articles, acknowledging the methodological diversity of the articles.

A second systematic review was conducted to explore health and wellbeing outcomes in communities of low and middle-income countries. Inclusion criteria matched that of the first systematic review. The Critical Appraisal Skills Programme checklist was used for qualitative articles and an adapted version was used for quantitative studies (29). Two authors conducted the data extraction and quality assessment and a narrative synthesis was also conducted to enable a comparison between the studies.

1.5.2 Part Two

The research presented in Part 2 and Part 3 form part of a larger HNA research project that was conducted by a team of Public Health researchers including the DrPH candidate in three local government areas in regional Queensland (30). The purpose of the larger HNA was not to specifically identify the direct impacts of mining activity, but to assess broader population level health and wellbeing issues in the communities and develop targeted interventions to address them[3]. The HNA framework was utilised in order to explore and identify inequalities in health and priorities for improvements. HNAs start with a population, rather than a project and utilise a systematic method to review health issues facing a population. The HNA design was theoretically underpinned by the SDoH framework. The SDoH framework considers the influencing factors on health that go beyond biological determinants. SDoH recognise that for equitable access to health to be achieved, socioeconomic, environmental, social and individual influences need to be considered. In 2005, the World Health Organization established the Commission on SDoH, which sought to build evidence of the causal links between health outcomes and SDoH, and advocate for a revised model of primary health care. Delivering health programs with recognition of SDoH require a holistic and multidisciplinary approach, and relies on strong engagement with policy-makers and funders. (31) Key steps include

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[3] *The comprehensive Health Needs Assessment is available at*
https://www.wesleyresearch.org.au/research/ruralremote/wellbeing/

defining the population and objectives of the assessment; identifying health priorities through data collection and defining perceptions of needs; assessing health priorities for action; planning for change and reviewing progress. (32) This research focuses on the first three steps of the HNA.

The findings from the HNA relevant to this thesis, and presented in Chapters 3-5 were obtained from qualitative inquiry with community members and health and service providers. Qualitative research techniques have been utilised in this research because of the exploratory nature of the topic. Applying qualitative methods enables a deepened and diverse understanding of the topic, relationships between key stakeholders, and identification of underlying causes, motivations or opinions. (33) It is necessary to first explore the setting where mining activity interacts with SDoH, to inductively generate rich descriptions and evidence that support the development of relevant indicators. Qualitative methods included in depth interviews (IDIs); focus group discussions (FGDs) and key informant interviews (KIIs) and the objective varied slightly for each tool and audience (see appendix 10.1). Workshops were also held where community members were asked to list and rank key health and wellbeing needs for their community.

1.5.3 Part Three
As described in Part 2, both Chapter Four and Five include qualitative analysis of primary data obtained from the HNA. This section describes the theoretical methodologies that guided the analysis for each Chapter.

1.5.3.1 Chapter Four
'Systems thinking' considers that a health system shares the characteristics of complex adaptive systems (CAS), in that although they are made up of separate parts, they can only be fully understood by appreciating the relationships and interconnectedness between the different parts and actors, including external factors such as the environment. (34, 35) The separate parts are, in their simplest form, described according to the WHO as building blocks - Leadership/Governance, Health Care Financing, Health Workforce, Medicine and Technology, Information and Research and Service Delivery. CAS recognises that these 'building blocks' don't simply add up to create a functioning health system. The relationships between the blocks and their behaviours are crucial, resulting in a system that might demonstrate self-organisation, non-linearity, co-evolution and emergence, which are characteristics of CAS. (36-38)

1.5.3.2. Chapter Five
Results presented in Chapter 5 were qualitatively analysed using the Framework method, which provides an initial structure whereby the researcher can systematically reduce the data in order to analyse it. Components of the SDoH model was used to develop the Framework and results were coded and analysed. Results from Chapter 5 were thematically analysed using the WHO Framework of 'Six Building Blocks of the

Health System'. (39) Results from KIIs with service providers were thematically analysed and presented in Chapter 5.

Part I: Reviewing the available evidence for an association between health and wellbeing and mining activity

2. Examining health and wellbeing outcomes associated with mining activity in rural communities of high-income countries: A systematic review

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Systematic Review

Examining health and well-being outcomes associated with mining activity in rural communities of high-income countries: A systematic review

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Abstract

Objective: It is recognised internationally that rural communities often experience greater barriers to accessing services and have poorer health outcomes compared to urban communities. In some settings, health disparities may be further exacerbated by mining activity, which can affect the social, physical and economic environment in which rural communities reside. Direct environmental health impacts are often associated with mining activity and are frequently investigated. However, there is evidence of broader, indirect health and well-being implications emerging in the literature. This systematic review examines these health and well-being outcomes in communities living in proximity to mining in high-income countries, and, in doing so, discusses their possible determinants.
Methods: Four databases were systematically searched. Articles were selected if adult residents in mining communities were studied and outcomes were related to health or individual or community-level well-being. A narrative synthesis was conducted.
Results: Sixteen publications were included. Evidence of increased prevalence of chronic diseases and poor self-reported health status was reported in the mining communities. Relationship breakdown and poor family health, lack of social connectedness and decreased access to health services were also reported. Changes to the physical landscape; risky health behaviours; shift work of partners in the mine industry; social isolation and cyclical nature of 'boom and bust' activity contributed to poorer outcomes in the communities.
Conclusion: This review highlights the broader health and well-being outcomes associated with mining activity that should be monitored and addressed in addition to environmental health impacts to support co-existence of mining activities and rural communities.

KEY WORDS: *international health, mining, rural population health, social determinants of health, well-being.*

Introduction

It is recognised internationally that regional and rural populations experience greater barriers to accessing services and have poorer health outcomes compared to urban populations. In Australia, rural communities are associated with higher mortality rates and health care costs compared to urban communities.[1] In some settings, these disparities may be further exacerbated by externalities like mining activity.

Mining activity can affect the social, physical and economic environment in which a person resides with consequential effects on health and well-being. Well-being has increasingly been measured independently of health and is commonly measured within *individual-* and *community-level* domains using a series of indicators that consider elements of life that impact on quality.[2] In this review, we explore well-being as a domain that is interrelated but separate to physical health and focus on subjective indicators. Well-being indicators have important implications for policy formulation and service delivery, providing a more realistic profile of the population that goes beyond physical health status.[3]

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What is already known on this subject:
- *We know that direct environmental exposure to toxins and chemicals from mining activity can have risks for human health*
- *Mining activity can affect the social, physical and economic environment in which communities live and there is emerging evidence of how these factors in turn affect health and well-being outcomes*
- *There is no systematic review available on the public health impacts of mining that consider broader, indirect and often longer term health and well-being outcomes*

What this study adds:
- *There is evidence of similar individual and community well-being outcomes associated with mining despite studies being carried out in different settings and countries*
- *Examining individual and community-level well-being in addition to physical health is imperative to provide a more comprehensive picture of how communities may be affected by mining*
- *Transparent, prospective and methodologically sound articles will strengthen the evidence base to inform development of programs and policies that better respond to health and well-being challenges faced by mining communities*

The scientific literature contains significant research on environmental health impacts of mining.[4–8] However, there is growing evidence that social and economic impacts of mining can influence mental health outcomes, family relationships and community connectedness.[9,10] For example, the influx of mining activity in otherwise rural communities can temporarily increase local housing and rental prices, which could in turn lead to economic hardship and poorer health and well-being.[11,12] Exploring these outcomes is imperative to understand how resident communities respond to change brought about by mining and what action is required to address them.[13]

This systematic review aims to explore the broader health and well-being outcomes of populations residing in mining communities in high-income countries and involves assessment of quantitative and qualitative literature to identify health and individual and community-level well-being outcomes of resident populations who live in proximity to mining. Rural populations are defined as 'those not residing in a metropolitan city and described in the study as rural, remote, regional or isolated' and mining activity is defined as 'the action, process, or industry of extracting ores and other materials from a mine.'

Methods

A systematic search of the bibliographic databases PubMed, MEDLINE, Science Direct and PsycInfo was performed by from 19th June 2014 to 1st May 2015 (Appendix 1). These databases were chosen based on their relevancy to the research question. PubMed and MEDLINE are also known to be more up to date and consistent with terminology for searching articles.

Articles were included if: target population was adults (18+) and defined as resident within the community; country of interest was classified as high income[14]; community was proximate to mining; individual and community well-being outcomes or health outcomes reported; published in any year; written in English; were peer reviewed and used primary or secondary data. The initial database search generated a large volume of articles related to direct environmental exposures and health outcomes in mining communities. There were many articles that explicitly sought to assess a causal relationship between a mining by-product and health outcome, for example water contamination from a specific toxin and the incidence of disease. An exclusion criteria was thus developed: 'mining-product and specific health outcome' which eliminated these articles from the review. To avoid duplication, this review therefore does not consider direct environmental health impacts of mining or occupational outcomes.

Summary information from each article was collated using a standardised data extraction form. Acknowledging methodological diversity and lack of guidance in the literature on a suitable single appraisal tool, an adaptation of two checklists was used to aid the qualitative assessment process.[15,16] No articles were excluded for reasons of poor quality. The lead author conducted the data extraction and quality assessment, which was validated by the second author. Narrative synthesis was conducted because of the diversity in study type and outcome measures.

Results

Two authors conducted the abstract and full-article screening. The snowballing technique of searching the bibliographies of each included article was conducted. After review of full articles, it was agreed that those
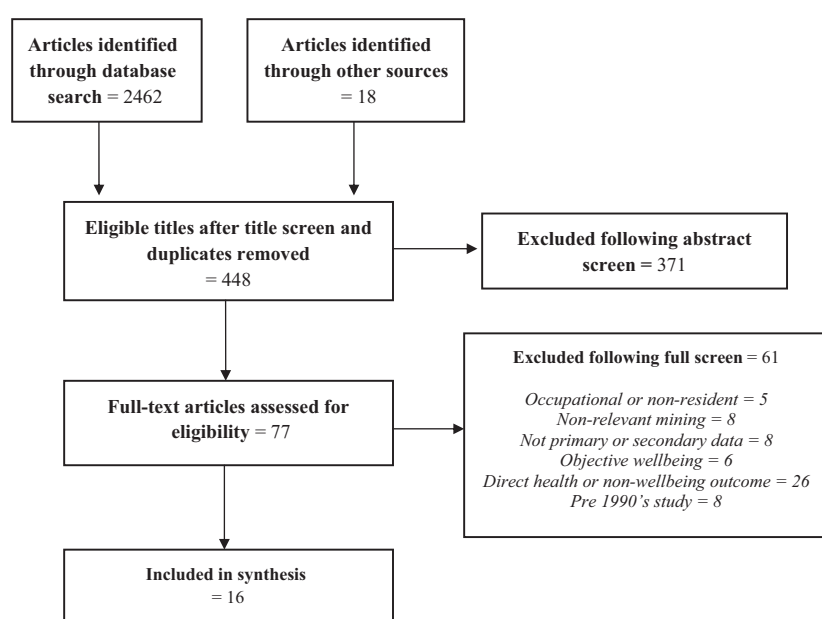
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┌─────────────────┐   ┌─────────────────┐
│ Articles identified │   │ Articles identified │
│ through database │   │ through other sources │
│ search = 2462   │   │ = 18            │
└─────────────────┘   └─────────────────┘
         │                     │
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      ┌───────────────────────────┐        ┌─────────────────────────┐
      │ Eligible titles after title │───────▶│ Excluded following abstract │
      │ screen and duplicates removed │        │ screen = 371            │
      │ = 448                     │        └─────────────────────────┘
      └───────────────────────────┘
                    │
                    ▼
      ┌───────────────────────────┐        ┌─────────────────────────────────────┐
      │ Full-text articles assessed for │───▶│ Excluded following full screen = 61 │
      │ eligibility = 77          │        │                                     │
      └───────────────────────────┘        │ Occupational or non-resident = 5    │
                    │                       │ Non-relevant mining = 8             │
                    ▼                       │ Not primary or secondary data = 8   │
      ┌───────────────────────────┐        │ Objective wellbeing = 6             │
      │ Included in synthesis     │        │ Direct health or non-wellbeing outcome = 26 │
      │ = 16                      │        │ Pre 1990's study = 8                │
      └───────────────────────────┘        └─────────────────────────────────────┘
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FIGURE 1: *Flow chart detailing selection, screening and eligibility process.*

prior to 1990 would be excluded due to irrelevancy of study designs, resulting in 16 articles for inclusion in the systematic review (Fig. 1)

Five articles did not report the type of mining activity; one was set in a community exposed to coal seam gas (CSG) and remaining articles were exposed to coal (Table 1). The stage of mining varied from exploration to closure and populations varied in their proximity to mining activity and distance from urban centres.

Robustness of findings

Quantitative

All articles were observational with primarily cross-sectional and ecological study designs ($n = 11$). Half of the articles included a comparator with a community without mining, national-level data or another mining community. Proxy measures for mining exposure were reported in five articles and were obtained from topographical maps of surface mining, density of abandoned mine land and publicly available coal production output figures. Remaining articles described the setting only. These factors, if not accurately reported, could affect the generalisability of the findings.

Strength of evidence was limited by selection bias and failure to account for known risk factors. Sampling bias was a potential limitation in three articles: participants were recruited via door to door contact during restricted hours[17,18] and participants were intercepted during visits to shopping centres and public events.[19] Two articles did not account for occupational exposure[20,21] but one sought to eliminate this potential confounder by conducting a female-only analysis.[22] Three articles examining overall health and cancer outcomes did not accurately account for smoking status.[17,22,23] Of the articles with secondary data, it was not possible to obtain information on length of time resident in the mining community and it was acknowledged that place of residence was not necessarily an indicator for proximity to mining. In some articles, bias was minimised by measuring covariates and assessing the demographics of non-respondents.[24,25]

Qualitative

Two articles did not justify research design or participant recruitment method[26,27] – all others used purposive sampling. One article assessed the relationship between researcher and participants and potential bias[28] and the majority reported ethics approval and explained data analysis methods.[28–30] All discussed credibility of findings with reference to existing literature and discussed the contribution of the study to existing knowledge around the topic.

Discussion

The environment within which mining communities are placed

Chronic diseases and poorer self-rated health were common outcomes in the coal-mining communities of America, Australia and Canada. Several authors acknowledged that outcomes were likely to be

TABLE 1: *Articles included in the synthesis with an extracted summary of target population, mining type and main outcomes (measures of effect and significance levels given where available)*

First author date	Community context	Mining context	Main outcomes
General physical health			
Hendryx 2008[39]	Females in multiple mining counties of one state USA	Active coal	Health status worsened with increased proximity to coal production. Risk of cardiopulmonary, lung, kidney and cardiovascular disease and diabetes increased with increasing proximity to heavy coal production.
Hendryx 2013[17]	Mining compared with rural non-mining community USA	Active mountain-top mining (MTM)	MTM communities had higher prevalence rates of multiple health problems including poorer self-rated health, chronic obstructive pulmonary disease and hypertension than non-mining communities.
Zullig 2010[24]	Mining compared to non-mining USA	Active coal	Health-related quality of life and self-rated health was significantly reduced among mining communities compared to non-mining in adjusted and unadjusted analysis.
Ellis 2014[19]	Indigenous and non-indigenous residents Australia	Undisclosed; active	Diabetes, cancer and heart disease were priority health concerns for indigenous respondents and cancer, heart disease and sick family members for non-indigenous respondents.
Veuglers 1999[21]	Mining communities Canada	Varied: active coal mining and closed steel mining	Increased mortality patterns in the county as a whole compared to national data. Life loss in females was primarily attributable to cancer and for males, cardiovascular diseases. Life loss from respiratory diseases and lung cancer was higher in coal mining communities.
Specific diseases			
Liu 2013[33]	Patients with diabetes ICD-9 code or at least 2 HbA1c measurements with age at first HbA1c measurement 30 years USA	Abandoned coal mine (AML)	Five AML variables associated with higher med-free HbA1c levels early in disease course and over time ($P < 0.05$). Density of physical hazards (component of chronic environmental contamination) was associated with HbA1c suggesting inhibition of physical activity.
Hendryx 2012[18]	Mining compared with non-mining USA	Active MTM	Odds for reporting cancer were twice as high in the MTM compared to the non-mining community (OR 2.03; 95% CI = 1.32–3.13) after adjustment for age, sex, smoking, occupational exposure and family cancer history.
Esch 2011[23]	Chronic cardiovascular disease (CVD) mortality data from metropolitan and rural USA	MTM and other mining; active	CVD mortality rates in MTM areas were significantly higher than non-mining areas and increased as a function of greater levels of surface mining ($P < 0.05$). MTM and other mining communities combined had an excess of 1,072 annual age-adjusted deaths from CVD.
Christian 2011[22]	Communities in a state with various degrees of mining and non-mining USA	Active coal	Relative risk of developing lung cancer was 1.21 and 1.17 in two clusters with high coal mining production ($P < 0.01$), compared with the rest of the state, but also reported that one cluster had *no* coal production but also an increased risk of lung cancer (RR = 1.04, $P = 0.0$)

(*continued*)

TABLE 1: (*continued*)

First author date	Community context	Mining context	Main outcomes
Individual and community well-being			
Carta 1991[25]	Two inland mining communities Italy	Undisclosed closure in 1987	15.3% of the sample (*n* = 374) sufferred from a mental disorder and females had significantly more mental health disorders than males (*P* < 0.05).
Carta 2012[20]	As above	As above	Decrease in depressive disorders from 1998 to 2008 across age groups except youngest age bracket (18–24 years), which increased (*P* = 0.574).
Albrecht 2007[26]	Key informants and community members Australia	Open cut coal mine; active	Sense of place, identity, physical and mental health, and general well-being affected by an 'unwelcome change' in the home environment, which led to *solastalgia*.
Hossain 2013[27]	Landholders, community members and service providers Australia	Coal and CSG; active	Changing community structure impacted on mental health. Succession planning for landholders, strain on health services and environmental concerns were perceived to have implications for mental health.
Lovell 2010[28]	Females with shift-working partners Australia	Undisclosed	Themes were identified around the impacts of mining work, isolation, culture and social environment, which negatively influenced female psychological well-being.
Shandro 2011[30]	Service providers in a remote town built for mining Canada	Coal; boom and bust stages	Stresses associated with having a partner who worked in the mine. Access to health care and social services was a limiting factor of living in mining communities.
Smith 2010[29]	Residents and key stakeholders England	Undisclosed closure	Positive themes around sense of place and bonding social capital. Negative themes around lack of perceived control and physical isolation that exacerbated poor access to primary health care.

exacerbated by existing characteristics of mining communities, including degree of rurality and lack of services.[17] Predispositions of some mining settings – where communities were characterised by socio-economic disadvantage, risky lifestyle behaviours or environmental degradation – created further difficulty in proving a causal relationship between mining determinants and outcomes.[31]

The construct of mining communities vary – some are built purposefully for industry and some are pre-existing agricultural or smaller industrial towns. The influx of mining in predominantly agricultural communities may bring about changes in the physical environment and increased concern for the land. The well-being of landholders, whose land has been lost to mining, may also be affected following economic hardship or conflict with mining companies.[26,27] It is imperative that mining companies consider the environment in which they operate, both in terms of how the land is affected physically and the community's cultural and spiritual connectedness to the land. This is an ongoing concern, particularly among indigenous populations.[32]

Mining activity and health-related behaviours

The link between land degradation, psychosocial distress and incidence of diabetes was discussed in one article and authors suggested that significant land degradation could lead to barriers in physical activity.[33] Risky health behaviours associated with mining activity included smoking and alcohol consumption, and the possible combined effects of smoking and inhalation of mining by-products on the risk of lung cancer.[22]

Having a partner who worked in the mine industry was associated with the risk of increased violence, stress and family breakdown.[30] Work–family conflict may arise from long hours of shift work and engagement in male-dominated leisure activities like excessive alcohol consumption.[28] These factors could leave women feeling socially isolated and solely responsible for the family.[9,34] Shift work was positively and negatively perceived in the articles. Positive associations with mining employment included greater financial security and opportunities. However, trade-offs

included feelings of isolation and relationship break-down between family members. These research findings are reported elsewhere in the literature, particularly among families that had moved to isolated, rural communities for employment in the mining industry.[9,34,35]

Social determinants of health and well-being

Education, the work environment, employment and housing are key social determinants of health, which can be strained by the influx of mining. Hendryx *et al.* considered the relationship between economic status and health and suggested that poor economic conditions in Virginian mining communities were exacerbated by the mining industry.[18] Mining communities can fail to capture the positive economic benefits from mining and instead be affected by higher housing and retail prices or job shortages due to population influx, for example.[13]

The Italian articles were set in communities that were characterised by vast emigration of young adults following mine closure, leaving a predominantly older population. The first article considered barriers in accessing health care, which could exacerbate the prevalence of mental health conditions. The authors considered that older populations who were at greater risk of depression may have been impacted by isolation and loss of social support following mine closure.[25] The second article reported that those with higher depression rates were the young adults in the two decades following mine closure, which could be associated with lack of employment and social opportunities for those that remained in the community.[20] The effects of population growth following the influx of mining on health and well-being outcomes have been reported elsewhere in the literature.[36]

The boom and bust mining industry in the Canadian article was perceived to cause knock on cyclical economic periods in the communities, which consequently influenced health service capacity and health issues. Increased rates of stress, anxiety and depression were linked with mine closure but have also been reported during mine activity.[20,25,27,30]

The influx of mining may affect the social fabric and bring about the sense of losing control over one's community, leading to social disruption and a lack of community connectedness.[9] The link between community connectedness and mental health is evident in the literature, particularly among the older generation.[37] Rapid population growth and a transient workforce were often perceived negatively by the communities. While a community displayed strong social capital in the study that had experienced mine closure, another

reported that existing social cliques negatively impacted on newcomers to the mining community. The inability to join social networks was particularly evidenced in women who moved to mining communities because of their husband's role in the mine work-force.[9] The importance of social participation as a mechanism for promoting community belonging and well-being is well known.[37]

Limitations

Broad criteria were set purposefully to capture indirect associations but this ultimately led to heterogeneity in study design and outcomes, which impacted on the quality assessment process. A limitation of the review is that only articles in English were included, which may have eliminated articles from non-English-speaking HICs that have substantial mining. While the 25-year time span of articles may be considered a limitation due to development of mine practices over time, health and well-being issues identified in the older articles were comparable to those in the more recent ones. Furthermore, the oldest study was conducted in a community with a closed mine. Potentially valuable grey literature would not have been captured, including industry-commissioned reports on potential community health impacts.

Conclusion

Mining is primarily a rural phenomenon. There is difficulty in separating the effects of living in rural environments with those of mining activity. The life cycle of each mining type needs to be considered – coal mining is generally a long-term activity, and uses a large workforce and it is possible that health outcomes might develop over longer periods of time following closure.[38] Coal is gradually being replaced by unconventional natural gas which has relatively short timeframes compared to coal, but broader health and well-being outcomes should be closely monitored as evidence emerges in the literature.[8,27] Future studies should consider the type of mineral and stage of extraction and include thorough consideration of the community construct in order to determine relevance of outcomes to other mining contexts.

This systematic review has contributed to the growing discourse around community health and well-being impacts of mining. The synthesis of available evidence strengthens the argument that mining companies and governments must measure and respond to broader health and well-being outcomes and their determinants, and highlights the importance for community health assessment that goes beyond direct, environmental exposure to mining activity.

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Appendix 1: Example search strategy used in systematic review search of scientific literature

Populations (rural OR region* OR remote OR isolated) AND mining (mining OR mine OR 'extractives industry' OR 'resource industry') AND health OR individual wellbeing (wellbeing OR happiness OR 'quality of life' OR 'personal satisfaction') OR community wellbeing ('social capital').

3. Exploring the broader health and wellbeing outcomes of mining communities in low and middle-income countries: A systematic review

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Exploring the broader health and well-being outcomes of mining communities in low- and middle-income countries: A systematic review

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ABSTRACT

Health and well-being outcomes in communities living in proximity to mining activity may be influenced by a broad spectrum of factors including population growth, economic instability or land degradation. This review aims to synthesise broader outcomes associated with mining activity and in doing so, further explore possible determinants in communities of low- and middle-income countries. Four databases were systematically searched and articles were included if the study targeted adults residing in proximity to mining activity, and measured individual or community-level health or well-being outcomes. Narrative synthesis was conducted. Twelve articles were included. Mining was perceived to influence health behaviours, employment conditions, livelihoods and socio-political factors, which were linked to poorer health outcomes. Family relationships, mental health and community cohesion were negatively associated with mining activity. High-risk health behaviours, population growth and changes in vector ecology from environmental modification were associated with increased infectious disease prevalence. This review presents the broader health and well-being outcomes and their determinants, and strengthens the evidence to improve measurement and management of the public health implications of mining. This will support the mining sector to make sustainable investments, and support governments to maximise community development and minimise negative impacts.

Introduction

Mining activity can contribute significantly to emerging economies in low- and middle-income countries (LMICs) and can support poverty reduction through employment opportunities and investment in community development. Mining can affect the social, physical, political and economic environment in which they operate with both positive and negative implications for the health of the local population.

'Industrial epidemics' or outbreaks of HIV/AIDS, sexually transmitted infections (STIs) or tuberculosis amongst mining workforces are reported in the international scientific

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literature (Baltazar et al., 2015; Coelho, Teixeira, & Gonçalves, 2011; Stuckler, Steele, Lurie, & Basu, 2013). At a community level, direct environmental health impacts are extensively studied. For example, a study of Goan communities in India revealed that fugitive dust emissions and subsequent poor air quality from iron ore activity negatively impacted on health outcomes (Noronha, 2001). A study in a gold mining region of Malaysia revealed that cyanide exposure increased the prevalence of headaches, dizziness, skin and eye irritation; and a study in a Kenyan gold mining community reported toxic levels of potentially harmful elements in the ecosystem that posed a public health risk. These included increased risk of cancer, infertility in women, heart and vital organ failure and respiratory illness (Hassan, Sahani, Hod, & Yahya, 2015; Ngure et al., 2014).

A study dating back to 1985 explored broader community-level impacts of a nickel-mining site in Indonesia. The influx of foreign mining companies to otherwise rural and isolated communities led to the availability of Western foods, transition from subsistence to a modern economy and reduced access to water and sanitation, which were perceived to have adverse consequences for the health of the local community (Robinson, 1985). More recently, there is recognition that communities can be affected by a broad spectrum of factors, including transient populations, economic instability or land degradation resulting from the influx of mining activity (Noronha, 2001; Onder & Yigit, 2009; Shandro, Veiga, Shoveller, Scoble, & Koehoorn, 2011; Stephens & Ahern, 2002). In high-income countries (HICs), there is evidence of increased mental health issues, lack of social connectedness and decreased access to services in communities impacted by mining activity (Mactaggart, McDermott, Tynan, & Gericke, 2016). The determining factors fall within the social determinants of health model, defining the broader influences on health arising from deviations in the environment, social setting, economy and community within which people live (Mactaggart et al., 2016; World Health Organization, 2015).

Whilst the association of mining and broader impacts on community health and well-being was alluded to some 30 years ago, there is little recent collective evidence to date in LMICs. There is also uncertainty around the mid- to longer-term impacts of mining activity on health and well-being. The significance of understanding these outcomes in mining communities as they undergo economic, environmental and social instabilities relating to 'boom and bust' stages of the mine life cycle is paramount. Findings are particularly relevant to government, health systems, community-based organisations and mining companies in strengthening planning and monitoring activities, and to inform future mine developments.

Study aim

This systematic review examines the broader health and well-being outcomes of populations residing in mining communities in LMICs, and in doing so, explores the wider social determinants beyond direct environmental health exposures. This involves a review of both the quantitative and qualitative literature to identify physical health and individual and community-level well-being outcomes of resident populations who live in proximity to mining activity.

Rural populations are defined as 'any population not residing in a metropolitan city and being described in the study as rural, remote, regional or isolated' and mining activity is

defined as 'the action, process, or industry of extracting ores and other materials from mines'. LMICs are defined as those low- through to upper middle-income countries with a gross national income per capita of less than $12,746 (USD) at the time of the study, calculated using the World Bank Atlas Method (The World Bank Group, 2015). Well-being has increasingly been defined as its own concept and in this review we explore it as a separate domain to physical health. Well-being is a term often used to describe elements of life that impact on its quality – determining an individual's level of personal satisfaction, happiness and psychological health gives an indication of individual well-being. Community-level well-being includes satisfaction with one's environment and level of social connectedness and belonging (International Wellbeing Group, 2006; Organisation for Economic Co-operation and Development, 2013).

Methods

Search strategy

A systematic literature search was conducted for articles from 19 June 2014 through to 1 May 2015 using the electronic bibliographic databases PubMed, MEDLINE, Science Direct and PsycInfo.

The search strategy included the key terms: rural populations (OR region* OR remote OR isolate*) AND mining (OR mine OR 'extractives industry' OR 'resource industry') AND health OR individual well-being (OR happiness OR 'quality of life' OR 'personal satisfaction') OR community well-being (OR 'social capital').

Inclusion and exclusion criteria

Articles were eligible for inclusion if all of the following criteria were met: adults (18+) resident within the community, country of interest was classified as low or middle income, residents proximate to mining activity, individual or community well-being or physical health outcomes reported, published in any year, in English, peer reviewed, and analysed primary or secondary data.

Data extraction and quality assessment

Acknowledging methodological diversity of the articles and lack of guidance in the literature on a suitable single appraisal tool, the Critical Appraisal Skills Programme (CASP) checklist was used for qualitative, and an adapted version of the CASP tool for cross-sectional/descriptive quantitative articles (Critical Appraisall Skills Programme, 2014). No articles were excluded for reasons of poor quality. The lead author conducted the data extraction and quality assessment, which was independently validated by the second author. Narrative synthesis was considered most appropriate because of the diversity in setting and outcome measures of the articles. The authors used a thematic analysis approach to identify themes in common and in contrast between the studies, which enabled a comprehensive exploration of the relationships between study outcomes. The authors then assessed the quality of evidence and robustness of the synthesis overall.

Results

Search yield

After screening titles and removing duplicates, 464 abstracts were assessed (Figure 1). Two authors conducted the abstract screening and discrepancies were discussed and resolved through consultation with other authors where necessary. After review of full articles, it was agreed that those prior to 1990 would be excluded due to non-scientifically based study designs, along with articles reporting baseline studies or evaluation of programmes in mine communities that did not discuss the association of health or well-being outcomes with mining activity. Twelve articles were included in the narrative synthesis. Recurrent themes identified in the synthesis reflected the social determinants of health model.

Study characteristics

A systematic method was used to extract data relevant to the review question (Table 1). Studies were conducted in iron ore communities in Asia (4), platinum, gold and
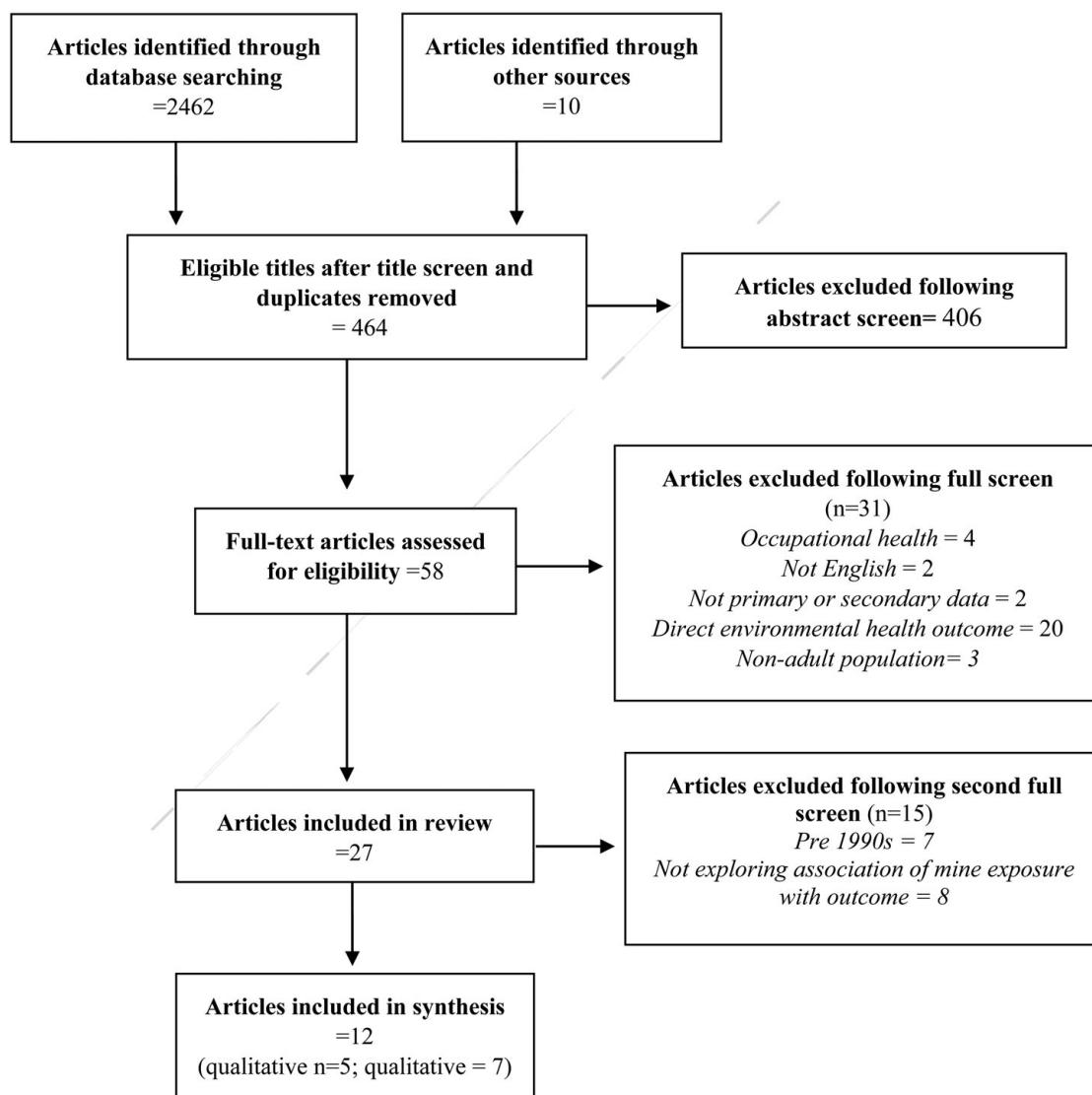

Figure 1. Flow chart detailing stages of the selection, screening and eligibility process.

Table 1. Articles included in the synthesis with an extracted summary of study type, target population, mining type and data collection method.

Study	Population and setting	Mining type and stage	Main outcomes
Quantitative			
Clift et al. (2003)	Residents (mine workers excluded) in two communities Tanzania	Small-scale and newer large-scale gold	No statistically significant difference between the two mining communities for HIV or STI prevalence, but overall prevalence was higher than non-mining rural areas. HIV prevalence in FRFW was double that of other females (42% and 18%, respectively, $p < .001$) and the same was found for active syphilis (24% and 11%, respectively, $p = .001$). FRFW in the mining community had higher HIV and STI prevalence compared to a previous non-mining urban study of hospitality workers. A high proportion of males did not perceive themselves at risk of HIV infection despite reporting frequent high-risk behaviour, including multiple sexual partners and erratic condom use.
Berger et al. (2012)	Community members in an isolated Amazonian rainforest French Guiana	Illegal gold	71% of the community participants experienced a malaria attack in the four months prior to study. *P. falciparum* was responsible for 57.8% of malaria attacks. The risk of contracting malaria was three times higher for 40–49-year-olds ($p = .01$) and those who hunted regularly ($p = .04$). Sixty-two illegal gold miners hunting nearby had 72 malaria attacks during the same time period.
Saha, Pattanayak, Sills, and Singha (2011)	Community members (mine workers excluded) India	Active iron ore	Those living 1 km closer to the mines were twice as likely to report a higher incidence of respiratory illness ($p > .04$). The environmental health effect is highly significant indicating that 1 km of proximity to mines is associated with a 3.3% increase in work days lost due to malaria. Those closer to the mines were on average further from the local health centres.
Miranda, Mercon-de-Vargas, Corbett, Corbett, and Dietze (2009)	Females in a mining community Brazil	Active gold	Approximately 30% of females sampled did not have access to health care during the preceding year. 53.6% had received information on HIV and STIs; 9.1% and 56.5% reported personal frequent use of condoms and oral contraception, respectively, and 34.4% reported prevalence of chronic disease. The authors reported risk factors associated with living in the community, which included alcohol consumption (24.4%), tobacco use (34.4%) and domestic violence (17.7%).
D'Souza, Karkada, and Somayaji (2013a)	Females in five mining and five agricultural communities India	Iron ore	Females in the agricultural community had significantly better general mental health ($p < .005$) and social functioning scores ($p < .01$) compared to the mining community. Females in mining communities reported more eye, upper and lower respiratory and psychological illnesses compared to those in the agricultural community and had poorer access to health care.
Qualitative			
Chenga and Cronje (2014)	Community members and key informants South Africa	Platinum mine site	'Family disorganisation' reportedly stemmed from migrant labour, poverty, unemployment and poor infrastructure, which had been exacerbated by mining activity. A lack of recreational activities in the community and feelings of isolation and stress were reported to affect health and well-being of residents. The construct of the community was such that residents were mostly migrants, who had arrived unaccompanied and settled in the mine community. Social risk factors need to be addressed to improve health outcomes in the community.

Table 1. Continued.

Study	Population and setting	Mining type and stage	Main outcomes
Lightfoot, Maree, and Ananias (2009)	Family members and professionals, (mine workers excluded) Namibia	Not reported	Issues in the community were associated with the structure of the male-dominated 'closed mining community'. The structure of the town meant that many lived far from their families and faced pressures that came with living in a remote location. High levels of alcohol consumption were perceived to result from a higher disposable income among some community members. Increased alcohol intake was linked to risky sexual behaviours and possible association with increased HIV risk.
D'Souza, Karkada, Somayaji, and Venkatesaperumal (2013)	Married females in a rural mining community India	Active iron ore	Poor well-being in the community was associated with poor literacy and mobility, lack of employment and income-generating opportunities, poor reproductive health choices and quality of marital relationships. Lack of employment opportunities was associated with loss of agricultural land to mining activity and family conflict and socio-psychological abuse was associated with increased alcohol consumption of shift-working partners.
D'Souza, Somayaji, and Nairy (2011)	Resident married females in a mining village, who were not employed in mining India	Active iron ore	Females in the mining community felt dejected, insecure and neglected in the male-dominated mining community. Some respondents mentioned the loss of agricultural land to the mining industry and how this impacted on financial insecurity and well-being. Others discussed the impact of mining on pollution, traffic volume and sanitation. There was no significant association of years spent living in the mining community with quality of life or reproductive health outcomes.
Yelpaala and Ali (2005)	Community members Ghana	Large-scale and artisanal gold and diamond mining	Malaria was the leading cause of outpatient cases. Illegal mining of the land for diamonds and digging within the mine site left large pits which could have created breeding sites for mosquitoes. Furthermore, large pits left behind were considered a health hazard to community members. Natural health providers (herbalists) who commonly treated community illnesses were concerned about depleted natural resources due to land degradation by the mine activity. Participants perceived there to be a high level of HIV/AIDS incidence in the mining community.
Caxaj, Berman, Varcoe, Ray, and Restoule (2014)	Community members Guatemala	Large-scale gold and silver	Mining activity influenced the socio-political environment and led to conflict in the indigenous community. Social unravelling characterised by climate of fear, discord and stress was experienced. Participants perceived mining as a threat to well-being and loss of social cohesion and erosion of community health. Respondents perceived that community fragmentation had occurred because of the lack of balance of power being tipped by the mine company. Locally relevant mental health support was recommended to address community well-being outcomes.
Caxaj, Berman, Ray, Restoule, and Varcoe (2014)	Community members Guatemala	Large-scale gold and silver	Community residents were determined to achieve a level of health that was protective, affirming, purposeful and creative in spite of impacts perceived from mining. Strengths were reflected in a shared cultural identity, spiritual knowledge and being, defending rights and territories and speaking truth to power. Community members perceived customs and traditions as core to cultural well-being, which included their connection to the land.

Note: Main outcomes given with measures of effect and significance levels where available.

diamond in Africa (4), gold in South America (2) and gold and silver mining communities in North America (2). The studies were conducted between 2003 and 2014, all were observational and the majority (*n* = 7) used qualitative methods.

Environmental conditions

Two studies in India and French Guiana investigated the prevalence of malaria and association with behavioural and environmental risk factors. The study in French Guiana linked the sudden increase in local malaria cases to illegal gold miners who had temporarily settled near the isolated community (Table 1) (Berger et al., 2012). Resident hunting and fishing spots were often utilised by illegal gold miners, who also accessed local health services in the community when they became ill with malaria themselves, increasing the opportunities for local transmission. Residents living closer to mine activity in the Indian study reported a significantly higher number of workdays lost to malaria compared to those living further away, and a higher incidence of respiratory illness (Saha et al., 2011). The authors reported on significant environmental changes that had occurred following the removal of vegetation for mining purposes near the communities, which may have affected vector ecology and subsequent malaria transmission. The authors considered the effects of ventilated kitchens, improved stoves and use of firewood on respiratory illness; however, these were not significant (Saha et al., 2011).

The study in Ghana explored perceptions of the community environment and health and well-being. Gold mining and associated large-scale digging brought about changes to the land, creating large pits optimal for mosquito breeding. Residents were concerned about malaria transmission and the hazards of walking near large pits. Land use changes also affected the ability of herbalists to treat the sick – supply of natural resources was depleted by mine activity affecting the ability to treat community members for anaemia, asthma and typhoid with traditional medicines. Poor understanding of drivers of HIV/AIDS incidence and poor access to services was perceived to further affect health outcomes (Yelpaala & Ali, 2005).

Social and cultural determinants

Two articles investigated the association of living near to gold mining activity and the incidence of HIV and STIs (Table 1). These studies were both set in communities with long histories of gold mining and associated political and social conflict. The study in Tanzania assessed HIV and STI prevalence both in the general community and female recreational and food workers (FRFW) who had moved to the community to service the mine workforce, working in guesthouses, bars, hotels and discos. High alcohol consumption and being single was associated with HIV positivity across the communities and population groups (Clift et al., 2003). Disposable incomes of the mine workforce, isolation from family and lack of social support were linked to high-risk behaviours in the community.

A female-specific study in Brazil was conducted to inform public health programmes in a mining community. Women in the mining community were affected by poverty, social exclusion and unemployment. They had access to health information but lacked the financial means to access services (Table 1). The authors highlighted the importance of addressing social determinants of health for this minority population (Miranda et al., 2009). The second female-only study was conducted in India and reported on the differences in

health-related quality of life and physical health of mining and agricultural communities. Residents in the mining communities reported more physical and psychological illness compared to those in the agricultural communities (Table 1). Social exclusion, poverty and unemployment were reported to influence these poorer outcomes. Coping strategies, such as social networks and spirituality, were reported to alleviate some of the burdens that were associated with being in an economically stressful environment with poor access to health care (D'Souza et al., 2013a).

Social and community networks

Three studies in Africa explored community perceptions of mining and health or well-being and two of these considered factors relating to the composition of the mine community (Chenga & Cronjé, 2014; Lightfoot et al., 2009; Yelpaala & Ali, 2005). The study in Namibia explored alcohol consumption and HIV transmission and considered how the structure of the mining community might influence high-risk behaviours. Residents in the community were either permanent or had moved to the area for mine-related employment. Participants linked alcohol abuse in the community to the male-dominated environment, lack of other recreational activities and higher disposable incomes of mine employees compared to other community members. Mine employees generally lived in the community without their families, which was perceived to influence alcohol consumption and risky health behaviours including low condom use and sexual relations with multiple partners (Lightfoot et al., 2009). The study in South Africa also associated the structure of the male-dominated community and lack of recreational activities with boredom and increased alcohol consumption. Employment-related stress was perceived to influence rates of depression and suicide, affecting both women and men. Loneliness, boredom and vulnerability affected the mental well-being of wives of mine workers, which was exacerbated by a lack of locally available health services (Chenga & Cronjé, 2014).

Two studies explored the perceptions of an indigenous community living in proximity to gold and silver mining in Guatemala. The first explored perceived impacts of mining on community well-being and the second explored mechanisms utilised to overcome challenges related to well-being in the communities (Caxaj, Berman, Varcoe, et al., 2014; Caxaj, Berman, Ray, et al., 2014). Communities had strong connections to the land, spirituality and well-being despite 'community fragmentation' and interruption of peace and safety brought about by mining activity. Coping strategies in the form of resistance, maintaining cultural identity and spiritual connections enabled community members to improve their well-being (Caxaj, Berman, Ray, et al., 2014).

Socio-economic factors

Two studies explored female perceptions of well-being and reproductive health status in the context of iron ore mining in India. Women had few economic opportunities in the mining industry and coupled with a lack of institutional power over lost land to mining, had poor well-being status. Women who had lost land to mining also had poor education, less work participation and felt dependent on husbands. Women were also concerned about family breakdowns, dejection and neglect by husbands. Wives of mine workers were also concerned for their husbands' alcohol expenditure and resulting

financial distress (D'Souza et al., 2013b; D'Souza et al., 2011). The study in South Africa also reported on the impacts of a family member working in a mine and associated family disorganisation and breakdown (Chenga & Cronjé, 2014).

Strength of evidence

Quantitative

With reference to the quality assessment tool applied to each article, all addressed a clearly focused issue, used appropriate methods to answer research questions and provided clear descriptions of data collection and analysis. All studies set out to investigate the exposure of living near a mine community on a health or well-being outcome and considered the length of time residents lived in the community. Most of the articles accounted for occupational exposures and gave an account of the community composition. Methodological issues included potential sources of bias from recruitment methods – no study conducted a calculation to determine minimum sample size. There was potential recall bias when participants were asked to retrospectively list their movements to explore potential sources of malaria transmission (Berger et al., 2012). There was also a risk of bias pertaining to the sensitivity of HIV and STI disclosure, and recruitment bias if those most-at-risk were less likely to take part (Clift et al., 2003). One paper aimed to overcome self-reporting bias by using two-stage residual inclusion estimation techniques and multiple analyses (Saha et al., 2011). One study was funded by a mine company, which could potentially bias the results if the relationship with the authors is not clearly stated (Clift et al., 2003).

Qualitative

Articles inconsistently reported participant recruitment methods. However, purposive sampling for participants was common – village leaders often assisted in the identification of villages and recruitment of appropriate participants. Several villages within the mine community were often approached to provide a broader representation and sample size calculations were used on occasion to strengthen study rigour.

Four studies did not state whether they had received formal ethical approval for the study, but in one study, researchers spent time with the families to build rapport and trust before interviewing (D'Souza et al., 2011). In another study, a research protocol was sent to village leaders for community acceptance prior to data collection (Caxaj, Berman, Varcoe, et al., 2014). Use of pre-validated research tools was common and content of interview guides was defined. One study did not specify the methods for data analysis (Yelpaala & Ali, 2005).

Discussion

Cultural and environmental conditions

Several articles considered the social and cultural context within which communities were placed and how these factors may be exacerbated by the mining sector. Community opposition, violence and conflict regarding the influx of mining activity can contribute to poor health and well-being (Caxaj, Berman, Varcoe, et al., 2014; Chenga & Cronjé, 2014;

Holterman, 2014). Tiainen, Sairinen, and Novikov (2014) argued that the mining industry should address local tensions in the regions they operate in, and promote stable and prosperous development through strengthened engagement and communication with government and local authorities. It is important to consider the policies and regulations implemented by governments to ensure mining companies operate within certain standards, and to understand that a lack of good governance in mineral rich countries has implications for the public health outcomes of communities (Dupuy, 2014).

In this review, changes in land use following the introduction of mine activity was associated with loss of economic opportunities and changes in vector ecology, which has been reported elsewhere in the literature (Briceno-Leon, 2007; Hausermann et al., 2012). It is of particular importance to consider the long-term impacts on communities whose land has been affected by mine activity. Short-term local benefits of mining might not outweigh the costs associated with environmental degradation and regeneration following mine closure (Saha et al., 2011). It is important to consider how environmental changes can affect local flora and fauna with consequential effects on access to fruit, vegetables and traditional medicines, and the incidence of vector-transmitted and zoonotic diseases (Hausermann et al., 2012; Puppim de Oliveira & Ali, 2011). Environmental impacts of mining activity can also influence community well-being outcomes such as distress, sense of injustice and powerlessness, which often affects indigenous populations who have strong spiritual and cultural connectedness to their land (Albrecht et al., 2007; Caxaj, Berman, Varcoe, et al., 2014).

Women were disproportionately affected by a lack of employment opportunities in the articles reviewed (D'Souza et al., 2013a; Lightfoot et al., 2009). There is increasing evidence of the gendered impacts of mining and the need for improved research in this area (Jenkins, 2014). Miranda et al. highlighted the repercussions following mine closure in a community in Brazil; women who had lost their land and livelihoods to mining were left with few income-generating alternatives (2009). This was exacerbated by social vulnerability and a lack of female empowerment. Poor well-being can further impact on the ability to sustain livelihoods and overcome economic hardship (Holterman, 2014).

Social and community-level determinants

Mine activity can attract large amounts of people in search of job opportunities and improved lifestyles. Mining activity can lead to major population growth and, as evidenced in this review, changes in community health needs, which could add pressure upon the capacity of local public health services (Chenga & Cronjé, 2014; Puppim de Oliveira & Ali, 2011). Rapid population influx can lead to community tension and conflict, which can consequently lead to social isolation, feelings of confinement and a lack of community cohesion (Caxaj, Berman, Varcoe, et al., 2014; Clift et al., 2003; Gusmao, 1980). These issues have also been identified in high-income country mine settings (Mactaggart et al., 2016).

There was a pre-existing shortfall in health system capacity in several of the communities studied (D'Souza et al., 2013a; Miranda et al., 2009), which intensifies the pressure upon and the ability to respond to emerging health and well-being needs at a local level. Availability of local mental health services was also identified as a priority need in mining

communities. Mental health in LMICs is not an area of extensive research but there is evidence of mental health implications of mining activity internationally (Hossain et al., 2013; Lund, 2014).

In this review, lifestyle behaviours associated with mining activity included increased alcohol consumption and high-risk sexual behaviours, which were reportedly influenced by higher disposable income, shift-work and the absence of families in many male-dominated mining communities. These behaviours can contribute to the risk of domestic violence and transmission of STIs with potential spillover effects to the community (Baltazar et al., 2015; Eckhardt, Parrott, & Sprunger, 2015; Jenkins, 2014). Improved access to recreation and educational services could strengthen social cohesion and mitigate high-risk behaviours.

Mining and higher disposable incomes has been linked to greater accessibility of Western diets and consumption of unhealthy food which are risk factors for chronic disease (Robinson, 1985). Interventions to improve health outcomes have been implemented in several mine settings often following baseline surveys, and include improving access to health services, roll out of mass media campaigns and educational programmes (Kis, 2010; Rispel, Peltzer, Nkomo, & Molomo, 2010). However, to ensure sustainable and long-lasting improvements in health, it is imperative to understand the socio-cultural context and drivers of high-risk behaviours in these settings and how these factors change over time with mining activity in addition to conducting baseline surveys (Dawson & Homer, 2013).

Implications for public health and policy

Collaboration to address public health implications

Social injustice in mining communities is described as unequal social distribution of rewards, burdens and opportunities for life changing outcomes, and reflects conflicting priorities of the mining sector in rural communities (Colagiuri & Morrice, 2013). The literature in HICs describes the emergence of 'metagovernance' in mine settings where local government, who play a central role in community development, has to manage and navigate a relationship with powerful mining companies (Cheshire, Everingham, & Lawrence, 2014). In mine settings in LMICs, public–private partnerships (PPPs) are common and reflect the resource sector's ability to contribute towards social development and interest in improving the livelihoods of those living near mining activity; and reflect government's need for support in delivering quality health services and strengthened financial and logistical input (Thomason & Hancock, 2011). PPPs are strengthened through stakeholder engagement and communication to understand core issues facing a community and the necessary approaches required to address them.

If managed and planned effectively, the presence of mining activity near communities could have positive health and well-being implications and prevent social injustice. A study in Australia reported that pro-active engagement between a mining company and local community led to informed decision-making and improved investment outcomes in the regional economy, minimised anti-social behaviour and improved community welfare initiatives and opportunities (Basu, Hicks, Krivokapic-Skoko, & Sherley, 2015). Mining companies can work with local services to increase access to specialised services

or support health promotion and awareness initiatives (Dupuy, 2014). Tackling the Sustainable Development Goals, within which health, well-being and societal development objectives fall, should be a key consideration of the private sector. The ability to invest in and overcome cross-cutting issues will require that the mining sector engage with multiple stakeholders to ensure investments are evidence-based and sustainable (World Economic Forum, 2015). Effective regulation, communication and partnerships are keys to ensure that the profitable and powerful mining sector does not outweigh the needs of rural communities.

Monitoring and mitigating public health impacts

The literature reveals a number of interventions and programmes implemented in mining communities to address health issues, particularly infectious diseases and education programmes (Dawson & Homer, 2013; Dupuy, 2014). This review, however, strengthens the evidence base of broader health and well-being outcomes and how their determinants are influenced by mine activity.

It is imperative to consider the broader context within which mining communities reside. This review revealed the multi-layered, systemic factors that affect outcomes and highlights the need for an approach that considers social determinants of health and the placing of mining activity within communities that are often characterised by poverty, unemployment and lack of services.

Monitoring and responding to the mid- and longer-term impacts of mining on communities is pertinent in enabling sustainable development beyond the lifecycle of the mine, and cannot be determined using traditional health impact assessments or baseline studies. Health needs assessments and other community-based tools that employ the social determinants of health framework to measure health issues are becoming more relevant in mine settings (Korfmacher, Elam, Gray, Haynes, & Hughes, 2014; Smith, Adams, & Bushell, 2010). Indicators for well-being at an individual and community level should be incorporated into community assessment of mining impacts. In order to meet the targets of the Sustainable Development Goals, a greater focus on developing tools with broader perspectives to assess impacts and outcomes is necessary (United Nations, 2015).

Limitations

This review aimed to capture the broader determinants of health, but in doing so, identified methodologically diverse studies. Some studies may have been excluded because the review was limited to including those written in English; and grey literature was not captured, so industry-commissioned reports on community health assessments would have been missed. Pre-existing factors that affect health and well-being in mining communities, such as food insecurity or poor access to health services, for example, were not always reported in the articles but may have interacted with the health or well-being outcome and its association with mining activity. The strength of evidence in this review is compromised due to the inclusion of articles with modest quality appraisal outcomes. However, this review serves as an exploratory synthesis of current available literature, and highlights the opportunities for improved primary data collection to strengthen the evidence base.

Conclusion

There is growing international focus on the longer term, indirect health impacts of mining on nearby communities in mineral-rich countries, evidenced by the push for better legislation of mining companies to mitigate social, environmental and health impacts; responsibility of governments to ensure sustainable development of their communities and involvement of scientific researchers in strengthening the evidence base (Dupuy, 2014). This review demonstrated that although communities often co-existed with varied types and stages of mine activity, similar patterns of health or well-being outcomes were reportedly associated with mining's influence on environmental degradation, livelihoods, high-risk health behaviours and the socio-political climate. The health and well-being of a population is inextricably linked to economic growth, and the commitment of the mining sector to socially responsible actions that are evidence-based and long-lasting is imperative to sustain such growth (Tiainen et al., 2014). Governments are responsible for the legislation, monitoring and regulation of social and cultural issues arising from mining and play an integral role in responding to the health and well-being needs of communities through effective policy-making and resource allocation. This review highlighted the need for rigorous and transparent monitoring of public health impacts with particular focus on the gendered impacts of mining and mental health implications.

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Part II: Examining health and wellbeing outcomes in Coal Seam Gas mine settings

4: Exploring the determinants of health and wellbeing in communities living in proximity to coal seam gas developments in regional Queensland

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Exploring the determinants of health and wellbeing in communities living in proximity to coal seam gas developments in regional Queensland

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Abstract

Background: There is some concern that coal seam gas mining may affect health and wellbeing through changes in social determinants such as living and working conditions, local economy and the environment. The onward impact of these conditions on health and wellbeing is often not monitored to the same degree as direct environmental health impacts in the mining context, but merits attention. This study reports on the findings from a recurrent theme that emerged from analysis of the qualitative component of a comprehensive Health Needs Assessment (HNA) conducted in regional Queensland: that health and wellbeing of communities was reportedly affected by nearby coal seam gas (CSG) development beyond direct environmental impacts.

Methods: Qualitative analysis was initially completed using the Framework Method to explore key themes from 11 focus group discussions, 19 in-depth interviews, and 45 key informant interviews with health and wellbeing service providers and community members. A key theme emerged from the analysis that forms the basis of this paper. This study is part of a larger comprehensive HNA involving qualitative and quantitative data collection to explore the health and wellbeing needs of three communities living in proximity to CSG development in regional Queensland, Australia.

Results: Communities faced social, economic and environmental impacts from the rapid growth of CSG development, which were perceived to have direct and indirect effects on individual lifestyle factors such as alcohol and drug abuse, family relationships, social capital and mental health; and community-level factors including social connectedness, civic engagement and trust.

Conclusions: Outer regional communities discussed the effects of mining activity on the fabric of their town and community, whereas the inner regional community that had a longer history of industrial activity discussed the impacts on families and individual health and wellbeing. The findings from this study may inform future health service planning in regions affected by CSG in the development /construction phase and provide the mining sector in regional areas with evidence from which to develop social responsibility programs that encompass health, social, economic and environmental assessments that more accurately reflect the needs of the affected communities.

Keywords: Health needs assessment, Wellbeing, Rural health, Social determinants of health

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Background

Regional Queensland has been a focus of Australia's coal seam gas (CSG) development over the past decade. CSG is a natural gas that is extracted via wells drilled in to coal seams, and involves exploration of land for CSG deposits, production, transportation and distribution. Significant CSG deposits are found in Canada, China, USA, and Australia, and were first explored in regional Queensland in the late 1970's, which led to commercial production from 2006. CSG is utilised domestically, but a proportion is converted in to liquefied natural gas (LNG) and exported internationally off the Queensland coast [1]. Growth of the CSG industry and the relatively large geographic span of exploration and extraction means that 'mining activity' often co-exists with primary production of some of Queensland's most diverse agricultural land, with positive and negative implications [1]. There is anecdotal concern that the environmental, economical and social change in the community brought about by the labour intensive development stage of CSG mining can have implications for health and wellbeing [2].

CSG development and public health

There is rich evidence of potential public health implications of extracting conventional resources like coal, diamond and oil internationally [3–5]. However, with the recent emergence of CSG development, there is less known of the potential health impacts in communities as they undergo changes in their environment [6–9]. Broader social determinants of health, like changes in working conditions, community networks or access to services could have serious implications for health and wellbeing in mining or resource settings, and are less understood [2, 10]. There is anecdotal concern that CSG development may have indirect and long-term impacts on the health of communities in which they operate but the scientific evidence is lacking [10].

Growth of CSG development has been rapid, in that approximately 1634 wells have been drilled between 2013 and 2014 alone, and reserves were being discovered at an unprecedented rate. Regional Queensland represents more than 90% of the total gas produced in the state [11]. CSG extraction often occurs on active farms and grazing properties, involving direct interaction with farmers and local community members, and there is some evidence that CSG development can bring about stress and anxiety [1]. There is also a huge demand for labour in the early stages of CSG development; these roles cannot be completely filled locally and thus large workforces often temporarily reside in 'host communities'. Population influx and influence on community structure can impact social capital through reduced social bonds and networks and there is concern for increased risky lifestyle behaviours like drug use and alcoholism that spill over to the communities from the mine workforce [12, 13].

The following paper forms part of a larger Health Needs Assessment (HNA) research project conducted in regions were CSG development was occurring. The purpose of the larger project was not to specifically identify the direct impacts of mining activity, but rather to assess broader population-level health and wellbeing issues in the communities and explore trends and possible determinants. Health is defined as 'a state of complete physical, mental and social wellbeing and not merely the absence of disease or infirmity' [14]. In conjunction, wellbeing is used to describe elements of life that impact on its quality, determining an individual's level of personal satisfaction, happiness and psychological health. Wellbeing may also include community-level factors, such as satisfaction with one's environment, and the level of social connectedness and belonging. This study reports on the findings from a recurring theme that emerged from the qualitative component of the analysis: that health and wellbeing needs were associated with the development stage of nearby CSG mining.

The cyclical nature of mining and the unpredictability of its activity lifespan can have serious implications for surrounding communities and presents governments with the challenge of responding efficiently and effectively to evolving needs. A deeper understanding of the health and wellbeing context in mining communities is pertinent to enable community and health services to prepare for the impacts of social, environmental and economic fluctuations that might come with a mining boom or bust.

Methods

Theoretical framework: Health needs assessment

This study utilised an HNA model to investigate the communities of interest. HNAs are a systematic tool to explore and identify inequalities and health priorities and are useful in identifying health gaps and trends [15]. An HNA starts with a *population* rather than a project and underpinning the HNA approach is the social determinants of health framework, which describes the complex, multi-layered influencing factors, which can impact the health of an individual [15]. These factors include individual lifestyle factors, social and community networks, and the broader socio-economic, cultural and environmental conditions within which one lives. Inclusion of wellbeing indicators at an individual and community level give an indication of quality of life and satisfaction with one's living environment [16].

Study setting

The study was conducted in three local government areas (LGAs): A, B and C in regional Queensland,

Australia during June and December 2014. The major township of LGA A, which is furthest from Queensland's capital city of Brisbane, de-identified as Region 1, is classified as outer regional. LGA B's two major townships, Region 2 and 3 are defined as inner and outer; and LGA C's major township, Region 4, is defined as inner regional, according to the Accessibility/Remoteness Index of Australia (ARIA) (Table 1) [17]. ARIA criteria determines remoteness by measuring road distance to service centres, and is compared to 'unrestricted' accessibility in major cities. Geographical areas are categorised as major cities, inner regional, outer regional, remote or very remote. [18] ARIA is deemed an appropriate index for this research given it explores implications of the rural context and social determinants of health.

Mining activity in all of the LGAs was in the development phase during data collection in 2014, which brought a high demand for labour, mostly in the form of non-resident workers, or fly-in-fly-out (FIFO) and drive-in-drive-out (DIDO) employees who resided in the communities whilst on shift. LGA B experienced an increase in non-resident population by 9100 during 2015, compared with 5120 in LGA A. The number of businesses increased from 495 in Region 2 in 2012 to 1255 in 2013, and to 1166 in 2014. In Region 1 a similar pattern was seen but on a smaller scale (435, 790 and 755). At the time of publication, however, mining construction has drawn to a close, leading to an operational phase and a marked decrease in housing and rental prices following the out flux of FIFO and DIDO workforce.

Study design

Qualitative research methodology was utilised to explore the health and wellbeing needs of the communities of interest. This method was part of a larger mixed-method cross-sectional study based on the five principles of HNAs as defined by the National Institute for Health and Care Excellence (Fig. 1) [15]. The research team is preparing a further manuscript that presents quantitative results from the HNA and aims to compare and contrast with qualitative findings.

Data collection tools

Qualitative methods included In-Depth Interviews (IDIs), Focus Group Discussions (FGDs), and workshops with community members. Key informant interviews (KII) were also held with service providers. Development and implementation of the overall HNA was overseen by a steering committee of representatives from academia, government and the mining sector. A community champion provided local-level knowledge and support during participant recruitment and implementation. The qualitative findings for this paper are from the first two steps of the HNA framework. For the full HNA report with comprehensive methodology, refer to: http://www.wesleyresearch.org.au/wellbeing/.

Theme content for the qualitative research tools was originally developed by the qualitative research team following review of the literature and discussion with both the steering committee and local community contacts. Theme lists were developed and included perceptions of health and wellbeing at a community (IDI, FGD, KII) and service level (KII); multi-sectoral interaction and support (KII); barriers and facilitators to achieving good health (all); influences on good health (all) and perceptions of how to engage the community in health and wellbeing activities (all). FGD theme lists were further developed from preliminary findings from the quantitative survey and KIIs; for example, few survey respondents answered the open-ended questions about health and wellbeing priorities and so the FGD questions were adapted to include an emphasis on exploring the prioritisation of needs.

For the workshops, participants were asked to list and rank key health and wellbeing needs and discuss a chosen photo that represented health or wellbeing in the community. Questions were open-ended and participants were encouraged to talk about topics in their own

Table 1 Demographic and economic summaries of four study sites in regional Queensland, 2014

	Region 1	Region 2 & 3	Region 4
Demographics			
ARIA classification	Outer regional[a]	Inner and outer regional	Inner regional[b]
LGA Land Area	58,800 km^2	38,000 km^2	10,500 km^2
Population	14,000	34,000	66,000
% aged <55 years	76%	74.5%[c]	80%
Economic environment			
Main industries	Mining and agriculture	Agriculture, mining and manufacturing	Mining and manufacturing
Median family income	$1444/week	$1294/week	$1941/week

[a]Significantly restricted accessibility to goods, services and opportunities for social interaction
[b]Some restricted accessibility to goods, services and opportunities for social interaction
[c]On average, population slightly older than the total Queensland population [37]
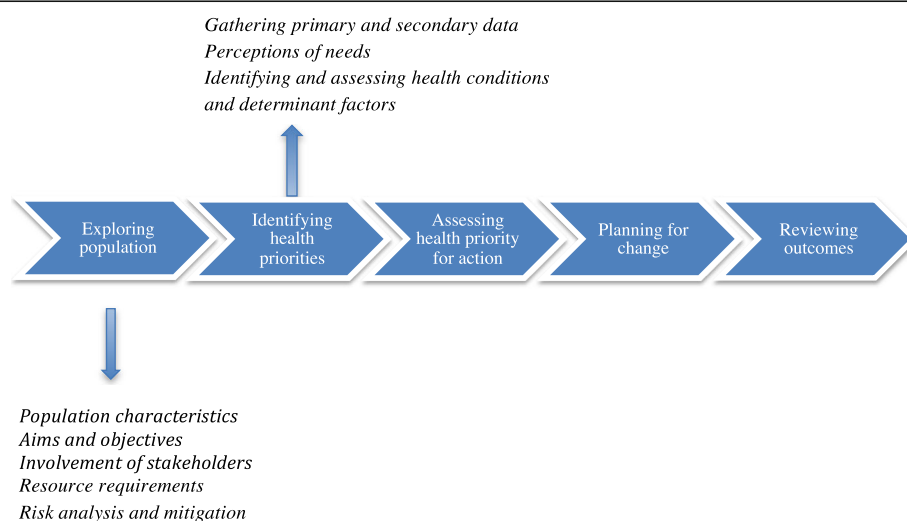
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Gathering primary and secondary data
Perceptions of needs
Identifying and assessing health conditions
and determinant factors

| Exploring population | Identifying health priorities | Assessing health priority for action | Planning for change | Reviewing outcomes |

Population characteristics
Aims and objectives
Involvement of stakeholders
Resource requirements
Risk analysis and mitigation

Fig. 1 A simplified HNA process describing the first two stages used in this study. *Adapted from Cavanagh and Chadwick* [14]

terms. Continual reflection and debriefing occurred within the research team following each interview. Field notes assisted with reflexivity of the experiences.

Recruitment of study participants

1. **Stakeholder analysis and consultation with service providers and community leaders**
   A detailed mapping process identified service providers, health authorities, local governments and key community leaders in the health and community sector. Stakeholders were informed about the research project and invited to participate in a KII. Additional informants were recruited via snowball sampling and through attendance at local interagency meetings. Only the resident population was contacted for research in this study.

2. **Community consultation with the general population**
   An expression of interest form was attached to the surveys sent out to a random sample of adults (>18 years of age) in each LGA (total = 6000) as part of the larger mixed method study. Those interested in further participation were invited to attend a FGD in their local community or an IDI over the phone. When there was clear indication of specific non-responding groups (e.g. young adults) to the survey or expression of interest, targeted stratified purposive sampling was utilised. Key informants assisted with promotion of research through email mail-outs and distribution of flyers. Middle- to older-aged community members were more likely to participate in the community FGDs and overall, females were more likely to be involved compared to males (Table 2).

Analysis

Qualitative analysis was initially completed using the Framework Method to explore key themes from the FGD, IDI, KII and workshop transcriptions. The Framework Method provides an initial structure whereby the researcher can systematically reduce the data in order to analyse it. This Framework Method was guided by the social determinants of health and social capital frameworks (Fig. 2). In the first instance the first and second author analysed the data for the comprehensive HNA. The first author then coded the data again based on the emerging theme of public health and mining activity, which was then independently verified by the second author. NVivo Qualitative Software was used to analyse the data. Findings from the KIIs, IDIs and FGDs were triangulated against each other to confirm and verify findings.

Ethical considerations

This study was granted ethics approval by the Wesley Hospital Human Research Ethics Committee, (reference number 1410). All participants were given verbal introduction to the study and provided with an information sheet to read. Participants were asked to sign a consent form if they wanted to proceed with the interviews and FGDs. Pseudonyms have been used and all other identifiable information removed for data storage and reporting.

Results

Communities in regional Queensland faced social, economic and environmental impacts during the development phase of the CSG mine cycle. These factors were perceived to have direct and indirect effects on individual lifestyle factors such as alcohol and drug abuse,

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Table 2 Qualitative primary research involved 45 key informant interviews with health and community service providers; and 11 focus group discussions and 19 individual in-depth interviews with community members across the four study sites

Region	Key informant interviews (KII) *Organisations (n)*	Focus group discussions (FGD) *Community members (n)*	Individual interviews (IDI) *Community members (n)*
Region 1	Primary care and community services (5)	Male group (3)	Male (1)
	Hospitals (4)	Female group (10)	Females (4)
	Specialised health and community services (3)	Mixed group (4; 1 male, 3 females)	
	Public health services (2)		
Regions 2&3	Specialised health and community services (11)	Male group (6)	Male (1)
	Primary care and community health services (4)	Female group (6)	Females (2)
		Mixed group (6; 1 male, 5 females)	
		Mixed group (9; 2 males, 7 females)	
Region 4	Specialised health and community services (10)	Male group (4)	Males (5)
	Primary care and community health services (3)	Female group (3)	Females (6)
	Hospitals (2)	Female group (4)	
	Government (1)	Mixed group (4; 1 male, 3 females)	
TOTAL	45	59	19

family relationships, social capital and mental health; and community-level factors including social connectedness and trust. Participants highlighted concern for sustained impacts on health and wellbeing, including how the community would cope in the 'bust' period; whether the community would regain its identity; how children would grow up following family-related stress during the current mining 'boom'; and how young ex-mine employees would respond to reduced salaries outside of the mining sector.

Socio-economic and environmental conditions

During the study period, participants in regions 1 and 4 were concerned with increasing cost of services in the
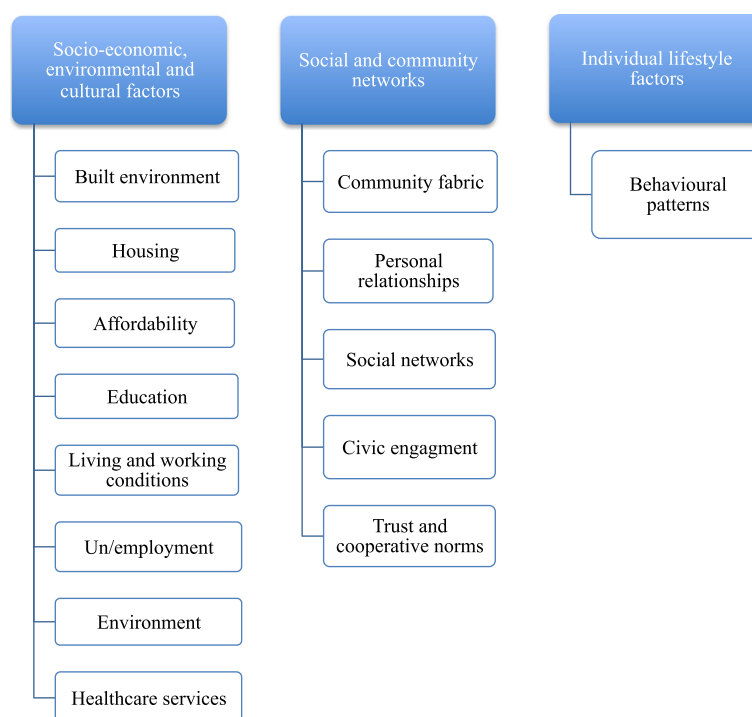
Fig. 2 The Framework Method was developed with reference to the social determinants of health model and provided the authors with an initial structure to systematically reduce and analyse the data

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community and subsequent stress and outmigration, and the perceived burgeoning division between those who benefited economically from the CSG development, and those who didn't.

Residents in all regions commented on development of built infrastructure - most noticeably the increased availability of food outlets, liquor stores and takeaway restaurants. Availability of these options was perceived to cater for the increase in shift workers and temporary residents. Participants were concerned about the increased availability of these services in the community, and thought that young families and time-poor adults might also take advantage of convenience foods, which are often less healthy than home-cooked meals. Air travel was also an issue due to the high costs of airfares during periods when FIFO employment was at its busiest. There was concern for affordability of airfares for both leisure and to attend health and emergency medical appointments in major cities. Participants also commented on the increased number of sporting groups and clubs, but felt they were underutilised due to time constraints of shift workers. Several participants commented on the looming mining downturn and the effects this would have on demand for social and community services that had opened during the 'boom' to meet population growth.

Some young men with higher disposable salaries, both community members who were employed in the CSG industry and those who lived temporarily in the host communities, were often associated with antisocial conduct including alcohol-related behaviour and spending less time with family. This was pertinent in region 4. One participant was concerned for the lifestyle of some shift workers:

> *"They come home, they spend an hour, have a shower and then they go to sleep because they start again the day after. And again, at the same time, link that to a low level of education and a low level of understanding, and self-awareness... drinking, constantly being with men, and having a lot of disposable income."* Service provider, specialised community services, region 4

Participants were concerned for spill over effects in the community and what impact the short-term contracts and uncertainty in employment would have on those who had moved to the community with their families, particularly in regions 1–3. A lack of employment opportunities following the mine downturn was predicted and there was concern for the community's ability to cope in this situation. One participant commented on the influx of people who sought work in the mining sector and remained in the community despite being unsuccessful:

> *"It normally peaks, it happens in these times. We have a lot of family breakdowns. It's normally because you know... A lot of people are saying we are an industrial city look what is happening. So we get these families who arrive thinking they will be getting these marvellous jobs on a $100,000 a year they get there with their family and realise they can't afford the rent and there is no work for them. The family breaks down... the husband starts drinking... Drugs as well."* Service provider, community service, region 4

CSG exploration and drilling occurred on private land and there was concern related to the disruption caused by flares, and the effects of CSG on water bores. There were issues raised relating to the environmental effects on fresh water sources in regions 2–4, which deterred participants from fishing for both recreation and consumption. CSG infrastructure also caused increased noise pollution and traffic, which affected community satisfaction with their environment and perceptions of safety.

High rental prices and poor housing availability was linked to the labour-intensive development stages and subsequent population growth, and forced many community members to move elsewhere, as summarised by this participant:

> *"Community member (CM): There has been a shift in the community in the last few years around [region 1]... there's been a lot around wellbeing and affordability too. I think there has been a lot of pressure on that just with the CSG industry in [region 1]; it's probably put a bit of pressure on some people's wellbeing, affordability wise... Probably not us specifically, but I have seen a lot of change around that in the community."*
>
> *Interviewer (I): OK and how has that impacted on people's wellbeing would you say?*
>
> *CM: I would say, stress.*
>
> *I: OK. And what are people doing?*
>
> *CM: "They are moving. They are leaving."* Community member, region 1

Housing issues related to both the mining 'boom and bust' were regularly commented on across all regions. Participants commented on the surge of houses and hotels built to meet the demand during the mining

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boom. However, increased cost of living and housing prices strained the ability of social services to meet housing demand. Participants felt that prices had started to 'return to normal' leading in to the operational phase of CSG. Conversely, there was then great concern for the surplus of housing and the lack of planning by council, as described by this community member during the downturn:

> 'The councils - they're to blame - they're building it up all the time - how it's going to be the greatest thing to happen to [region 3] and then they... Look at it now they've all left town, it was only going to be short term anyhow until they built everything and it's all been built. There are suburbs out here with houses and houses and there's no one in them but the fact is they're still building them on the flood zones.'
> Community member, region 3

Service providers and community members discussed the effects of living and working conditions associated with the mining sector in all regions. There was concern for the impact of shift work on families and social behaviour of mine employees in the community. Service providers commented on a marked increase in family disconnection, unbalanced lifestyles, stress and a lack of social networks for newcomers to the communities. These issues were particularly pertinent for the inner regional area 4:

> "Mental health is an increasing issue for all regional communities and I think here in particular we have problems with isolation because families move here for work and they aren't supported; or families move here and the husbands are out, or they go out for a week or two weeks at a time, and leave what is essentially a single family, a single parent family." Service provider, community service, region 4

Community members and service providers commented on relationships between male mining employees and their children and felt that a lack of time spent together due to long working hours could have detrimental effects on child development. Long hours and shift work also placed pressure on mothers to carry out dual responsibilities. These issues were traded off against higher wages afforded to shift workers and the benefits of having financial security.

> "Shift work. I think that there is some comorbidities that develop amongst the communities that is very much related to long hours, separation from family, unnatural working hours... Even though people who do continual shift work begin to see that as normal,

> in actual fact it deters that negative impact on us as you know, people. I think you see stress, depression, obesity, diabetes, and dysfunctional relationships."
> Service provider, tertiary services, region 4

Individual lifestyle factors

Linked to an increase in a male-dominated environment and higher disposable incomes, participants perceived an excessive use of illicit drugs and alcohol in the community. References to drugs and alcohol were particularly salient in region 4, with concerns for the increased availability of drugs in regional communities:

> "I: What would be the most pressing health need for the community or for people in your area?"
>
> CM: Probably the drinking would be a big thing.
>
> I: The drinking - ok - and any other things?
>
> CM: Ah in some particular mining camps the drugs are getting in there now.
>
> I: And is that having much sort of spill out into the community?
>
> CM: "From time to time there is and there has been an increase in the drug raids happening in and around town due to mining people getting hold, of bringing in drugs and then selling them." Community member, region 4

All communities were concerned for the effects of excessive drug and alcohol consumption among young mine employees. Service providers in region 4 linked the sudden demand for domestic violence support services to the behaviours of partners' who worked in the mine industry. Participants in region 4 mentioned anti-social behaviour in the town centre and insecurity felt by female residents alone in the town at night. It was perceived that these behaviours in the community were unwelcoming to other newcomers outside of the mine workforce.

> "The other thing some of the local ones, I won't say all of them because I know they all don't do it but some of the local ones who have scored jobs in the industry have been on outrageous wages and what are they doing with those wages, I only have to go I won't tell you where I have to go to buy cocaine and methamphetamine and whatever, but it is so easy to get and these people have a disposable income and they're young they've got no common sense that they're not old enough to have that yet."
> Community member, region 2

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Residents in region 4 cited the influx of the mine workforce in pubs and high purchasing rates of alcohol in the community, particularly during poor weather when employees were unable to work. It was felt that workers had little else to do in the community. Participants in regions 2 and 4 felt that the traditional, family-oriented pub culture of the community had dissipated because of expensive prices and over-crowding by the mine workforce. In region 4, participants commented on the cultural changes and the lack of social nightlife in the main town:

"I think probably there are just a number of groups and they interact at different times out of need. I think that springs back to the basic social lifestyle, which is around shift work. Like you know, this town it's really busy, you can go in at 9'o clock on a Friday and everyone is just about disappeared apart from the nightclubs. You know, it's just an unspoken rule because people are up travelling at about 3.30 am/ 4am. So, because of that, it doesn't evoke community as much. People aren't sitting around until late at night, just enjoying themselves down town because people have gone." Service provider, tertiary services, region 4

Social capital and community networks

Communities in each region experienced rapid population growth during the study period. Several references were made to the transient nature of the population – interstate, multi-state and overseas migration led to an impact on community culture, particularly because of the impermanent nature of newcomers and contrast with more traditional and regional community values. One participant recalls the traditional clothing often worn by country Australians, which was associated with farming and agricultural lifestyles, and how this is less prevalent in the community now.

"There is a change in the values. And there is a lower density of Akubra hats and moleskin [trousers] as you go down the street; it's more reflective gear and every second vehicle has a flag on it. And that's a whole different culture to what was here." Community member, region 1

Participants discussed the impact of population growth and CSG related infrastructure on social isolation in regions 1–3. Residents withdrew from services in town because of the changing nature, and this was a particular concern given that many residents lived on rural farms with few socialising opportunities outside of their visits to town.

"I think too, with the influx of the gas, you know we call them 'glow worms' - with the big bright shirts, they are everywhere you go in the coffee shops, in the restaurants, everywhere you go. You walk down the street and the vehicles with their little flags. You think 'ohhh gosh,' just from a visual point of view, that just impacts. And the traffic got a lot more. I mean there are positive and there are negatives, but from a community point of view the ones that have been here longer term have probably withdrawn from the services, they don't feel so connected. Like people can say oh it's not the same place I moved to." Service provider, specialised services, region 1

Long-term residents felt that newcomers did not want to contribute to the community. Conversely, newcomers felt isolated and some felt they weren't welcomed in the 'cliquey' town. One participant commented on feeling unwelcome in the community due to temporary residence on a street with other FIFO employees.

"Being isolated as a worker like I'm a – they call workers like myself a townie. A townie is somebody who works in town, they're here for 3-5 years usually or shorter and I'm actually not part of the community, so some community events some church events they don't always make workers like myself feel particularly welcome because they know they're only here for a short period of time. So that's difficult - a bit of a cliquey town. There's lots of wealthy land owners as well as workers in town... that probably comes back to isolation and not having sort of a connection to this community because they don't have family." Community member, region 1

Newcomers were often described as transient people who were 'coming for the economy with no intention to stay'. Community members in region 4 mentioned the under-utilised cemetery as an example of the few people who stayed permanently to retire and live the rest of their life in the region.

Participants in region 1 linked poor community well-being to inadequate engagement and communication with the mining sector; Participants were also concerned for the level of community reliance on the mining sector. They felt that the relationship between community members and the sector could be improved, as described by these participants:

"CM 1: You know so we're a corporate town, we've been 'corporatised' and now I think people are getting it in their head that they're de-culturising and that if the town wants something, well the resource company will fork out the money and we'll just leave it up to

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them and I think a lot of the young people are seeing that. They're seeing that the school - you don't have to work for it. Yeah that's right the money will just come from them. You're not seeing, like I was very offended to see those signs on the school on every side of the school there's a [mining company] sign and I was thinking now hang on when the brothel comes to town, are they going to be allowed to sponsor the school and put their signs up and what about the hundreds and hundreds of parents over the years that have contributed to that school so where's their name around the oval."

I: I'm just trying to make sure we add it to this, what's the wellbeing need there?

CM 1: "To keep more community engagement."
Community members, region 2

Discussion

The findings in this study support anecdotal evidence of broader health concerns arising from nearby CSG development beyond direct physical health impacts. Communities in this study perceived there to be both direct and indirect impacts of CSG development at both an individual and community level. Outer regional communities (regions 1–3) discussed the effects of mining activity on the fabric of their town and community, whereas the inner regional community (region 4) that had a longer history of industrial activity discussed the impacts on families and individual health and wellbeing. Region 1 is much larger than regions 2–4 but with a much smaller population, which could explain the prominence of community-level health and wellbeing impacts of mining. Region 4 had a greater transient and a younger population, which could explain the focus on individual-level health wellbeing needs [19]. Regions 1–3 were predominantly agricultural regions, which could explain why community members were concerned for the stages following construction, when the population would decrease as quickly as it increased, along with employment opportunities and demand for services. Region 1–3 may be more sensitive to the impacts of CSG development because they are smaller and less developed than region 4. The density and geographical size of the community and its previous experience with mining or other industries is predicted to influence the magnitude of impacts felt [20].

Socio-economic and environmental conditions

The Queensland Government described CSG and LNG development as a 'once in a generation opportunity providing jobs, energy security and prosperity for citizens' [21]. This study demonstrated how the stage of mining activity and subsequent local economic fluctuations affected the social and environmental fabric, which in turn had consequences for health and wellbeing needs at individual and community levels. The 'rapid' nature of CSG development is perhaps a reflection of the labour-intensive development stages, and the short-term impacts this had on the community. It would be valuable to study the effects on health and wellbeing during the consequent stages of mining, to ascertain if the results from this study are unique to the development/pre-construction phase.

A key source of economy for regional Queensland is farming and agriculture. CSG activity commonly occurs on active farms and grazing properties which provides increased opportunity for human interaction and conflict [1]. In the study sites and in the wider literature, CSG development was perceived to disproportionately affect farmers [22]. CSG development involves large water supply usage, environmental disruption and overlap with existing farmland. These conditions could contribute to financial and environmental concerns and influence stress and anxiety levels in an already vulnerable population [23]. Apprehension related to the increased cost of living and uncertainty was thought to force residents out of the communities in search for more affordable living. Economic insecurity can negatively affect mental health [24]. Local mental health services in mining-affected communities need to be aware of the potential triggers during 'boom' periods in order to effectively target services, and monitor and respond to needs.

During the study period, mining communities in regional Queensland experienced significant changes to the built environment and natural landscape, including rapid growth of takeaway and fast food outlets to meet population demands. The public health implications relating to the marked increase in these services is a concern, considering the higher rates of overweight and obesity in rural areas compared to major cities [19]. Increased availability of fast food and takeaway outlets is linked to increased prevalence of obesity in young Australian adults [25]. CSG development utilises a large amount of land due to the multitude of dispersed gas wells, difficult road access, pipelines, and processing plants and dams [1]. In concentrated community centres, this has led to concerns around traffic, volume of activity and destruction to the natural environment, impacting on community wellbeing. Local government is responsible for planning and managing such changes, but unforeseen impacts of the fast-growing and new industry may have contributed to negative community perceptions. Ex-gas mining communities in the US have been branded as 'ghost towns' and 'contaminated communities', reflecting the exodus of people following the mine downturn and little incentive to stay in such

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altered environments [26]. Evidence-informed planning and communication between local government, mining companies and the public is integral to ensure that long-term effects in the community are mitigated.

Living and working conditions

Social conflict, substance abuse and domestic violence has been linked to the social 'costs' of CSG development and are often considered tertiary socio-economic impacts [12]. These issues were key concerns in the study regions, particularly the social impacts of shift work on families and partners. A lack of understanding of the duration of mine activity led to some tension between longer-term community members and the temporary residents who arrived to work for the mining companies. Some temporary residents felt isolated and unwelcome, feelings of which can lead to poor health and wellbeing and a lack of community cohesion [23].

Individual lifestyle factors

The communities were concerned that working conditions, particularly for young males, led to anti-social behaviour in the community and excessive drug and alcohol abuse. These risky lifestyle behaviours can have significant impacts on mental health and long-term chronic diseases like lung cancer and liver disease. The working conditions of mine employees and potential for risky lifestyle beahviours is often referred to as a socio-economic product of the 'boom town effect' [12, 27]. There has been little research on the implications of CSG development on women but communities in this study were concerned for the impact of working conditions on families and the effects of social isolation on women. There was an identified need for improved social services to support women in these situations.

Social capital and community networks

Social capital represents social connections and the benefits they generate. Social capital can be sourced at an individual (e.g. family support) or wider collective level (e.g. volunteering) [28]. The framework used in the analysis demonstrated the link between CSG development and community fabric, neighbourhood interactions, community satisfaction, trust and cooperative norms.

It was important to community members to understand what was happening in their communities. As CSG is a relatively new industry there was significant uncertainty and anxiety around the unknown effects. Brashier [2011] stated that community reaction to mining development spans four stages: enthusiasm in the initial stages; followed by uncertainty; then panic and finally, adaptation [29]. The term 'solastalgia' has been coined to describe the melancholy felt following the unwelcome change in one's community and is often used

in the CSG development context [30]. At a community level, there is a responsibility of local government to provide evidence, transparency and awareness around the CSG mining process to mitigate negative reactions. It is possible that perceived impacts of CSG development on health and wellbeing may reflect an unavailability of reliable sources, inadequate community consultation and a possible reliance on media for information.

'Community resilience' is a term often used in the context of mining and regional communities, and it is even quoted as a local government objective [31]. Resilience can be defined as responding to changes in one's community with a view to reinstate, maintain and enhance community wellbeing [31]. A key focus of research in this context is being able to provide evidence that supports communities in preparing for the local effects of CSG development rather that experiencing uncertainty and disruption.

Public health and policy implications

Extraction of CSG can occur alongside communities for over a decade. There is obvious concern that a lack of assessment of ongoing and cumulative health impacts leads to mining projects being carried out without a thorough understanding of the consequences for host communities [8]. In Australia, this is evidenced by submissions of concern by leading public health organisations to the NSW independent enquiry and commentaries from prominent academics in the field on NSW CSG development in 2013 [7, 8, 32, 33]. There is currently a lack of cohesion in identifying what health and wellbeing outcomes should be considered when examining population-level impacts of mining, and which stakeholders should be held accountable. Research demonstrates that impacts of CSG development stages relate to social, economic and environmental factors that can affect an individual beyond the state of physical health [12, 34]. Furthermore, evidence points to community—level health and wellbeing impacts that, although harder to measure due to the myriad of possible causes, merit attention (Table 3).

There is still much debate and uncertainty around the best tools to measure health and wellbeing impacts in CSG development regions. In the health sector, proxies to determine health impacts include assessing hospitalisation rates and access to health services [6]. Historically, the potential impacts of mining was assessed through health, environmental and/or social impact assessments. According to the International Finance Corporation guidelines, a Health Impact Assessment (HIA) involves the collection and evaluation of baseline data and subsequent risk assessment, and the outcome should include an action plan that addresses the risks

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Table 3 Summary of key findings and recommendations

Key Findings	Context	Recommendation
CSG mining during development stage has implications for the social determinants of health (SDoH) and health and wellbeing outcomes	Direct and indirect impacts both at individual and community level	Potential impacts of CSG mining could incorporate standardised assessment of SDoH at individual and community level, with acknowledgment that setting (e.g. level of remoteness can affect magnitude of outcomes; avoid 'one size fits all' approach
Density and remoteness affects magnitude and type of impacts felt	Inner regional experienced more individual level impacts vs outer regional which experienced more community level impacts	
Effects on health and wellbeing may vary with the stages of CSG mining	Lack of assessment of ongoing and cumulative health impacts through the stages	Monitor health and wellbeing over time to enable evidence-informed planning and response to fluctuating demands
Lack of community understanding of CSG timeline and local impacts	Insecurity, lack of trust and concern for the future following completion of CSG mining could exacerbate negative perceptions	Communication of short and long term impacts is imperative alongside effective mitigation and planning
Population level studies are effective to highlight opportunities for targeted research	Groups that might be disproportionately affected by CSG included farmers, young families and women	Targeted research to determine what services are in place or required to meet temporary or longer term needs
Measuring and responding to the impacts of a mining project is not the responsibility of the mining company alone	Assessments should focus on the population, not the project, in order to uncover health and wellbeing outcomes that may not have otherwise been captured	A partnership approach involving local government, communities, research institutes, mining companies and social and health organisations is imperative

previously identified and a monitoring and evaluation strategy [35]. HIAs should incorporate tools to capture broader health and wellbeing outcomes under the social determinants of health framework, and outcomes should be monitored at several points throughout the mining lifecycle.

This study highlights the importance of gaining community views to understand broader health implications of CSG development – the study revealed interesting associations between mining activity and both individual and community level wellbeing. The findings demonstrate the importance of engaging with communities to identify issues throughout the mine cycle, and to use primary qualitative research to gain a deeper understanding of some of the drivers of poor health and wellbeing.

The prevalence of sex work was not mentioned by participants in any of the regions. Sex work in mine settings is a relatively well known occurrence and there are legalised brothels in Queensland, potentially making it a 'non-issue' in these communities [36]. It is also possible that with the discretion around sex work, its occurrence may not have been obvious to participants, or they simply did not consider it as a health or wellbeing need in this region.

This exploratory study highlighted potentially vulnerable groups that may be affected differentially by CSG development, including women and farmers. It is also important to consider whether effects on health and wellbeing differ between migrant populations and permanent residents. Further research could involve assessing health and wellbeing needs of specific groups using the HNA approach. What used to be an 'iron triangle' of

government, industry and science needs to incorporate civil society, media and broader stakeholders to enable monitoring, prediction and management of cumulative impacts at a local community-level, and at all stages of mine activity [10].

CSG mining is often referred to as 'rapid' due to the growth of the industry over a short time, labour intensive yet relatively short development phase, and lack of understanding of the possible implications in the local community. It is imperative to understand the context within which CSG mining occurs to predict and control health and wellbeing impacts. More populated communities with existing mining and industry may be less likely to 'feel' impacts of development stages. As our understanding improves of the implications of CSG mining and communities are better prepared for the development stage, effects may become less damaging.

Individually regulating impacts on health and wellbeing is virtually impossible because multiple companies often work in one region and impacts cannot be solely attributed to a particular mining activity [1]. There is also variation in the institutional frameworks that define what health and social assessments must be conducted as part of a mining company's corporate social responsibility, and the findings are often not available in the public domain. HNAs focus on the population rather than a project, and therefore encompass broader health and wellbeing needs and, because of this, HNAs take the responsibility of implementation away from being solely that of the mining sector towards a joint obligation with communities, local government, research institutes and

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social and health organisations. HNAs are implemented with a partnership approach and significant community involvement, and the outcomes are useful for policy to inform regional and local strategic planning.

Limitations

It is important to note that the HNA process would not have enabled the possible *positive* health implications of mining activity to be revealed, because the aim of the assessment was to determine *needs*. Older women were more likely to take part in the qualitative research and there is a risk of bias and misrepresentation in perceptions because of this. Furthermore, it was known to the research team that the study sites had experienced significant consultation fatigue due to other social, economic and health-related research in the area, which may have contributed to the small population sampled. This corroborates the need for a unified approach to measure, manage and respond to health and wellbeing impacts of CSG development. It is also preferable to gain perceptions from a heterogeneous cross-section of the population with a broader age range than that of this study.

Conclusion

There is evidence of indirect and long-term health and wellbeing implications of living in proximity to CSG development. How communities respond to the boom, post-boom transition and 'bust' of CSG development is important for government, the mining sector and the scientific community. The findings from this study may inform health service planning in regions affected by CSG development and provide the mining sector in regional Queensland with evidence from which to develop social responsibility programs that encompass health, social, economic and environmental assessments that more accurately reflect the needs of the community.

HNAs are a valuable tool for determining cumulative outcomes and needs and operate at population-level rather than project-level. Measuring wellbeing in addition to health provides a more realistic profile of the community. It is recommended that further research is conducted at all stages of the CSG mine cycle to determine trends in health and wellbeing and appropriate responses.

Abbreviations
ARIA: Accessibility/ Remoteness Index of Australia; CM: Community member; CSG: Coal seam gas; DIDO: Drive-in-drive-out; FGD: Focus group discussion; FIFO: Fly-in-fly-out; HIA: Health impact assessment; HNA: Health needs assessment; I: Interviewer; IDI: In-depth interview; KII: Key informant interviews; LGA: Local government area; LNG: Liquefied natural gas; SDoH: Social determinants of health

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Part III: Examining regional health systems within which the Coal Seam Gas industry interacts

5: Community, climate, economics and geography: understanding rural health systems through the lens of systems theory

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Abstract

Health issues affecting rural populations differ from those in urban areas with disease risk factors, mortality rates and degrees of illness positively associated with increased distance from major cities. Rural health systems are complex. However, response to rural health issues has largely been reactive to specific problems, considering only linear relationships between causes and solutions. The current study analysed the perceptions of 45 services providers from three regional and rural areas of Queensland, Australia, using systems theory to explore issues contributing to health disparities. Results showed that rural communities are closely interconnected with the health system and that rural health systems are defined by geography and fluctuating climate and economic changes. Understanding unique system pressures is important for recognising the impact that policy decisions may have on rural health. Decentralisation of decision making, greater flexibility and predictability of programs will assist in health system strengthening in rural areas.

Background

It is well recognised that health issues affecting people living in rural areas differ from those living in urban areas. Disease risk factors, mortality rates and degrees of illness are positively associated with increased distance from major cities (Eberhardt and Pamuk, 2004, Smith et al., 2008, Australian Institute of Health and Welfare, 2008). Rural health systems are also complicated by issues of workforce shortages; onerous workloads; and challenges with designing appropriate service delivery models to accommodate for vast distance (Bourke et al., 2012, Hartley, 2004, Viscomi et al., 2013, Sibley and Weiner, 2011, Smith et al., 2008). Research has however shown that a rural residence does not always equate to poor health outcomes suggesting that there are other socio-economic and environmental factors at play (Eberhardt and Pamuk, 2004, Smith et al., 2008). This paper investigates the health systems of three rural and regional shires of Queensland, Australia through the lens of systems theory in order to explore the key contributions to success and failures of health policy and services.

In Queensland, rural areas are characterised by significant geographical, environmental and social diversity presenting some significant challenges for the planning and delivery of health services (Queensland Health, 2010). Along with the typical issues of isolation and access, rural Queensland faces extreme weather conditions including floods and droughts, with the small communities being highly vulnerable to the associated impacts (Teufel et al., 2014). In some instances, droughts and floods have contributed to a significant economic decline in small towns leading to closures of banks, post offices and small business (Alston and Kent, 2004, Horridge et al., 2005, Queensland Health, 2010). In contrast, other communities have seen major population growth as a result of expansion of the mining and resource sector (Rolfe et al., 2007). These shifting demographic, economic and climatic characteristics of rural areas bring about emergent characteristics including variations in population profiles and health needs which are likely to impact on health disparities.

Addressing rural health issues has largely been reactive to specific problems, considering only linear relationships between causes and solutions for rural health problems rather than new models that embrace uncertainty, non-linear processes,

the uniqueness of local context, and emergent characteristics (Paina, 2012, Bourke et al., 2012). That is, policymakers and planners – usually based in urban centres - have tended to respond to the known health inequality by creating strategies and action plans designed to improve specific aspects of the system without fully acknowledging the complexity of rural health systems (Paina, 2012). For example, addressing recruitment and retention of medical doctors through incentive schemes has also created increased workload due to the associated administration requirements, diminishing the perceived benefit (Russell et al., 2013, Kecmanovic and Haal, 2015). The implementation of decisions by health sector management and policy planners is sometimes defeated by the system's response to the decision itself, due to the often unrecognised interplay between context and individual players existing within the system. As a result, this can lead to counterintuitive, unanticipated or more modest effects than expected (Agyepong, 2012). Efforts to shift the rural health system's response to address health discrepancies within rural areas will benefit from the application of systems thinking, where an appreciation of dynamic, complex systems can lead to proactive health planning and service delivery (Johnston et al., 2014, Leischow et al.).

Systems thinking considers that a health system shares the characteristics of complex adaptive systems (CAS), in that although they are made of separate parts, they can only be fully understood by appreciating the relationships and interconnectedness between the parts and different actors, including the environment and historical context in which it is situated (Victora, 2005, de Savigny, 2012, Adam, 2012, Agyepong, 2012, de Savigny, 2009). CAS are dynamic and have a number of defining characteristics that include self-organisation, non-linearity, co-evolution and emergence; which provide important insights into the ways in which health systems function and develop to address health issues (Waldman, 2007b, McDaniel, 2003, Sturmberg, 2009). The key features of CAS are outlined in Table 1. The application of systems thinking forces planners and strategists to focus on processes, interactions and causes of poor outcomes, rather than individual players, isolated components of a system or interim results (Waldman, 2007a). CAS has been applied in the fields of Engineering, Economics and Organisational Management (Evidence Centre, 2010). The theories and methodologies underlying CAS have, however, been underutilised for understanding health systems processes

in rural settings (Agyepong, 2012, Paina, 2012). There is a paucity of peer-reviewed literature that examines rural health systems with the lens of systems theory. There is an opportunity to explore existing elements that interact and influence health system capacity and test the applicability of the components of CAS in strengthening regional health systems.

Table 1. Features of complex adaptive systems

CAS Feature	Description
Path Dependence	The potential for the sequence of events to alter the course of a dynamical system. This means that from the same starting point, an occurrence can have several different non-reversible paths with different outcomes, with history constraining possible directions of future decision-making. For example, path dependence may explain why one health program is effective in one country but not in another.
Scale Free Networks	Scale free networks are structures, which are dominated by a few influential focal points or 'hubs' with an unlimited number of links following a power-law distribution. For example, influential people within a health system who disproportionately influence the adoption of health practices in certain communities.
Feedback Loops	Can be positive or negative and occur when the output of a process within a system becomes the input of another process. Positive feedback increases the rate of change of the variable in a certain direction. Negative feedback works by reversing the direction of change of some variable, where any disturbance is resisted as the system moves towards a state of equilibrium. For example, the 'vicious circles' between poverty and ill health; or malnutrition and infection constitute negative feedback loop.
Self-organisation and emergent behaviour	The process by which numerous local interactions create order without the direction from the top. As a result of self-organisation, patterns of behaviour emerge within the system.

Given the unique context of rural healthcare, the health system is likely to differ in its implementation needs compared to more populated areas. A systems thinking approach provides an opportunity to examine broader causes of health inequalities in rural health (Peters, 2014). This paper aims to investigate health system complexities in rural health contexts through the lens of systems theory. The findings will assist policy and planners of rural health programs in other high-income countries to broaden their approach to tackling rural health issues, particularly in rural settings impacted on by climatic and economic fluctuations. This research was part of a larger mixed-methods study investigating the health and wellbeing needs of rural and regional communities in Queensland, Australia.

Methodology

Study Design

The aim of this study was to define influencing factors of rural health systems with the lens of systems theory. The objectives were to identify the perceived barriers and facilitators to service delivery in the context of regional Queensland; reveal the interrelated factors that influence health system capacity; and apply the components of CAS to develop a deeper understanding of system functionality Qualitative research methods were used to examine health system complexities. (Pope C., 2006). Qualitative enquiry originates in social science and is concerned with the meaning and context people attach to their experiences and social environment. Social phenomena like behaviours, interactions and relationships are explored in the subject's natural setting using a phenomenological approach (Pope C., 2006). Fieldwork for this research was completed from July to December 2014 and involved semi-structured interviews with 45 service providers.
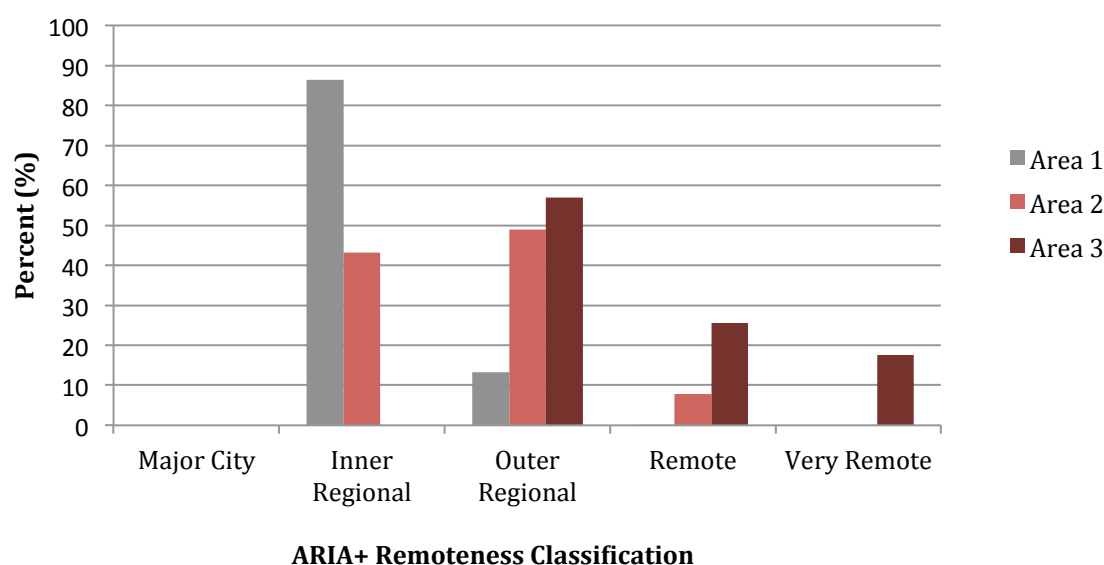
Figure 1: Population distribution by ARIA+ Remoteness classification by study area

Study setting

The study sites included three different local government areas (LGAs) in Queensland, including one inner regional area as defined by the accessibility/remoteness index of Australia (or ARIA) and two other shires considered mostly outer regional but with some areas within the shire considered remote (Figure 1). According to the ARIA criteria remoteness is identified by lack of accessibility to services regarded as normal in metropolitan areas (Australian Institute of Health and Welfare, 2004). This is deemed an appropriate definition for this research given it explores implications of the rural context on the health system. Each area also had the presence of farming, mining and other industries. The demographic and economic profiles of each study site are represented in Table 2. The research was conducted amidst a number of key national health policy changes and restructuring initiatives within aged care, disability, and government health services. There were also a number of changes within the resource industry associated with the communities of interest with many of the areas impacted by the boom and bust cycle of new oil and gas production and downturn of other mining initiatives.

Table 2: Profile of study sites

	Area 1	Area 2	Area 3
Demographics			
Land Area	10,500 km^2	38,000 km^2	58,800 km^2
Population	66,000	34,000	14,000
% aged <55 years	80.0%	74.5%	76.0%
Economic environment			
Main Industries	Mining and Manufacturing	Agriculture, Mining and Manufacturing	Mining and Agriculture
Median family income	$1941/week	$1294/week	$1444/week

Study Population and Recruitment

In order to accommodate for the broad influences on health in small communities, participants were not limited to the health and human service sector and included representatives from education; safety and security; economics and finance; environment; recreation; infrastructure; and other community organisations. Initial recruitment of informants was completed via purposive criterion sampling where key local representatives were targeted due to their known roles and leadership in the communities; and initial health profiling and gap analysis, which identified potential areas of health needs. Invitations to participate were distributed via local networks including local inter-agency meetings or appropriate email list serves. Additional informants were then recruited via snowball sampling whereby previously identified community leaders were asked to suggest others who may be willing to be involved and relevant to the project. To increase flexibility of participation in the research, participants were also given the option to complete in-depth interviews over the phone, which provided further opportunity for working within the time constraints of the service providers. Study participants included 16 participants in area 1, 15 participants in area 2, and 15 participants in area 3. A summary of type of services represented and number of participants is outlined in Table 3.

Table 3: Summary of type of service and number of participants by area

Type of Service	Area 1	Area 2	Area 3	Total
Aboriginal and Torres Strait Islander	2	2	0	
Disability Service	2	2	1	
Financial Counselling	1	3	0	
General Community Health	4	2	4	
Mental Health	0	1	2	
Pastoral Care	0	1	0	
Culturally and Linguistically Diverse	1	0	1	
Tertiary Health Service	2	0	4	
Youth Service	1	4	0	
Total	**14**	**15**	**16**	**45**

Data Collection Procedure

The initial framework and themes for the semi-structured interviews were developed through consultation with the entire research team, review of the literature and informal discussion with local contacts. Continual reflection and debriefing following each interview was also conducted to ensure that researchers remained responsive to informants, which helped to refine the next data collection session. All questions were open-ended establishing the topic or issue for discussion but not suggesting how to respond. Participants were encouraged to talk about topics in their own terms. Field notes were also completed throughout the entire research process to assist with reflexivity of the experiences.

Analysis

Thematic analysis was conducted through a lens of systems theory by the first and second author to further understand the interconnectedness and influences on the system. Thematic analysis is a flexible and iterative qualitative research method that allows the researcher to take a structured approach to initial analysis with the aid of a coding framework. Thematic analysis involves familiarising oneself with the data; developing initial codes and themes; triangulating findings with co-authors and research field notes, and confirming key themes (Lorelli, 2017). A code-recode

strategy was used to improve dependability of data. In cases of discrepancy in coding, a third researcher coded the selected text in question. The final coding and emerging themes were discussed with all authors and adjusted where appropriate. N-Vivo qualitative software was utilised to help organise codes, develop themes and explore the findings.

Ethical Considerations

This study was granted ethics approval by the UnitingCare Health Human Research Ethics Committee. Reference number 1410. Informants were given an information sheet to read and asked to sign a consent form if they wanted to proceed with the interview. Informants were reminded that they could leave the study at any time.

Results

The results suggest that rural and regional communities are more closely interconnected with the health system than would be expected of urban areas. Changes within the rural community were observed to often have significant implications for the health system and vice versa. The informants spoke about their community and health system as a single entity with 'the system' often having to react and adjust quickly to even small changes. Difficulties with retention and recruitment of human resources was a commonly reported issue by all informants, with access to people with the right skills, a history of high turnover, isolation and greater responsibilities of roles reported as key contributors. However, using a systems theory lens, the thematic analysis of the interviews suggested that issues such as these could be further explained by other system interactions such as the impact of externalities, including changes in the community context, extremes of weather, the economic climate and geographical setting. Each community was also observed to possess their own unique needs, with the impact of external and internal agents resulting in different feedback on the system in different communities. The results show that there are a number of factors that impact on health system functionality at the local level, with external agents playing a significant role. The following analysis explores key themes that emerged from the data – community, climate, economic conditions and geography as significant influences on health system responses in the rural Queensland setting.

The community

Understanding the people and community character of regional and rural areas was observed to be integral for anticipating health system response. The makeup and circumstance of the community was perceived to drive how and why health services were accessed and used. For example, in areas with agriculture as a primary industry, the respondents acknowledged that the impact of isolation and access to resources often created a stoic and autonomous population.

I think for many people, isolation has a real big impact. Isolation can also foster strengths with people that are facing difficulty. They can out of necessity become either quite autonomous or can form their own support networks. People are very stoic, possibly out of necessity. Community Health Service, Area 2.

In more rural areas, this was observed by a few respondents as a reluctance to engage with outside services, an attribute that was sometimes not well recognised by people in more regional centre or urban capitals. As one care provider advised:

…we do travel to people, rather than expecting them to come here, or do everything on the phone. I find that face to face delivery works particularly well with people out in the more rural areas. Disability Service, Area 2

The community was also often considered an extension of the health system, particularly in more rural areas, and therefore the management of health needs often extended beyond the walls of clinical care. It was however noted by a few that the way in which the community was a part of the health system had changed over time.

… Yeah that's changed. All that has changed. Because it was part of the capacity of the community to respond to difficult times. Ah, there are not those people you know when I was growing up. In autumn and spring (on the properties), there would be a number of tennis days… heaps of cricket played, or there would be some other thing going on… If you ever said to any of the people attending those that they were in a group therapy session they would probably run you out of town in a row. That is exactly what they were doing. It was good, you know… I can clearly remember one of my first memories of mental health issues is when a neighbour's son committed

suicide. And the whole district just gathered around them and got the family through
that. There was no need to call in outside counsellors or anyone like that...
Financial Counselling, Area 2

For health workers, the community also impacted on the way they provided services. Smaller populations allowed for increased connectivity of community members and health service providers. This relationship could have both positive and negative implications for delivering services. For example, formation of a strong relationship between services was integral for success of service delivery. This was evident particularly in the way in which information within the system was delivered, with word of mouth often being the strongest influencer.

…you could promote something until the cows come home and make it all pretty
pictures and put it in every article in the newspaper and people would still say I
didn't know about that. So it really is for us out here it really is word of mouth.
Community Health Service, Area 3

Good communication channels allowed for information to be spread further despite limited resources. Respondents acknowledged that community champions from various backgrounds, not just health services, were important conduits of health information. These community champions or conduits included bank managers, local publicans, sport and recreation club managers or other community group representatives.

…you know times you will come across people that you go, "you are a conduit", you
know, "you want to help the community." Financial Counselling, Area 3.

Understanding the role of these conduits and how information was absorbed by communities was particularly important for any external stakeholder trying to deliver a service or elicit a reform within the community. However, recognition of this was often poorly understood by those outside the community. This was particularly evident in application of policies developed externally as one respondent explained of urban policy makers:

… every community is different you know, it is no one shoe fits all. And to have these overarching federal policies of funding agreements, it's like—yeah—what might work over here might not work over there. Community Health, Area 3

In spite of explicit directives from centrally developed programs, it was sometimes observed that local services and frontline workers adjusted delivery methods to align with community needs. For example, one participant advised that her service included assisting a 94 year old farmer with wound care following a fall off a tractor. The farmer however insisted on remaining an active farmer despite his injuries and so the service had adjusted its typical delivery to meet him on his farm over 100kms away from the service. However, the funding for this service was attached to a national program that had a specific limitation on time spent traveling to and from clients. Therefore the local service ultimately absorbed the extra hour of travel that it cost. Many respondents felt that urban head offices did not recognise the difficulties of providing services in the regional and rural context. This sentiment is highlighted by the following:

You have got to have a sense of humor. We have got photos of incidents from going out of town to people's places—and the car has got goats standing on the roof. You know, we fill out an incident report but I don't know what they think back in Brisbane (at head office). Community Health, Area 2

Climatic conditions
Many rural respondents agreed that climatic conditions and extremes of weather seemed to drive how relationships formed between the health system and the community, including how services were delivered and accessed. Droughts and floods often brought hardship, particularly to the agriculture sector. The long term impact was also felt within the associated small towns with people moving away and businesses and services closing down. Respondents attributed the extremes of weather as a factor in increasing mental health issues, substance abuse and domestic violence due to financial stress and other associated pressures. In regions where agriculture was common, the impact of climatic and inter-related economic conditions was at the forefront for considering any health need.

Mental health is an issue for rural people. Loneliness, isolation, stresses of farming. Farming is a very difficult lifestyle. It doesn't matter where you live; you are at the vagaries of weather and prices of the markets and all the rest of it which is totally out of your control. And somehow you have to make a living. People out here have had it tough for the last few years. And will continue to do so. Mental health is a significant issue, and loneliness and isolation, and the stresses that come from that.
Tertiary Health Service, Area 3

It was also frequently observed, particularly in more rural areas, that different weather events could result in differing health needs and target populations. Therefore different approaches were required and the health system needed to be prepared.

…target groups and target areas shift once you have a drought or a flood. Yeah so we have a pretty adaptive lot out here, I think... We can't get too stuck in our ways; we think 'ok we have to change tack now'... Being able to have that real organic change and think 'ok this is the direction that we need to take'. Because this is more important now, this is taking a priority you know. Community Health, Area 3

For example, during floods some respondents reported that the community seemed more willing to seek out mental health support. Whereas, due to the nature of the slower and more hidden impact of a drought, the community members were observed to be more reluctant to seek mental health support and required more active but discrete engagement.

During drought, if you go and knock on someone's door in that rural community to see if they need help, you will have to knock on all of his neighbours as well to ensure that the person is not singled out. Financial Counselling, Area 2

As community settings became more rural, the health system was more likely to be reported as acutely sensitive to weather events. In part, this reflects local geography—remoter areas tend to have lower rainfalls, but are not immune to the extremes that produce occasional flooding. The economic and social conditions also impact on the population, which has resulted in a changing population composition.

For example, the outmigration of younger aged groups has resulted in an aging population and difficulties with succession planning for farmers and their families. As the community profile has changed, the health needs also changed with increasing need for chronic disease, mental health and other aged related services in some areas. However, it was believed that the health system often lagged behind in their response to effectively meet the shifting needs.

Economic climate

The changes in the economic climate—including market changes in agriculture, access to funding, and increasing or decreasing industry activity—has had notable impacts. Difficulties with accessing health funding and uncertainty about funding longevity were typical issues raised by all respondents in both rural and regional areas. In more rural areas, particularly where similar local jobs were limited, funding uncertainty for continuing positions contributed further to high staff turnover. As one respondent suggested:

I don't know how it is that you are supposed to get people to be confident in their careers and confident in their jobs and be fully motivated when there is no guarantee that they are going to have a job in 12 months. Youth Service, Area 2

As a result of changing funding structures and restructuring of services, combined with limited job opportunities and limited access to a pool of skilled professionals, local people were observed to frequently change roles and responsibilities. The impact that this had on the overall system was particularly evident in more rural areas.

… Even knowing who is who. In my short time I have seen two or three key people sort of move organisations. You know: 'You are not in that position anymore?' You know: 'You don't work for them anymore? You are over here?' It is difficult to keep up. Community Health, Area 3

In areas where positions were vacant or discontinued, the system was observed to self-organise, with other workers absorbing the responsibilities of the unfilled or discontinued roles. The high autonomy of positions along with limited access to an

available workforce also had a significant impact on altering and morphing role responsibilities. For example, it was often observed that the person in the position defined the role due to their particular skills and not necessarily the particular service needs.

It's one of those places where you have got people moving in and out of the area. So you get some level of instability. Let's say someone working here as a counsellor will have their specialist area. One of my colleagues here in the past was very clued up and a specialist in grief counselling. So she ran some programs in relation to that. And now that she is not here that is not happening. Community Health Service,   Area 1

In more rural areas, where the health system and community were already closely entwined, funding fluctuations were often heavily felt, and cuts to positions in the service often needed to be confronted on a more personal level, as well as at the service level. As one respondent explained:

… (Previous funding arrangements allowed for) somebody in that role full time and that person supported (the rural) schools. However, we didn't get funding from the government this time. I actually had someone from one of the schools call me quite recently and say 'you know you've always supported us but we haven't seen anybody this year, what's going on?' So I had to explain to her that we didn't have any funding. Youth Service, Area 2

In some areas, the rising cost of living also had direct implications for the health system and was particularly evident in areas where the resource industry was prominent. The increased cost of living was often quite sudden and extreme, particularly in towns that were experiencing a resource boom. For example, increased housing rents in response to demands by mining personnel had implications for the delivery of welfare services, particularly to those on low incomes, homeless or in complicated situations. As one respondent explained, it also had consequences for surrounding areas:

We couldn't assist as many people with the housing program because we couldn't get any more money from the government. We (also) couldn't afford to rent from the private market … So we were … paying for people generally, people with a mental health issue of some sort. We were putting them on a bus and sending them to (the next town), where they could rent a unit at the beach… And the drag of that is, you take people away from your support network. But at least they have sufficient money to live. Mental Health Service, Area 1

The associated high costs of living for industry rich areas also had implications for attracting and retaining skilled workers in health and services roles across all areas. One respondent explained their experience during the height of a mining and resource boom:

… For services like ours, if you needed to recruit a new worker, you would get interest but you would have to be up front. Accommodation, 'is what it is.' Non-existent or very expensive or you had to share. My GP left town to pay cheaper rent in (the next town)… and she was very, very, good. And so, across the board, we are faced with that as a major issue… So it really had a fair old whack on just keeping people… And, it was just terrible if you lost staff, because you knew to replace that staff member would be so difficult. Community Health, Area 1

It was also agreed that in areas where the resource industry was prominent, higher paying industries tended to siphon off some of the lower paid workers in health. As one community health service respondent explained:

And we have found, that amongst the semi-skilled workforce that often the mining industry has been quite attractive and people can earn quite large amounts of money doing semi-skilled work. And are perhaps less likely to work for what is traditionally a lower paid, but highly satisfying industry (laughing). Community Health, Area 2

However, the mining and resource boom was also reported as having a positive impact on the health system due to increased opportunities for recruitment. That is, as more people moved into the towns for industry related occupations, they often

brought partners with skills in health services. This occurred in both rural and regional areas.

We have been fortunate… we have some really good and qualified staff and some of those have actually come as a result of the resources industry. Because someone comes out to work on the gas field they have a partner that has got some qualification in disability and so we have picked up a couple of really good quality staff through that. That may change as the workforce moves on those staff.
Disability Service, Area 2

Industry rich areas also meant increased options for obtaining private funding for local programs, although despite most acknowledging the benefits, there were ongoing concerns about the sustainability of the funding.

Geographical factors

Transport and access to health services were some of the most frequently mentioned issues from respondents across all areas. Transport difficulties stemmed from limited public transport options, reduced access to family to provide transport and, costs involved with travelling large distances for appointments. It was also often reported that city based health services did not appreciate the effort that some patients had to go to attend appointments.

…a lot of specialists think that everybody lives around the corner from them. You get an 88 year old, you know, that has a cataract and they want her back in 2 days or 3 days… I mean they really don't think somebody has to travel 8 hours to see them.   Tertiary Health Service, Area 3

Access to health services was further complicated by the extensive service boundaries that many rural and regional services had. As one respondent remarked:

So I have a really broad area that I cover. It's about the size of Victoria (State of Australia). Disability Service, Area 3

These extensive service boundaries were also often reported to be poorly

appreciated by management of organisations that were governed from urban areas.

I guess the other thing is the fact that head office does allow us to travel, even though they have no concept of what it means to us. They think that we can just pop out to the next town (over 100km away). You know, be home by morning tea.
Community Health Service, Area 2

In some cases respondents reported that the extensive service boundaries often resulted in theoretical coverage only. That is, despite having an area listed as being covered by a service, actual capacity to do it was often lacking.

…if we did get a referral from [town x], it would be a one day trip if you went that far… It's not that we wouldn't provide services [to town x], it's just that distance is a barrier. Mental Health Service, Area 2

In more rural areas, engaging in a more superficial service was further exacerbated by the uncertainties around employment. The health worker's own expectation of how long they will stay in the position also impacted on their engagement with how they provided the service. As one respondent explained:

I will see how I go really, like I am interested but, because of my family and I also have a partner living in Brisbane… and as much as I would, I would like to, because you see if I continue… I could actually start to develop things more in a structural way. Like my service is very superficial at the moment but with more of a long term input into the service you could start to change it in a structural way, so you didn't have to do a superficial service. Disability Service, Area 3

Difficulties managing large areas along with uncertainty of positions were therefore likely to result in negative feedback on the system, such as continuing high turnover of staff.

Discussion
The rural health setting provides a unique context to consider how health system responses may impact on the nature of system constraints and agent interaction.

Rural health systems are complex, with community, environment and socio-economic characteristics core to understanding the issues. Using systems theory, unique system pressures can be identified and used to recognise the impact that policy decisions may have on service outcomes in rural and regional settings. The research suggests that poor consideration of these impacts may lead to weakening the health system's capacity to achieve health goals. A summary of the potential system influences observed in this rural and regional setting is outlined in Table 5.

The rural health system was observed to be embedded in social relations with individual behaviours, actions of community groups, networks between individuals and existing power relations within the community creating feedback on the system. Scale-free networks were shown to exist and influenced how health messages were delivered or how services were accessed. In more rural areas it was evident that there were key influential focal points or influential people, not limited to those working in the health sector, which could assist with leadership of health programs. Ignoring their impact could result in failures to build capacity to address health needs. This finding resonates with previous discussions of 'the rural locale' as a particular setting in which social relations are constituted and where rural health outcomes occur (Bernard P et al., 2007, Bourke et al., 2012). As a result formal and informal responses emerged to meet the needs of local communities. For example, although there was strong evidence that state, national and local program regulations did flitter down to the frontline, there was evidence of adjustments being made to accommodate for rural needs.

Path dependence of a rural health system was observed to be very sensitive to external influences to the health system context such as economic conditions, new industries and climatic changes. The results support the need to consider each external influence differently. For example, droughts often have significant health effects that are typically mediated through complex environmental, economic and social pathways, and are characterized as slow-moving disasters. Droughts therefore provide a unique threat to health and consequent demand on the health system compared to other acute weather events and natural disasters, such as floods and storms (Vins et al., 2015). Changes to community cohesion has also been previously reported as a significant impact of the mining and resource boom

with small communities suddenly housing transient non-resident workers (Hossain et al., 2013, Rolfe et al., 2007). External influences such as these on the health systems in metropolitan areas are rarely acknowledged. This may be because the impact is greatly diluted by the scale of operation, diversity and magnitude of the population, and types of economic activity existing compared to non-urban areas.

External leadership and governance decisions that happen outside the small communities were reported to often have substantial implications. Changes or reforms that may be considered small in an urban area were observed to be felt more acutely in regional and rural towns. Even small changes in funding arrangements or staffing had lasting implications, with the system often having to respond on a more personal level. System responses in rural and regional areas therefore can sometimes operate in isolation to the broader health system. That is, health policy and services are conceptualised with national and state program directives that are operationalized within defined health services boundaries. Understanding this highly intricate relationship is paramount to the success of solving local problems and community uptake of health services, as well as integration of services for efficiency and effectiveness.

Incremental internal and external changes were observed to have significant implications for how health workers integrated within the community and the health system. For example, the intermittent stopping and starting of programs, and unpredictable funding and staffing in rural and regional areas, often impact on community rapport with health services. The transient workforce brought about by changes in economic conditions also has an impact on self-organisation and emergent behaviour of the system with patterns of the profile of human resources no longer aligned with what central planners and policy makers imagine are available in rural centres. Modifying, or dissolving services due to lack of staff or changes in funding, results in reduced capacity to achieve health goals. Small changes in program arrangement may have severe local consequences as health staff often provide a significant contribution to the community and economics of rural areas.

Conclusion

Health policy and health services are often conceptualised and driven centrally. In rural health, variability in service provision and circumstance suggest that this one-size-fits-all approach will not work, particularly in communities facing transition due to industry, climate and economic conditions. Centralised decision-making that lacks deep knowledge of influences to rural health systems, has the potential to create negative feedback on the system which includes the adaptation of national programs to local needs without explicit reference to central management. Application of systems theory to rural health systems sheds light on the spatial and social relations among local residents as well as the actions of local health professionals and consumers that are both enabled and constrained by broader health systems and social structures (Bourke et al., 2012).

The findings suggest that there are a number of changes that should be considered to assist in mitigating unanticipated responses of rural health systems. This includes the decentralisation of decision making and policy development and increasing predictability of health program duration particularly in more rural areas to assist with health worker retention and community confidence in health services. Enabling local management of human resources to take advantage of local skills would also assist in sustainability of health programs.

Programs to improve rural health will be most effective when based on policies which target all risk determinants collectively contributing to poor rural health outcomes. Focusing solely on 'area-based' explanations and responses to rural health problems may divert attention from more fundamental social and structural processes operating in the broader context to the detriment of rural health policy formulation and remedial effort. Understanding unique system pressures is important for recognising the impact that policy decisions may have on rural health. Poor consideration of these impacts may lead to the weakening of the health system capacity to achieve health goals.

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Authors' contributions

CG designed the Health Needs Assessment study. AT led the research team in the field. FM and AT both collected data, analysed and interpreted the data, which was validated by LM. AT wrote the first draft of the manuscript. FM, LM and CG provided significant input on the structure of the paper and discussion components. All authors read and approved the final manuscript.

6: How does the Coal Seam Gas industry interact with the health system in regional Queensland, Australia? Perceptions of service providers

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<u>Abstract</u>

The Coal Seam Gas (CSG) industry has received a lot of attention in recent years due to its rapid expansion with relatively unknown impacts on communities and the environment. In regional Queensland, Australia, several mining companies operate in close proximity to communities. Queensland is the second largest state in Australia and most people live in urban areas. Health services in regional and remote areas are commonly constrained, with fewer human resources and funding, and fragmentation of services. The mining sector, through its corporate social responsibilities, provides an opportunity for local services to strengthen their planning and delivery. This paper explores opportunities and challenges that arose in three regional Queensland communities in 2014 through interaction between health and community services and the mining sector. 45 key informants were interviewed, and data was analysed using phenomenology theory. Of these, 23 mentioned the presence of CSG or mining activity at least once during the health and wellbeing interviews without any leading questions relating to mining activity. Mining activity was perceived to influence the ability of service providers to meet demand, recruit and retain staff, and effectively plan and maintain programs. The level of interaction between mining companies with service providers and regulatory bodies were also commented on. Several key informants identified pathways for the mining sector to engage with services more effectively, which included strengthening multi-sectoral engagement and enabling transparent, public consultation and evidence-based funding initiatives. This study adds to the body of evidence on the health and wellbeing challenges faced by mining communities as they transition from rural to resource-based, and the multi-sectoral approaches adopted to respond to them.

Background

Regional and remote communities in Australia have higher morbidity and mortality rates than their urban counterparts and often face significant barriers to accessing health and community services, including cost and geographical distance [1]. Mining activity is a major contributor to Australia's economy, particularly in Queensland and Western Australia, where iron ore, gold, coal and coal seam gas (CSG) amongst other commodities are mined in proximity to regional and rural communities. In regional Queensland, several communities have undergone a shift from agricultural to resource-based as a consequence of the ongoing CSG resource extraction (used synonymously with 'mining activity' herein) driven by demand from rapidly developing Asian countries [2]. This shift in already underserved communities can have significant implications for the health and wellbeing of the local population [3, 4].

Internationally, mining activity has been associated with cyclical environmental, social and economic changes at the local level, which often reflect the lifecycle stages of a mine project [5]. In the Queensland context, there is emerging evidence that cumulative impacts of CSG development can in turn affect individual-level health outcomes like mental health and quality of life; and community-level outcomes like social connectedness and constraints in accessing services [6-9]. There is also concern for the risky lifestyle behaviors of the mine workforce and spillover to the local community, including drug and alcohol abuse [10]. Fluctuating health and wellbeing needs can pose significant challenges to health systems. For example, services may not be able to meet demands associated with the 'mining boom' such as responding to population influx; lacking capacity to respond to mining-related injuries; or suffering from a loss of health professionals to the mining industry because of competitive salaries [6, 11]. During the 'mining bust' health systems may be slow to react to emerging health and wellbeing issues or have to re-structure their workforce to meet reducing demand.

Regional health services in Queensland often provide maternity, medical, surgical, accident and emergency, children's services, outpatients, pathology, palliative and aged care through regional hospitals and clinics[12]. Allied health services and community health care are provided in most country towns. Due to geographic distance and

relatively low population density, the health system often adopts a hub and spoke model, which is complemented by outreach and more recently, telemedicine [13, 14]. Regional health systems are commonly constrained by recruitment and retention issues, fragmentation of services and financial shortfalls compared to urban counterparts [13]. Innovative strategies have been developed to tackle some of these issues, including providing greater flexibility and scope around roles and responsibilities; financial incentives to work in the regions; government support for multi-disciplinary primary care approaches; and increased consumer engagement [15].

Integral to the provision of health services in regional areas is the integration of services and partnerships – it is common for stakeholders external to the health sector, such as transport, police or environmental departments to be involved in health service planning and delivery. In regional mining communities, there is emerging evidence that the mining sector may play a larger role in health service planning in rural and regional communities than previously expected, but the pathways in which they do this in the health sector are not clear [16].

There is a dearth of scientific evidence of the ways in which the mining sector interacts with the health system in the communities in which they operate; what the costs and benefits of this interaction might be and how it might be optimized to enable long-lasting health improvements. This is particularly important in mining communities where there is evidence of changes in social determinants of health during mining 'booms' [10, 17], and in communities where mining activity is soon to cease, leading to uncertainty and economic downturn.

This paper reports the findings from a key theme that emerged from a Health Needs Assessment conducted in regional Queensland: that the mining sector played a role in health and community service planning and delivery. This paper reports the perceived mechanisms of interaction between the mining sector and service providers in responding to health and wellbeing needs in mine settings. The findings assist in understanding capacity and resilience of health systems as they go through 'boom and bust' CSG development.

Methods

Study Setting

Regional Queensland has experienced unprecedented change over the past decade due in part to the rapid development of CSG extraction [18]. The study takes place in three local government areas (LGAs) situated near extensive CSG development in regional Queensland, Australia. The three LGAs comprised of four major townships, de-identified as outer regional (region 1), inner and outer regional (region 2 & 3) and inner regional (region 4) according to the Accessibility/Remoteness Index of Australia (ARIA) (Table 1). CSG extraction involves large workforces in the construction phase, often referred to as the 'boom' and has a much shorter timeframe than coal. CSG is expanding in Australia, USA and the UK, and the broader public health effects on communities are still largely unknown [19].

Regions 1, 2 and 3 are predominately agricultural with CSG development recently in construction phase. At the time of this study, regions 1, 2 and 3 experienced rapid and transient population growth, inflated housing prices and barriers in accessing services, which were linked to the 'boom' stage of mining activity in the local area. Regions 1, 2 and 3 had recently been affected by severe flood and drought conditions, which created further challenges for the communities. Region 4 has a long history with industry due to housing a large shipping port, and also has international liquefied natural gas (LNG) exportation operating in the area. The region was described as nearing the end of construction phase during the time of the study, reflecting a reduction in mine workforce and infrastructure. This region is a source of considerable mining activity in addition to CSG, however, including aluminum smelters and coal operations.

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Table 1: 2014 demographic and economic summaries of four study sites in regional Queensland

	Region 1	Region 2 & 3	Region 4
Demographics			
ARIA classification	Outer regional*	Inner and outer regional	Inner regional**
Land area	58,800 km^2	38,000 km^2	10,500 km^2
Population	14,000	34,000	66,000
% aged <55 years	76%	74.5%***	80%
Economic environment			
Main Industries	Mining and Agriculture	Agriculture, Mining and Manufacturing	Mining and Manufacturing
Median family income	$1444/week	$1294/week	$1941/week

*Significantly restricted accessibility to goods, services and opportunities for social interaction
** Some restricted accessibility to goods, services and opportunities for social interaction
***On average, population slightly older than the total Queensland population [20]

Study Design

Fieldwork was carried out between July and December 2014. A mixed method cross-sectional study was originally developed to explore themes around health and wellbeing in the communities as part of a larger health needs assessment (HNA) of three LGAs in Queensland. For the full HNA report with comprehensive methodology, refer to: http://www.wesleyresearch.org.au/wellbeing/. The qualitative findings reported in this paper result from the first two steps of the HNA framework. Qualitative design was underpinned by phenomenological theory. Phenomenology allows one to describe a 'lived experience' or phenomenon, without use of a framework or guide, and builds on the perspectives of the people involved in the phenomenon [21].

Recruitment of Service Providers

Key informant interviews (KII) were conducted with 45 service providers from the health and community sector, who were purposefully selected because of their knowledge of community needs and their ability to provide information on the mechanisms employed at a local level to respond (Table 2). Service providers were identified following a comprehensive stakeholder analysis conducted by two research team members and invited to take part in the study at a time and location convenient to them. Further recruitment was conducted through snowball sampling, local interagency meetings and consultation with community leaders. The Social Determinants of Health model was considered throughout the process, and stakeholders external to the health system were also identified [22].

Table 2: Qualitative primary research involved 45 key informant interviews with health and community service providers across the four study sites. (Note: some participants from the same organisation were interviewed together upon request.)

Region	Key informant organisations	Number of informants
Region 1	Primary care and community services	5
	Hospitals	4
	Specialist health and community services	3
	Public health services	2
Region 2 and 3	Specialist health and community services	11
	Primary care and community health services	4
Region 4	Specialist health and community services	10
	Hospitals	2
	Government	1
	Primary care and community services	3
		45

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Data Collection and Analysis

Initial themes for the KIIs were developed through review of the literature and consultation within the research team. Interviews were conducted to elicit perceptions and opinions about health and wellbeing needs at both community and organisation level; barriers and facilitators to delivery of health and wellbeing services; and levels of multi-sectoral interaction and support. It is important to note that service providers were *not* specifically asked to comment on the mining sector. Following verbal consent, digital recordings were taken of all KIIs and later transcribed and de-identified by a member of the research team. Interviews were supplemented with field notes. Each KII took 30 minutes to one hour to complete and were held over the phone with those who were not able to meet in person. Observational notes were also taken through out the field-work to support credibility of research findings.

All transcriptions were coded and analysed using NVivo qualitative software (QSR International Pty Ltd, Australia). Analysis involved search for meaning and experiences to describe perceptions of the phenomenon and was conducted by the first author and independently reviewed by a second researcher. The second author validated themes derived from the data. In cases of discrepancy in coding, a third researcher reviewed the data. Data collection was completed when all research team members agreed that thematic saturation had been reached.

Ethical Considerations

This study was granted ethics approval by the Wesley Hospital Human Research Ethics Committee, Reference number 1410. Informants were given an information sheet to read and asked to sign a consent form if they wanted to proceed with the interview. Informants were reminded that they could leave the study at any time. Participants were given the option to be entered in to a prize draw to win up to $500 to spend on fuel or groceries in their community.

Results

Twenty-three key informants out of the total amount interviewed for the broader HNA (66%) mentioned the presence of CSG or mining activity at least once during the health and wellbeing interviews without any leading questions relating to mining activity. Themes around the mining sector's perceived direct and indirect impacts on service needs; funding of health and community-based programs; and level of engagement and influence over service planning and resourcing were identified and are discussed further below.

Indirect impacts of mining activity and health service planning

Transient and increasingly diverse population growth led to emerging trends in the type of services required, particularly those that supported new arrivals with navigating local services and connecting with the community. An informant in region 1 commented on the use of health services by the temporary residents:

"There are health issues related to the gas industry. We have a huge population of people coming and going all the time. They quite often become clients of the health service, if something happens whilst they are here. But their lifestyle is such that their general health and wellbeing is not terribly well looked after either." Tertiary health service, region 1

Informants also discussed that health needs of the population fluctuated, and included the need for services that supported culturally and linguistically diverse populations, domestic violence and social support and availability of primary health care.

Population growth constrained the capacity of health and community services to respond to health needs. Informants remarked that opening hours of certain services in region 4 needed to extend to meet the requirements of shift-workers, but this was often constrained by a lack of funding and human resources. During the height of CSG development, informants commented on the difficulty in recruiting and retaining human resources in the health and community sector, due to higher wages afforded by the

mining sector and the transient nature of the community. Informants in region 1 were also concerned about the rapidly changing aesthetic environment that may have deterred potential employees from moving to the area. It was perceived that the increasingly fragmented community and high cost of living further deterred health professionals from considering employment in the area. In some cases, existing employees had to move out of the regions due to unaffordability.

"Housing has been up until the last twelve months, very, very, very expensive in [region 1] area; [region 2 and 3] are just exploding at the moment. It's - and if you are someone on an average wage, you are not going to feel inclined to spend $400,000 on a house in region 1 not knowing what it would be worth in five, ten, fifteen years. There has been a drift largely through, in particularly nursing and allied health and our medical staff. But for people outside of those areas, it is difficult because housing doesn't come as part of their role." General community health, region 1

Informants recommended that the mining sector subsidise housing prices to encourage more health and community professionals to move to the area. There was evidence of this already occurring in region 4, but there was uncertainty around which types of health personnel were eligible to receive subsidies.

Some informants believed services benefited from the population growth associated with mining, from people with specialised skill sets who moved to the region with their families, one of whom worked in the mining industry. However, there was concern about the longevity of staff when the construction phase was over as the quality and continuity of care was reportedly affected by a high turnover of staff. This was perceived to be a particular concern for older clients in the community who held traditional values of being seen by the same family GP, for instance. Lack of sustainability in resourcing was a concern to service providers.

"Someone comes out to work on the gas field, they have a partner that has got some qualification in disability and so we have picked up a couple of really good quality staff

through that. That may change as the workforce moves on, we have had one where that has happened already." Disability services, region 3

The mining sector as a source of funding for health and community services

When asked to describe general barriers and facilitators of delivering services in the community, many informants mentioned that one or more mining companies operating in the region provided some funding for social integration services, youth programs, staff positions, sponsoring of sporting teams, or transport and hospital infrastructure improvement. This source of funding was seen as both a barrier and facilitator for service planning and delivery. A small community in the outskirts of region 4 received funding from a mining company to initiate a community-based program for men that promoted health and wellbeing. The initiative was sustained beyond the funding and recognised as a successful, sustainable investment. This was provided as an example of where funding was appropriately provided to address a gap in community services and where the resources were in place to continue the service.

Conversely, there were several references to programs or commodities that had been funded by a mining company with little consideration of its effectiveness or utility. For example, one company funded a bus service in region 4 but service providers commented that the community didn't use it because of its operation at irregular hours. An organisation in region 1 also received a bus through a funding scheme from a mining company but it was consistently being used by other services and one wasn't enough to meet the demand. An informant in region 2 discusses the scope of funding by a mining company, and implies that funding for discrete projects are valued but don't overcome existing challenges about more entrenched funding constraints:

"I mean the mines and energy sector is huge around here at the moment. [Mining company] has bought us a bus, which is fantastic. We have had that for two to three years now and it has really helped our program and we really appreciate that. But as far as support for actual day-to-day funds for the program, we haven't been successful with them." Youth service, region 2

Informants commented on existing funding constraints felt at the local level and the little reliable support received from government funding bodies. Service providers therefore sought alternative sources of funding, which included approaching mining companies, or applying for community grants advertised as part of mining social impact management plans and corporate social responsibility (CSR) commitments. Several informants perceived mining companies as viable and necessary sources of financial investment in their resource-constrained communities, but there was concern for the dismissive or tokenistic nature of the funding. Others mentioned that they had to 'beg' for funding from the mining companies because they had little other choice. There was also concern for competition between organisations for mining-commissioned grants and bias towards more prominent organisations that provided generalist health services. Furthermore occasionally duplicated services funded by mining companies raised concern about intent of investment and media-driven motives:

"This is where I do get irritated with industry, because they will give money to services very often that are duplicating things that are already happening in the community. And because we are smaller, and because we are church affiliated, I think that almost counts against us. In terms of getting that grant, or those grants. But we are the only ones that offer the services that we offer in town. There is nobody else because we didn't want to reinvent the wheel. We didn't want to offer something that was already being offered in the community. So, we try to keep our programs… that niche is just for the gaps. Where we find a gap. Like I just found a gap, another gap now, we have nothing in terms of social interaction for the disabled." Pastoral care, region 4

There was some concern that mining companies invested in niche services rather than those that could reach a larger population. Several informants recommended that the mining sector invest in infrastructure or public health initiatives rather than specific projects that reach a smaller population. Public initiatives like urban landscaping that encourages people to walk and cycle were recommended:

"I think more could be done by the local industry to put in to infrastructure, as opposed to sponsoring a team to play football. That might affect the 20 kids, but if they were to

spend money on you know, landscaping and so on that encourages people to walk and cycle, then that would be more useful." Tertiary health service, region 4

There were many differing perspectives about how the mining sector should allocate financial resources to the community, suggesting that there has been little assessment of the current status of services or consultation with the wider community in the decision making process.

Partnerships with the mining sector for health system support

A key to the success of health and wellbeing services in regional communities is multi-sectoral partnerships. Understanding that health outcomes are often influenced by a broader set of determinants arising from environmental or economic conditions, for example, is vital in designing programs and interventions to address them. Key informants cited several collaborations with, and initiatives between, the mining sector and government. This was more prominent in region 4:

"And we are starting to talk. We have this initiative called (health-related program), which is run by (mining company). And that involves, not just us but the private sector, and the state and federal members of parliament, and the council. So we are beginning to talk about what we are actually going to do tackle this as a group. So we see the end point but there is a lot that happens before we get there." Tertiary health service, region 4

There were fewer references to committees or meetings that brought together environment, transport, housing and health stakeholders. Some informants commented on the lack of effective communication between sectors despite formal collaborative agreements. Service providers wanted to see more meaningful relationships with the mining sector to avoid 'winning hearts and minds' with opportunistic or media-driven funding opportunities. Consultations between the mining sector, service providers and community members were sometimes perceived to be 'tokenistic' and insincere; this has also been a perception amongst some mining representatives [23].

The partnerships and engagement theme was related to the need to strengthen planning for when the CSG development began to subside and for any potential developments in the future. Furthermore, it was recommended that the relationship between the sectors be formalised:

"I think having high profile industry come in has been a considerable help I think for us to be aligned and to find out how they can support and we have had support from the training of midwives in the past, and that has been a great benefit. I think we should really try and streamline that, more than just an adhoc application for a midwife. We actually need to plan long term as well.' Tertiary health service, region 4

The role of the mining sector in governing aspects of the health system

In some cases, mining companies acted like quasi-governments in the provision of services. For example, a group of companies in the mining sector funded extra police to work at night to curb excessive alcohol and anti-social behaviour in region 4; the program was a success and ran for two years. When the initiative ceased, it was felt that the social issues returned yet local council did not continue the service to regulate the problem. Informants questioned the prior communication between the group of mining companies and local government and felt that there was a lack of foresight for sustainable planning.

Informants discussed the relationship of the mining sector with federal government and that decisions were made at the macro level with little consideration of local government's capacity or the input of local stakeholders.

"You know if big industry and [Federal Member] thinks it is a good idea, you can be pretty sure that it will happen. I am not saying that they don't listen to the community agencies. I think they do. I just think that there seems to be a one size fits all. Throw money at it and that will sort it out." Specialist health and community services, region 4

Informants talked about the mining sector as a key source of funding, and a relationship that was worth building and maintaining. In some instances, this relationship was seen

to be more effective than that with local government or other funding sources. The allure of funding possibilities makes industry a key influencer in the health sector.

[Mining company] giving back to the community organisations is really, really good. We have a great relationship with [mining company 1]. And [mining company 2]. We use them all the time if we can, but we don't want to overdo that either. I do feel that we are more supported by industry then we are from our local government. Specialist health and community services, region 4

Discussion

A growing understanding of health and wellbeing needs in communities living in proximity to CSG mining activity has led to discussions around models of health care that might better address community needs. Digital health tools (including telehealth) for improving access to health services for regional communities are being implemented across Queensland to meet the demands of an ageing and growing population and to overcome challenges with recruitment and retention in rural settings [24]. This strategy could offer a solution to the increased demand and diversity of needs during 'boom' periods in regional communities, and when increasing the workforce on the ground is not a viable option [5].

Several informants commented on the rapid progression of CSG development and that 'boom and bust' impacts needed to be better predicted so as to support health system capacity throughout, for both the temporary population and pre-existing community members. The indirect determinants of health may require a response that is external to the health system – such as the transport and housing departments – necessitating a multi-sectoral approach to mitigation and response [25]. Integrated monitoring systems that incorporates indicators within and external to the health sector, and governed at the local level, is important for stakeholders to build understanding and capacity in responding to changes in their community. There is evidence of these systems in the public domain but their effectiveness or uptake has not been evaluated yet [26].

There is evidence in the literature of a tendency of mining companies to fund tangible outputs and avoid complex social issues or 'soft' health outcomes such as mental

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health. Investment initiatives often take the form of infrastructure projects over human capacity building with generally low developmental impact, short-term scope and inadequate community consultation [27]. The mining sector might provide short-term solutions during its temporary stay, but this could lead to declining public investment in the community and raises questions over legitimacy. This is of course dependent on the scale of funding provided by the mining company and how much influence this has on overall health spending in the community.

Whilst it can be recommended that stakeholders make evidence-based decisions to mitigate impacts on the health sector and allocate funding effectively, it is important to consider the current lack of public health information systems to enable this. Public consultation and multi-sectoral engagement at the local level is imperative to determine issues and needs, but should be triangulated with robust evidence to support decision making and forecasting. There is some evidence of addressing this in the literature, but no system has been designed with a social determinants of health framework [28]. The development of a monitoring system is not without challenges – including those of ownership, transparency and accountability, and the ability to measure long term outcomes [29].

If mining companies are to act as quasi-governments, they need to adhere to the principles of good governance, which includes transparency, mutual accountability, active participation and efficiency in resource allocation. The extent to which the mining sector plays this role seems to be influenced by the political landscape – who is sitting in local government and what their relationship with the mining sector is. This political influence might be at a central or local level, but could have significant outcome for health service providers. Local government is at the forefront of mining impacts and therefore pivotal in controlling the level of input to local service delivery. In other Australian settings, multi-sectoral collaborations were formed to monitor, manage and communicate the impacts of mining activity but there was seldom any decision-makers involved, and there were issues around trust and relationship building [30].

These findings corroborate existing evidence regarding the challenges faced by local government in navigating the responsibilities and roles of mining companies on the ground. In regions 1, 2 and 3, this was a new relationship to navigate given the recent introduction of CSG development to the area [31]. Being overshadowed by the influence of mining companies, with the lack of a regulatory framework can lead to dependence and delegitimisation, which is unsustainable, particularly when the mining company ceases operation in the area and moves on [23, 31]. This has implications for the community, who, as evidence shows, are more involved in the actions and decisions of mining companies and local government than in previous years [11, 32]. This is facilitated through immediate access to media and information through technology, and the unprecedented growth yet uncertainty around CSG development and its impacts [33]. As evidenced in this study, service providers experience the effects in the community first hand and are a vital source of information.

The history, geography and population of the communities in this study must be considered in interpreting the results of this study. Informants in the region 4 (bigger, higher income, and history of mining) provided a lot of content around power and the governing role of mining companies, whereas regions 1-3 (smaller, lower income and predominantly agricultural) more commonly discussed the ways in which mining companies fund projects and the influence on service delivery. These characteristics are important to consider in monitoring and mitigating the impacts of future CSG developments.

Conclusion

This study adds to the body of evidence on the health and wellbeing challenges faced by mining communities as they transition from rural to resource-based, and the multi-sectoral approaches adopted to respond to them. Integral to research findings is the need to strengthen identification, measurement and reporting of outcomes so that the community is informed, local stakeholders can respond effectively, and the mining sector can support appropriately. The design of a monitoring system that generates evidence for health and community services, government and the mining sector is a necessity to enable informed decision-making and resource allocation. The governing

role sometimes played by the mining sector extends to the local health system, and highlights the need for improved regulatory frameworks, transparency and accountability. Health systems in regional settings are unique and influenced by the community. The findings from this study have relevancy to governments, health professionals and the mining sector with the objective to strengthen pathways for sustainable community development and improved resource allocation and planning.

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List of abbreviations:

ARIA   Accessibility/ Remoteness Index of Australia

CSG   Coal Seam Gas

CSR   Corporate Social Responsibility

GP   General Practitioner

HNA   Health Needs Assessment

KII   Key Informant Interview

LGA   Local Government Area

LNG   Liquified Natural Gas

Funding information:

7. Discussion

7.1 Overview of this Chapter

This thesis sought to strengthen understanding of how the mining industry can adversely affect the social determinants of health and wellbeing of surrounding communities, with a focus on the potential impacts of CSG mining. The hypothesis that there may be broader, direct and indirect impacts on health and wellbeing at an individual or community-level was demonstrated both internationally and through a case study. The secondary aim was to examine the relationship of stakeholders in the local health system and the mining sector, with the intention to develop recommendations that improve measurement, monitoring and response to potential impacts of mining in surrounding communities.

This Chapter brings together primary and secondary research to review major findings identified from the research topic. The first key theme is the corroboration that broader health and wellbeing concerns can arise from living in proximity to CSG mining development, and that there are some similarities with other settings and other types of mining. The second major theme is identified through exploring the complexity and functionality of rural health systems in communities commonly affected by UNG mining, and examining how key stakeholders can work within this environment to optimise investment. Synthesis of major findings led to a set of recommendations, which highlight the key considerations for communities, health and service providers, governing agencies and mining companies. A review of existing models for monitoring and evaluating broader, or public health, impacts is presented and recommendations towards an improved framework outlined.

7.2 Key Themes Identified in this Thesis

1. There is global recognition that mining activity can affect the social determinants of health in surrounding communities

The objective of Part 1 was to *review the available evidence for health and wellbeing effects of mining activity* in low, middle and high-income countries**.** The systematic reviews presented evidence for the interaction between the presence of mining activity and social determinants of health. Primarily rural communities living in proximity to mining activity in HICs complained of poorer health, and there was evidence of an increased prevalence of chronic diseases. Beyond physical health, communities also suffered from relationship breakdowns and decreased social connectedness, which was negatively associated with the influx of mining personnel and physical changes in the community landscape.

In LMICs, in communities with typically poorer access to health services and employment opportunities, mining activity (iron ore, gold and diamond mining) was perceived to influence health behaviours, employment conditions, livelihoods, and socio-political factors, which were linked to poorer health outcomes. There was evidence of negative effects of mining on broader community health issues in LMICs dating back thirty years.

There were common threads between LMICs and HICs: the presence of mining was perceived to influence the social determinants of health. Effects on the *environment* from increased mining activity affected hunting and fishing opportunities in French Guiana, or the desirable landscapes of a rural farming town in Australia, which had onward implications for food security and quality of life. Mining presented inequitable opportunities for male *employment* in rural Indian communities, and families with shift-working partners in Australia felt isolated. Lifestyle behaviours associated with mining personnel in Tanzania and a population boom from secondary employment opportunities in Canada affected *health services* capacity. Mining activity exacerbated issues around unemployment and migrant labour, which led to feelings of isolation and poor wellbeing of communities in South Africa, and landholders in Australia felt a changing community structure had negative implications on mental health and *social networks*. Crucially, there was no methodological consistency in how these broader issues were identified or monitored.

To the author's knowledge, this was the first systematic review conducted to explore broader public health issues with synthesis of findings across multiple countries. The majority of studies included in the review focused on coal mining and other conventional mining methods, which led the authors to question the potential public health impacts of modern mining methods, such as UNG.

2. Living in proximity to coal seam gas mining can have implications on the social determinants of health

The objective of Part 2 was to *explore the association between CSG development and public health outcomes* via a case study in regional Queensland, Australia. The research objective was particularly pertinent in Australia, where CSG extraction had been growing exponentially since 1995, hitting 30% of the country's overall gas production and a subsequent 'boom' in 2015 – 2016. CSG development suddenly became visible in the rural landscape and activity was met with apprehension and in some cases lawful protest amongst the local populations, and on an international scale.

Results of the case study reinforced several of the findings synthesized in the systematic reviews: there was evidence of social, economic and environmental impacts of CSG mining, which influenced health and wellbeing outcomes. These community-

level impacts were perceived to have onward direct and indirect influences on health and wellbeing outcomes at community and individual level. Communities were concerned for the influence of high-risk lifestyle behaviours (e.g. drug and alcohol abuse), which had reportedly increased during the mining boom, on families and the social fabric of the town. There was concern for how fluctuations in the local economy (e.g. housing price variability) would impact affordability, quality of life and mental health. It was felt that certain groups of people in the community were particularly vulnerable to the impacts of mining (e.g. farmers), and that conditions could exacerbate their already weak relationships and trust within the community. Social costs of CSG development was linked to a perceived increase in social conflict, substance abuse and domestic violence. The methodological design of this study enabled the identification of wellbeing-related outcomes, factors relating to quality of life, or social cohesion, which were influenced by CSG development.

3. **Perceived effects of CSG mining on the social determinants of health appeared to vary with the lifecycle stage of mining and characteristics of the communities**

In exploring the association between CSG mining and health in the case study, patterns emerged relating to the size and history of the region studied and the stage of mining. During the study, the four regions experienced a 'mining boom' in that CSG had recently passed the exploration phase (drilling across several locations to identify if gas can be produced profitably) and was firmly in the construction phase, bringing a high demand for labour and infrastructure. With this there was a boom in population, changes to the built environment, and increased demand on local services, which were characteristics also experienced in other settings. Following construction (approximately two years), CSG development moves in to the production phase (approximately 20 years) where much of the physical presence of the industry in the community and imported manpower is reduced.

Communities involved in the study were cognisant of the lifecycle stages of CSG mining, and cautious of even more change in the face of the mining downturn. However, they didn't know when the transition of stages was planned for, which added to the feelings of uncertainty and distrust. Two of the outer-regional towns were concerned that the identity of their otherwise rural farming town was permanently lost. There was concern that community networks and social fabric of the towns would not recover. People questioned how local residents, who had been temporarily employed in the industry with significantly higher wages than what they were used to, would react in the downturn. The impact on services was discussed in all regions, with concern that health and community services (e.g. primary health care facilities and social support centres) would find themselves with a sudden decrease in demand. Participants from the inner-regional town were concerned about individual-level impacts following the transition from CSG

construction to operation, which could reflect advanced demographics of the town and urban characteristics compared to the more rural towns.

4. **Health systems in rural communities are unique: they are closely interconnected with the health system. Rural health systems are defined by geography and fluctuating climate and economic changes**

The objective of Part 3 was to *explore the interaction between the CSG industry and health and community sector, and opportunities to optimise outcomes* through a case study in regional Queensland, Australia. Prior to studying this interaction, it was pertinent to explore rural health systems and strengthen the understanding of how they operate on a local level. Rural communities often face disproportionate access to health and community services, and health status in regional Queensland populations was generally poorer than urban counterparts. Rural health systems in the case study were largely reactive and significantly affected by local shifts in demography, climate and economy. The community was more closely interconnected in the health system than would be expected of urban settings, and were seen to be an extension of the system. Each community was also observed to possess their own unique needs, with the impact of external and internal agents resulting in different feedback on the system in different communities. The results show that there are a number of factors that impact on health system functionality at the local level, with external agents playing a significant role. It is important to consider these characteristics when examining the association between mining activity and perceived health issues, and the potential pathways for health system response.

5. **There are pathways and opportunities for the mining sector to positively contribute to the operations of the local health system within which they operate**

Health services in regional and remote areas are commonly constrained, with fewer human resources and funding, and fragmentation of services. The mining sector, through its corporate social responsibilities, provides an opportunity for local services to strengthen their planning and delivery. Regional Queensland is characterised by harsh environmental conditions, vast geography and small, isolated populations. The health sector is often constrained by a lack of human resources to deliver services as planned; poor decision-making at the federal level reflecting a lack of understanding of local ways of life; and inability to respond and adapt to fluctuating community needs in the face of flooding, drought, and mining activity.

Mining activity was perceived to indirectly influence the ability of service providers to meet demand, recruit and retain staff, and effectively plan and maintain programs. There was a strong consensus that the mining sector presented an opportunity to inject

finances in to the local health system, but conflicting views on the most effective way to do this. Mining companies were seen as megalithic entities with the ability to exert power and influence over local governments and service planning. Strengthening multi-sectoral engagement and enabling transparent, public consultation and evidence-based funding initiatives was seen as priority measures to improve the relationship between the mining sector and service providers, and ultimately improve and sustain health and wellbeing outcomes for communities.

6. **There is a lack of consistent and robust methodologies to monitor health and wellbeing outcomes in communities living in proximity to mining activity**

A major theme that emerged from the systematic reviews and case study was the lack of empirical and systematic methodology to measure health and wellbeing impacts of mining and response. The majority of studies included in the reviews were exploratory and cross-sectional, consisting of qualitative research design to examine general health and wellbeing, and quantitative methods to examine direct health impacts. Few studies employed mixed methodologies to examine outcomes.

Quantitative studies determined prevalence of particular diseases that were hypothesized to be greater in communities exposed to mining; these measures of association were strengthened when a comparator was included in the analysis (e.g. additional measure of disease prevalence in a community with no proximity to mining). In some studies prevalence was measured against proxy indicators such as variation in distance to mine sites.

The case study in regional Queensland used an HNA methodology, which contrasted with traditional HIAs in its population-level focus and ability to capture broader issues through qualitative inquiry. Whilst the HNA enabled the researchers to identify broader health and wellbeing issues, they were *perceptions* of participants and no causal association with mining activity could be made. The difference between real and perceived impacts of mining could be determined through a combination of quantitative and qualitative inquiry using quasi or experimental studies.

Synthesis of research articles in the systematic reviews also revealed little consistency in the indicators used to measure health and wellbeing outcomes. In some studies, there was little consideration of potential confounders and effect modifiers, weakening the strength of any association made.

7.3 Summary of Key Findings
This research established that there are both common and unique health and wellbeing issues experienced by communities living in proximity to mining internationally. Our understanding of the ways in which CSG mining activity can influence the social

determinants of health has been improved. This thesis argues the importance of understanding how local health systems operate in order to maximise engagement with the mining sector. There are pathways and opportunities for the mining sector to contribute to community development, and this requires engagement with the community and local service providers. This research has highlighted key characteristics of communities, which could serve to inform indicators and tools to improve measurement and response to the impacts of mining.

7.4 Recommendations and Suggestions for Further Research

Research objectives for this study were developed during a time when the rhetoric of the subject included expressions like 'extractivism', 'resource curse' and 'contaminated communities'. (40) These terms reflected a non-reciprocal and negative relationship between communities, the broader public and UNG mining activity. In the academic community, collective effort was made to examine the local factors that had led to development of these terms. Social scientists, political analysts and economists investigated the issue from different angles. The issue was also researched with a public health lens, of which publications from this research made key contributions. (41, 42)

Today, the unresolved issue of inadequate monitoring of UNG mining activity in surrounding communities is on the global agenda. A major conclusion from the collective studies was that our international understanding of the potential local level impacts of mining activity has vastly improved, but studies have been conducted in isolation, and there is little connection between research findings and response mechanisms by key stakeholders. There is recognition that a multi-disciplinary set of stakeholders is needed to overcome the challenge and that a solution can be found through standardising the approach for measurement and mitigation. This has helped shift the dialogue towards optimistic and objective vernacular.

The primary recommendation put forward in this thesis is to improve the measurement and monitoring of the potential implications of UNG mining, and focuses on components of a standardised approach, rather than one specific to the case study. The recommendation is underpinned by the premise that three key stakeholders must be involved for any monitoring framework to be effective– the community, health and community service providers, and the mining sector. Whilst this research topic has been explored with a public health lens, the author acknowledges that for a truly effective framework, collaboration across social, economic, environmental and political disciplines is required.

1. Standardise measurement of SDoH and wellbeing impacts and formalise response and feedback mechanisms

In October 2017, the Scottish Parliament voted in favour of it's government's decision to extend a moratorium on shale gas, a UNG similar to CSG. (43) Public consultation and the commission of several public health reports followed, which uncovered serious gaps in the knowledge of potential exposure on health, socio-economic conditions and climate change. (44) The Government and key stakeholders went on to consult community groups, industry, regulators and public sector agencies, whose opinions and comments were fed in to the inquiry. Significantly, the national inquiry involved a comprehensive review of the peer-reviewed literature to inform its assessment. This national inquiry in to potential public health impacts corroborates the findings in this research, that UNG development cannot continue without critical inquiry and standardised assessment of potential health and wellbeing impacts of its activity.

   I. **Standardise measurement and monitoring**

The objective of monitoring is to assess progress, identify risks and mitigate negative impacts of a project or activity. In order for a monitoring system to be effective, it must have clear definitions of indicators and data sources, defined periods within which data is collected, and a designated owner who oversees the system. It is imperative that information generated via the system is fed back to key stakeholders to continuously improve its program design or implementation. In this context, the program or activity might be CSG development that will shortly commence in a rural community. It is recommended, however, that the program sit within a broader system that monitors indicators at a population level to avoid duplication of data and enable identification of relationships that may have been missed in an isolated system. This approach goes beyond the traditional health and social impact assessments, arguing for a continuous measurement against a set of indicators tailored to the local context.

Through the findings generated in this research, clear recommendations are put forward herein as prerequisites for a standardised monitoring framework for the health and wellbeing impacts of mining activity at a local level:

- ❖ Design with a multidisciplinary approach, considering the multi-faceted and complex interaction of determinants and outcomes, evidenced by recent literature reporting an association between mining activity, climate change and adverse health outcomes - therefore a multi-criterion and holistic analysis is imperative (40);
- ❖ Design should reflect the social determinants of health model, considering both subjective and objective data sources;

- ❖ The effects of cumulative impacts are difficult to measure, but are successive, incremental and can combine impacts of one or more activities. Therefore monitoring systems cannot be specific to one mine site or development activity;
- ❖ The objective of monitoring is not to identify risks and negative impacts, but to gain a holistic understanding of what is happening in the community throughout;
- ❖ Assessments must be periodic, capturing the various stages of the mine lifecycle: exploration, construction, operations, decommissioning and closure including post-closure, and comparison with a baseline; and
- ❖ Consider medium to long-term impacts long after specific mining programs have ceased. This corroborates the need to implement the system within a broader community-based monitoring framework.

The systematic reviews and case study in regional Queensland provided insight in to the diversity of indicators that should be included in a monitoring framework, and can be tailored to local contexts. With reference to the literature, in summary, a tailored framework should consider:

- ❖ That variables influencing the magnitude of impacts felt by communities are previous experience and population density/size: data on the occurrence of mining activity and demographics can be readily obtained;
- ❖ That the relative risks to communities could vary with the extent of mining – how many wells drilled, what land area, the size and proximity of the local population, how the mining industry is perceived and whether information is readily available to the community (43);
- ❖ Data on vulnerable groups in the community who may be disproportionately affected by mining activity e.g. quality of life indicators for farmers;
- ❖ Assessment and possible alignment with existing policies and frameworks for health and wellbeing at the local level which reduces the risk of duplicating data collection and enables wider dissemination of information generated;
- ❖ Standardised indicators of wellbeing, that could support identification of community level impacts of mining activity; and
- ❖ The combination of existing indexes and frameworks that have been recommended by other researchers in this field. The Human Development Index of the UN Development Programme has been put forward as a relevant tool for monitoring impacts; and the environmental sustainability index, which compares countries based on over 100 indicators divided in to five groups: environmental systems and stresses, human vulnerability, societal adaptability and global stewardship, has also been recommended; and another study used a multi-criterion analysis, measuring 18 sustainability indicators across environmental, economic and social determinants. Social indicators included the incidence of work injuries, public support index, diversity of direct employment. (45, 46)

II.   Formalise response and feedback mechanisms

A monitoring system relies on quality data collection, robust analysis and dissemination of information in a format that facilitates uptake and action. An independent regulatory body must own the proposed monitoring system and it must have legal standing. (41) The Global Reporting Initiative (GRI) is an independent regulatory body that oversees sustainability reporting of their members, and empowers decisions that enable social, environmental and economic benefits. (47) GRI is an example of the type of independent, regulatory stakeholder that could govern a broader system, but this would be challenging at a local level. Academic oversight is also necessary to assist with data capture methods and quality assessment.

The system should be able to provide real-time feedback to key stakeholders to assist with resource planning and decision-making, which could be enabled through an online, user-restricted platform. This could assist the mining sector in directing resources at the community level that address current health and wellbeing issues. Secondly, this could also support the health sector in adapting their services to meet existing needs and providing the evidence from which to seek additional funding and resources. Thirdly, this platform could also be accessed by the community, which would offer a credible and transparent source of information.

2.   Strengthen community resilience through engagement with the mine lifecycle and monitoring system

An influencing factor for wellbeing in communities was dealing with uncertainty and the political nature of mining activities. Improving the public dialogue around mining activity relies on effective and meaningful community engagement. Rural communities in Queensland demonstrated a close interaction with the health system, in some ways shaping the way services were delivered and acting as contributors as well as being the end-users. Interaction with and involvement of the community is imperative to overcome challenges associated with the mining industry, and the monitoring framework is suggested as a mechanism to achieve this. As a first step, it is crucial to understand how the community interacts with the mining sector, including pathways for receiving information and responding to local activity, which has implications for the feedback mechanisms in a monitoring framework. The public deserves the right to be informed about what is happening in their community and effective feedback mechanisms can enable dissemination of transparent, evidence-based information. Another consideration from this research is the need to build a community's adaptive capacity, and resilience to the potential impacts of mining activity. Community resilience can be defined as responding to adverse external impacts with a view to reinstate, maintain and enhance community wellbeing using available resources. (48) In regional Queensland settings,

building community resilience was a local government objective, to overcome the impacts of climate change, such as drought, in addition to mining. (40)

3. **Support service providers to respond to health issues and harness investments made by mining companies for effective community development**

Health service planning and availability can be strengthened through investments and support from the mining sector. This can be most effectively achieved by decentralising ownership and decision making, given that policy makers and planners based in urban centres have little understanding of the local nuances that influence the effectiveness of health services. A monitoring framework would assist service providers in proactively planning and delivering health services, providing clear datasets from which to design relevant programs. These may be specific vulnerable groups, or population level initiatives that can be readily funded by mining companies looking to act on their social corporate responsibilities.

4. **The mining sector must engage with the community in a meaningful and transparent manner to improve relevant resource allocation**

Whilst it is not the primary objective of a mining company to invest in the local community, there are significant benefits in doing so. If this investment is informed by the needs of that community then it will have greater impact. In order to develop evidence-based strategies and funding initiatives that avoid tones of patronage and *clientelism*, it is vital that the mining company has access to information that reflects the state of the community and addresses gaps. (49) A monitoring system that is accessible and robust would provide this information. A challenge to consider is the settings where those operating on the ground are local contractors, and the managing mining company is situated further away without little understanding of what happens to the community, but with decision-making authority.

A significant issue is the meta-governing role powerful mining companies often take in local communities, alluded to by service providers in the case study and noted in the broader literature. Local governments were overshadowed by powerful companies, and unable to respond quickly to the impacts in their communities. This relationship has been investigated significantly in the literature, with evidence that mining companies use the weakly defined social license to operate as an entry to exploit communities and local governments. (50) The monitoring system would need to be complemented by the continuous assessment of how mining companies are operating on the local level and whether they are adhering to principles of good governance.

8. Conclusion

Unconventional natural gas extraction and the implications of mining activity on nearby communities is a subject of major concern internationally, particularly in high-income countries. Through the application of core public health theories and methodologies, including the Social Determinants of Health model, complex adaptive systems theory and health needs assessments; this thesis has significantly contributed to the discourse and demonstrated a significant association between mining activity and community health:

- ❖ There is global recognition that mining activity can affect the social determinants of health in surrounding communities;
- ❖ Living in proximity to coal seam gas mining can have implications on the social determinants of health;
- ❖ Perceived effects of CSG mining on the social determinants of health appeared to vary with the lifecycle stage of mining and characteristics of the communities;
- ❖ Health systems in rural communities are unique: they are closely interconnected with the health system. Rural health systems are defined by geography and fluctuating climate and economic changes;
- ❖ There are pathways and opportunities for the mining sector to positively contribute to the local health system within which they operate; and
- ❖ There is a lack of consistent and robust methodologies to monitor health and wellbeing outcomes in communities living in proximity to mining activity.

It is beyond the scope of this thesis to present a comprehensive standardised framework for monitoring broader health and wellbeing implications of UNG development, as this relies on a multidisciplinary approach. However, this thesis presented a set of key recommendations and suggestions that could be considered in designing the framework, and highlights characteristics that should be tailored at the local level. Formalising, publicising and regulating this process is the next step along the road to mending and preventing fractured communities from the potential impacts of mining.

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10. Appendices

10.1 Search strategies for Chapters 2 and 3

Search strategies for PubMed, PsycInfo, ScienceDirect and Medline

(((health OR wellbeing OR happiness OR quality of life OR personal satisfaction OR social capital)) AND (mining OR mine OR extractives industry [Title/Abstract])) AND (rural OR region* OR remote OR isolat*)

Any Field: health OR wellbeing OR happiness OR quality of life OR "personal satisfaction" OR "social capital" *AND* **Abstract**: mining OR mine OR "extractive industry" OR "resource industry" *AND* **Any Field**: rural OR region OR remote OR isolate *AND* **Population Group**: Human *AND* **Age Group**: Adulthood (18 yrs & older)

(health OR wellbeing OR happiness OR 'quality of life' OR 'personal satisfaction' OR 'social capital' AND (rural OR region* OR remote OR isolat*)) and TITLE-ABSTR-KEY(mining OR mine OR 'extractives industry' OR 'resource industry').

(health OR wellbeing OR happiness OR 'quality of life' OR 'personal satisfaction' OR 'social capital' AND (rural OR region* OR remote OR isolat*)) and (mining OR mine OR 'extractives industry' OR 'resource industry')

All limited to humans, adulthood (18 years +), English

10.2 Qualitative Research: Key Informant Interview Guides

KEY INFORMANT INTERVIEWS IN HEALTH AND WELLBEING – DIRECT SERVICE PROVIDERS

Date:
Region:
Town:
Name of facility:
Type: (hospital, community service, government department)
Informant: (name, position)
Interviewer:

Key demographic questions (to be completed in survey form)
 ➢ What are your qualifications?
 ➢ How many years have you worked in your current profession?
 ➢ How many years have you been living in this community?
 ➢ How many years have you been working in this community?
 ➢ Have you lived/work in another rural and regional area? If so where?

Perception of health and wellbeing of community in general
 ➢ Can you describe health and wellbeing?
 ➢ In your own words can you give an overall summary of health and wellbeing in your community?
 ➢ What do you consider are the health and wellbeing priorities for this community?
 ➢ Can you describe some activities related to health and wellbeing that exist or should exist in this community?
 ➢ How important do you think health and wellbeing is to the community? How interested do you think people are in health and wellbeing in this community? What do people do in this community to maintain health and wellbeing? Why do people participate in health and well-being activities in this community?
 ➢ Can you describe what influences people's health and wellbeing? What are the barriers and facilitators for optimal health outcomes in the community?
 ➢ What has impacted on the state of health and wellbeing in the community, positive and negative?
 ➢ Are there groups in the community that experience higher levels of health and wellbeing? If so who and why?
 ➢ Are there groups in the community that experience lower levels of health and wellbeing? If so who and why?
 ➢ Can you describe how people interact in your community? (Perceived connectedness of community members)

Overview of role and service
 ➢ Can you describe the organisation that you work for?
 ➢ Can you tell me a bit about your role here? Can you describe your role in this service? What do you do here? How does it relate to health and wellbeing in

your community? (Perception of role of service/individual role in managing the health needs of the community)
- Can you describe the history of this service in this region? (development, activity in region, reason)
- Can you describe the target population for this service?
- Can you describe how and why you become involved in this work?
- How does your role impact on health and wellbeing for the service target group? for the community? What influence do you have? (Perception of power and influence over health and well-being priorities for community).
- How are you involved in driving health and well-being solutions for the service? For the community? What is your power and influence in mobilising solutions, influencing others for positive change and facilitating communication within the communities? (Are they a Driver, Blocker, Supporter, Bystander or Abstainer/ Opinion Leader, Advisor to policy maker or decision maker)

Perception of health and wellbeing needs for people accessing your service
- Can you describe the health and well-being experiences of the population you work with? (Is it different from what you mention before for the broader community?
- How is health and wellbeing achieved by this population? What are the successes and limitations for health and wellbeing of this group?)
- How important is an issue like health and wellbeing to your client group?

Barriers and facilitators to delivering health and well-being services in your community
- What helps you deliver services effectively? What doesn't? (Perception of work and practice issues limiting or strengthening current situation for managing health needs in community). (Perceptions of barriers/challenges and facilitators to improving health and wellbeing in the community. E.g. Services, staffing, financing, governance, access to technology, health information systems.)
- Perception of what interventions/ services have been implemented to improve the health and wellbeing of communities?
    o What worked and what didn't?
- Perceptions of what interventions/ services are lacking in the community that will assist in managing health and well-being services.

Multi-sectoral interaction and support
- What is the level of collaboration with other disciplines within the community?
- Perceived level of support from local, state and federal government
- Perceived role of other sectors that have influential power on health and wellbeing of the communities.
- The role of: Economy and employment; Security and justice; Education and early life; Agriculture and food; Infrastructure, planning and transport; Environments and sustainability; Housing and community services; Land and culture.
- Perception of who are the Drivers, Blockers, Supporters, Bystanders or Abstainers for obtaining health and well-being priorities.

Summary and Recommendations
- ➢ Is there anything else you would like to add?
- ➢ Can you recommend someone else who may also like to be involved in this research.

10.3 Qualitative Research: In-depth Interview Guides

IN-DEPTH INTERVIEW: COMMUNITY MEMBERS

Date:
Region:
Town:
Participant ID:
Interviewer:

Background
➢ What brought you to live in the area?
➢ Have you worked or lived in any other rural or regional area?
➢ Why do you think people live in regional or rural areas? Why do people choose to live out there?

Health and Wellbeing beliefs
➢ What makes people healthy?
  o How does wellbeing fit into this
  o What are your thoughts on wellbeing?
➢ How important do you think people in the community consider health and wellbeing to be?
  o How much do you think people here invest in health and wellbeing (for themselves, their families, their community)?
  o How do you know this, what actions do people take to show that they are trying to improve their health and wellbeing, OR what actions do they take that show that they are not?

The health and wellbeing environment for the community
➢ What affects the health and wellbeing of this community (positive and negative)
  • E.g., socio-economics, socio-cultural conditions/ variety and inclusiveness of community, living conditions/ natural environment impact, safety/ security issues, dynamics and resilience of local economies, community engagement, service provision, working conditions/ opportunities, educational and recreational opportunities, individuals/ institutional influences, community connectedness and resilience, historical events/ recent changes, transient populations
  • What are the reasons people have poor health and wellbeing here?
    o What are the perceived reasons for why people in community may have poorer health and wellbeing? What are the barriers?
    o Why do some people have better health and wellbeing here? E.g. behaviour, pursuits, personal histories, circumstances, supports, education, pressures (peer, family, community), work, finances, environment (where they live who their influences are)

- o What do you consider to be some of the risky health and wellbeing behaviours of the community?
- o What are the good health and wellbeing behaviours of the community?

Potential influences on acceptability of health and wellbeing interventions
- ➢ What activities have you heard about that aim to improve health and wellbeing for the community? (local initiatives, state and federal)
  - o Have they been effective? Why
- ➢ What influences acceptability of health and wellbeing interventions.
  - o E.g. Socio-economics, socio-cultural, living conditions, natural environment, service provision/ access, employment profile, education, attitude etc.
  - o Perception of the role of mentors, role models, community champions, local leaders, government and policy makers to promote health and wellbeing activities.
- ➢ How can we encourage people to engage in health and wellbeing activities in your community?

Health and wellbeing information seeking behaviour
- ➢ How do you think most people in the community get information about health and wellbeing"
  - o What are the key sources/ local channels of health and wellbeing information for the community? E.g. online, peer, from health professionals
  - o How do people make decisions about health and wellbeing? What guides them?

- ➢ Who do you consider to be the key people involved in health and wellbeing for the community?

10.4 Qualitative Research: Focus Group Discussion Interview Guides

THEME LIST: FOCUS GROUP DISCUSSION WITH COMMUNITY MEMBERS

This theme list is not meant to rigidly structure the focus group discussion but instead be used as a guide to the discussion where necessary. Themes have been developed around the key objectives of the project.

THEMES

Health and well-being beliefs and priorities
Beliefs about community health and wellbeing
- What makes people healthy?
- What does wellbeing mean (for the community)?
- Importance of health and wellbeing in the community.

Perceived health and well-being priorities
- What are the health and well-being priorities of the community?
- Who are/ what groups are being most impacted/ should be targeted?
- What are the perceived actions that should be taken?
- How serious is the problem of these identified priorities?

The health and well-being environment
Perception of social and community influences on health and wellbeing in the local area
- What affects the health and well-being of this community (positive and negative) E.g., socio-economics, socio-cultural conditions/ variety and inclusiveness of community, living conditions/ natural environment impact, safety/ security issues, dynamics and resilience of local economies, community engagement, service provision, working conditions/ opportunities, educational and recreational opportunities, individuals/ institutional influences, community connectedness and resilience, historical events/ recent changes, transient populations (FIFO, DIDO, BIBO, seasonal workers, grey nomads etc),
- What are the perceived reasons for why people in community may have poorer health and wellbeing?
- What are the perceived reasons for why people in community may have better health and wellbeing? E.g. behaviour, pursuits, personal histories, circumstances, supports, education, pressures (peer, family, community), work, finances, environment (where they live who their influences are).

Perceived barriers and facilitators to achieving health and wellbeing goals of the community
- E.g., Physical, social, environmental, historical, economic etc.

Health and well-being knowledge and information seeking behaviour
Health knowledge and perception of health and wellbeing behaviour in the community

- What are the risky health behaviours of the community?
- What are the good health behaviours of the community?
- Knowledge of preventative health strategies for individuals and the community.
- Knowledge of the role of key people in health and wellbeing for communities and individuals.

Information seeking
- What are the key sources/ local channels of health and well-being information for the community?
- Who are the key people involved?

Strengthening community action
Perceived motivation for improving health and wellbeing in the community
- How important is health and well-being to the community?

Perceived solutions for improving health and wellbeing
- What would improve health and wellbeing here?
- Perception of how to maintain or improve health and wellbeing as a community?
- What should be done/ what community actions are needed?

Potential influences on acceptability of health and well-being interventions
- Have you heard of any activities around improving health and wellbeing for the community?
- Have they been effective? Why
- What influences acceptability of health and well-being interventions. E.g. Socio-economics, socio-cultural, living conditions, natural environment, service provision/ access, employment profile, education, attitude etc.
- Perception of the role of mentors, role models, community champions, local leaders, government and policy makers to promote health and well-being activities.

Perceived strategies to strengthen community action for improving health and wellbeing
- How can we encourage people to engage in health and well-being activities in your community?