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Title: Preconception health in England: a proposal for annual reporting with core metrics.

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Abstract: There is growing interest in preconception health as a critical period for influencing not only pregnancy outcomes, but also future maternal and child health, and prevention of long term conditions. Successive national and international policy documents emphasise the need to improve preconception health, but resources and action have not followed. We argue for a dual intervention strategy at the level of public health (e.g. by improving the food environment) and individuals (e.g. by better identification of those planning a pregnancy with support to optimise health before conception) in order to raise awareness of preconception health and to normalise the notion of planning and preparing for pregnancy.
Existing strategies that target common risks factors, such as obesity and smoking, should recognise the preconception period as one of special opportunity for intervention, based on evidence from life course epidemiology, developmental (embryo) programming around the time of conception and maternal motivation. To describe and monitor preconception health in England, we propose an annual report card using metrics from multiple routine data sources. Such a report card should serve to hold governments and other relevant agencies to account for delivering interventions to improve preconception health.

Preconception health in England: a proposal for annual reporting with core metrics.

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For the Preconception Partnership.

Preconception health in England: a proposal for annual reporting with core metrics.

Background

The recent Lancet series on Preconception Health drew attention to this under-appreciated period in the life course when health, behavioural and environmental 'exposures' can have far-reaching consequences not only for pregnancy outcomes but also for health across generations [1-3]. Besides extensive media coverage, the series was discussed in the UK Government (House of Lords) debate on childhood obesity [4]. Soon afterwards, Public Health England produced a suite of resources making the case for a focus on preconception care [5]. The Preconception Partnership, a group of engaged stakeholders, convened to discuss how to translate findings into policy and practice. The Partnership proposed an 'annual report card' to describe the state of, and trends in, preconception health using routine national data sources (metrics). The report card would offer methods for continued surveillance and accountability of relevant agencies in improving the nation's preconception health. This paper describes the conceptual framework for the report, including a dual intervention strategy and a set of core metrics, with illustrated examples of how the accumulated data could best describe and monitor the national state of preconception health. Going forward, we invite suggestions for other suitable metrics to help capture the national picture.

Conceptual Framework

The conceptual framework for the annual report draws on evidence presented in the Lancet series and by Public Health England, including the mechanism whereby parental preconception 'exposures' contribute to the developmental origins of health and disease (2). It also incorporates our proposal for differing definitions of the preconception period: (1) the biological perspective (days to weeks before embryo development); the individual perspective (a conscious intention to conceive, often weeks to months before conception); and the public health perspective (months or years beforehand to address preconception risk factors such as diet and obesity). This framework provides the basis for a dual intervention strategy operating at population level, irrespective of pregnancy planning, and at individual level for those who plan to or become pregnant. The dual strategy responds to all three definitions of the preconception period as it addresses factors key to the biological perspective, such as folate deficiency, as well as the individual and public health perspectives.

At the level of the individual, we need to improve the identification of women or couples planning a pregnancy who would likely benefit from actions to improve health before conception. This requires reorientation of the health services and health care professionals to normalise conversations about planning for pregnancy during routine visits, e.g. for contraception, cervical screening, and for management of long term conditions such as diabetes. Since plans to conceive may not be disclosed spontaneously

to health care professionals, we need to heighten awareness, among healthcare providers and the public alike, of the importance of optimising preconception health. The Preconception Partnership endorses the need for services across this critical period of the life course to dovetail with those preceding and following, to provide a continuum of support and care [6-8].

At population level, a wider, parallel strategy is required to reduce preconception risk factors, irrespective of pregnancy planning. Key to this is recognising the impact of the wider determinants of health - poverty, education, employment and support networks - on preconception risk factors. The preconception health agenda will best be served by a general reduction of social inequalities in health and by supporting individuals to develop health awareness. Advocacy must emphasise society's responsibility for preconception health and create a demand for an environment that fosters good preconception health; it is not just women's business. Opinion leaders and politicians with portfolios across social care, the food industry, environment and employment need to engage. Advocacy efforts should go hand–in-hand with a social movement that draws attention (e.g. through media campaigns) to the societal gains in terms of human capital from supporting for young people to achieve good health before conception.

Transnational advocacy to improve preconception nutrition has begun. The World Health Organisation (WHO) global consensus on Preconception Care to Reduce Maternal and Childhood Mortality and Morbidity was initiated in 2012 and released a strategy for member states to stimulate action [9]. The United Nations General Assembly Decade on Nutrition 2016-2025 [10] has stimulated a focus on women of childbearing age and adolescent girls in several initiatives including: the Comprehensive Implementation Plan on Maternal, Infant and Young Child Nutrition [11]; Global Action Plan for the Prevention and Control of Noncommunicable Diseases 2013-2020 [12] Commission on Ending Childhood Obesity, [13] Global Strategy for Women's, Children's and Adolescent's Health (2016-2030); [14] and the United Nations Sustainable Development Goals. [15] As these initiatives stimulate a surge of intervention activity worldwide, it is important that we have robust measures in place to detect the outcomes.

Strategies need to be tailored for different stages in the life course (3): i) children and adolescents; ii) adults with no current intention to become pregnant, and iii) adults intending to become pregnant (again).Together, these strategies seek to increase preconception awareness, planning and preparation for pregnancy - related but distinct aspects of preconception health that can be captured through a variety of measures (Table 1). *Awareness* refers to recognition at any age that health before conception affects the chances of a healthy pregnancy and baby, as well as disease risk in later life. *Planning* implies a conscious intention to become pregnant in the near-to-medium future.

Preparation means taking action to improve health before pregnancy. Neither awareness nor planning alone is likely to have much impact on preconception health (women can plan pregnancies around domestic circumstances without changing health behaviours), whereas preparation is impossible without planning and some awareness, combined with motivation and engagement.

A national intervention strategy with potential core metrics for preconception health.

In 2017 there were 679,106 live births and 2,873 stillbirths in England and Wales, and an estimated total fertility rate of 1.76 children per woman. Fertility rates in women in their thirties and forties have been increasing since the late 1970s, while the fertility rate in women under 20 has declined significantly this century [16]. Our analysis of the national maternity data for England (see below) estimates that 35% of all pregnancies in 2017 were first pregnancies. We have recently proposed intervention strategies to improve preconception health (3). These are summarized in Table 1, alongside core metrics, with further description below. Strategies and metrics addressing smoking, alcohol, nutritional status, pregnancy planning and birth interval all apply to paternal, as well as maternal, preconception health.

Children and adolescents

For children and adolescents who are not intending to become pregnant for many years (if at all), the concept of preconception health needs to be integrated into a wider educational curriculum about healthy behaviours that also explains why health is something to consider before, rather than after, a pregnancy occurs. In addition to national datasets, such as the National Child Measurement Programme, [17] which provides estimates of overweight and obesity levels in primary schools, organisations such as the Schools Health Education Unit [18] and the Association for Young People's Health [19] also collect or collate large scale data relevant to preconception health from government statistics, household and school surveys. The forthcoming introduction of mandatory Health Education alongside a reformed curriculum for Relationships and Sex Education in schools [20] presents an ideal opportunity to introduce the notion of optimal health before planning a future pregnancy, in addition to the more immediate concerns of avoiding unwanted consequences of sexual activity. The inspection framework of the Office for Standards in Education (Ofsted), the regulatory board for schools in England, is currently under review; this might provide an opportunity to consider ways to assess the effectiveness of a school curriculum in which preconception health is integral to a broader health and wellbeing curriculum.

Food environment

Improving the food environment presents wide-ranging opportunities and challenges, from mandatory food fortification (e.g. fortifying flour with folic acid and other vitamins) and fiscal measures (such as minimum alcohol pricing and sugar sweetened beverage levy) to

regulation of the food retail and food service industries (e.g. food labelling and marketing and promotions of unhealthy foods, location of supermarkets and fast food outlets). The UK Government has recently announced a consultation on mandatory folic acid fortification of flour to prevent fetal abnormalities. Over 80 countries have already taken this important step and all studies have observed a subsequent decrease in prevalence of neural tube defects (NTD) [21] Data on the number of NTD diagnoses and terminations are available from congenital anomaly registers in the UK from which it is estimated that 2014 fewer NTD pregnancies would have occurred had folic acid fortification been implemented in 1998, as it was in the USA [22].

The priority that governments place on developing an environment supportive of preconception health and nutrition could be monitored through content analyses of national and local government policy documents and publicly available information. Public Health England recently published a suite of resources to help in planning and preparation for pregnancy; these should be embedded into healthcare systems and updated on a regular basis. The food industry has particular responsibilities for improving the food environment for adolescents and young adults; monitoring of the corporate social responsibility statements, company websites and marketing practices of national food retailers and manufacturers should be undertaken. Where appropriate, health insurance companies should be required to demonstrate how their health promotion activities are contributing to preconception health. This might be strengthened by international bodies such as the United Nations Global Compact, which liaises with many large and small private sector organisations under initiatives such as Health is Everyone's Business[23], or by WHO building on its Framework of Engaging with Non-state Actors[24]. The findings from these analyses would provide an overview of the commitment and leadership of these organisations to optimising preconception health and could provide impetus for generating future action through competition [25, 26].

Progress on key environmental indicators can also be measured using national datasets. The Family Food datasets derive from the annual Living Costs and Food Survey which is conducted with approximately 5000 families in the UK and provides information on household food and eating out purchases [27]. Data from those of reproductive age could be used to monitor household purchasing and expenditure patterns, among those of childbearing years, on food categories that are markers of healthy or unhealthy preconception diet including fruit and vegetables, wholemeal versus white bread, takeaway foods and sugar sweetened drinks. The Food environment assessment tool (Feat) provides data on the density of fast food outlets and supermarkets by local authority, and can be used to assess density by neighbourhood deprivation. [28] Fast food outlets are most prevalent in deprived neighbourhoods [29, 30] and monitoring using Feat could support local authority planning decisions to help improve preconception health among disadvantaged groups [31]. EuroMonitor data could be used to track sales of vitamin and

mineral supplements, such as folic acid, recommended before conception by the NHS, as an indicator of increasing societal awareness of the importance of micronutrient sufficiency for a healthy pregnancy. If routine assessment of the healthfulness of the in-store environment of retail outlets were combined with environmental health food safety audits, then data on availability, variety and promotional activities for healthy and unhealthy foods could be examined.

Current public health strategies and surveys

The 'Improving Prevention' work stream of the Maternity Transformation Programme, led by Public Health England, places emphasis on improving the health of women before, during and after pregnancy. This work stream has targeted initiatives to increase the proportion of smoke free pregnancies, improve perinatal mental health and embed prevention throughout the maternity pathway. Since several risk factors during pregnancy, such as smoking and obesity, are already targets of public health strategies, we need to highlight the preconception period as one of special opportunity for intervention, based on evidence from life course epidemiology, developmental (embryo) programming around the time of conception and maternal motivation [1-3].

Routine surveys can provide useful data on nutrition, smoking, alcohol and other risk factors for pregnancy. For example, the UK National Diet and Nutrition Survey (NDNS) is a nationally representative, rolling programme that collects detailed information on the food consumption, nutrient intake and nutritional status of the general population aged 1.5 years and over . Now in its eleventh year, the survey uses a four-day estimated (unweighed) diary and covers a representative sample of around 1000 people per year. Methods are robust, but under-reporting of nutrient intake is known to be a problem, particularly in women with higher BMI. The Health Survey for England, commissioned by NHS Digital, is another useful source. It provides nationally representative data on smoking, alcohol, BMI, physical activity and fruit and vegetable consumption, as well as biomarkers (blood pressure, cholesterol and glycated haemoglobin) from nearly 8000 people aged over 16. The latest report combines these data to assign a multiple risk score; the proportion of women with no risk behaviours was highest (17%) for women aged 25 and 44 years, while the most common combination of risks in women was low fruit and vegetable consumption with obesity [32]. The public health outcomes framework [33] includes several measures relevant to a report card on preconception health, including MMR vaccination coverage, rates of excess weight in children and adults, physical activity, smoking, consumption of fruit and vegetables, under 18 conceptions and breastfeeding.

Primary care databases

Primary care databases are another useful source of data on risk factors for pregnancy health [34] (Figure 1). The Clinical Practice Research Datalink (CPRD) contains computerised

primary care records, including diagnoses, prescriptions, tests from primary care and referral data covering around 9% of the UK population. The Royal College of General Practitioners (RCGP) Research Surveillance Centre (RSC) includes over 400 practices (around 5% of the population of England) [35]. Both are long established, provide good quality data that is broadly representative of the population (UK or England respectively) and can be linked using pseudonymised NHS number to other large databases (e.g. hospital and cause of death data). The RCGP RSC is one of the oldest sentinel networks in Europe. It provides continuous feedback to practices about data quality, through visits now augmented by a dashboard. [36] Practices can collect samples, administer questionnaires and recruit to studies. While data quality is among the best in primary care, variation in completeness and accuracy of data brings limitations. [37] By contrast, no routine, consistent or reliable data on preconception health are collected in sexual and reproductive (family planning) or assisted reproduction (IVF) clinics. The national Maternity Services Dataset (below) provides a new opportunity to link data from primary care databases on individual women before conception to data from subsequent pregnancies and resulting offspring.

Maternity datasets and pregnancy planning

The NHS Maternity Services Dataset (MSDS) is a new source of data which flows from all maternities in England [38]. It records individual data from the antenatal booking appointment, through scans and screening tests for fetal and maternal health, to delivery (method of delivery and birth complications) and outcome (gestational age, birthweight, stillbirth, live birth, Apgar scores, newborn examination). Content includes demographic and social factors (English as a second language, social support, complex social factors), health behaviours and lifestyle factors relevant to preparation for pregnancy (BMI, smoking, alcohol, folic acid supplementation), obstetric history (previous pregnancies and outcome), relevant medical history (asthma, epilepsy, diabetes, cardiovascular, mental health etc.) and medical complications developed during pregnancy (gestational diabetes, hypertension).

The dataset provides a national cohort (>600,000 records per year) which can in future support population surveillance of inequalities, trends over time, local and national benchmarking and international comparisons. Since it can link subsequent pregnancies in the same woman (figures 2 and 3), it will be possible to estimate birth interval and interconception weight change which are important risk factors for maternal and child health. Linkage of the MSDS to other datasets such as Hospital Episode Statistics (including neonatal care) and Community Services Dataset (growth, nutrition, child development outcomes) for assessment of longer term health and development outcomes is in development. MSDS version 2 will replace earlier versions in April 2019 and is more flexible, lending itself to further data on preconception health such as glycated haemoglobin (HbA1c) at the booking visit. Since the MSDS carries financial incentives for compliance with data coverage and quality standards, completion rates are good (e.g.

booking data 80-90% complete in 2017 with 1% missing for deprivation, 14% for ethnicity) and are expected to improve further.

The London Measure of Unplanned Pregnancy (LMUP) is a validated measure, composed of six simple questions, that scores (from 0 to 12) the extent of planning for a current or recent pregnancy [39]. The sixth question asks specifically about actions taken in preparation for pregnancy such as eating more healthily or seeking health advice. Extensive research shows that the LMUP is easy to complete and acceptable to women. It is sensitive enough to detect changes in the rate of unplanned pregnancy over time, across subgroups or following preconception intervention. It is currently being piloted in two large London maternity services with a view to inclusion in the Maternity Services Dataset that will enable national surveillance of unintended pregnancy rates, similar to the way that antenatal HIV tests are used for surveillance of HIV infection.

Data linkage and modelling

The ability to link big data across high quality datasets is particularly exciting; it brings new opportunities to track individual reproductive health trajectories - from preconception to first pregnancy, interconception and subsequent pregnancies – at scale. It means we can go beyond a national picture of preconception health to examine associations between preconception exposure and outcomes, spanning, for example, maternal obesity or diabetes to preterm and still births, child health and cognitive development. We can also explore evidence for the effectiveness of preconception interventions in improving such outcomes.

While estimates of effectiveness from randomised trials are only just emerging [3], we can explore the feasibility of modelling the impact of preconception interventions, using evidence from the literature to estimate the relative impacts, cost-effectiveness and net benefits of different preconception interventions on a range of maternal and child outcomes, including long-term outcomes relating to health, education, earnings, welfare use and crime. Models that combine estimated intervention impacts with the routinely available data presented here could guide the investments of policy-makers and donors in this crucial and increasingly prioritised area of the life course. Conti and Heckman [40] summarise the evidence on the returns on investment for interventions to promote child well-being from conception to age 5, within an integrated developmental framework. We aim to extend this period backwards to estimate the costs and benefits of investing even earlier in the life course, that is, during the preconception period. We have previously conceptualised a schematic overview of an economic model for nutrition interventions [3]. Here we expand on this to consider other relevant behaviours and risk factors including contraception use and other indicators of pregnancy planning, smoking, substance use, diabetes, population-level interventions and individual preconception counselling advice, and their consequences (Fig 4).

Discussion

The data sources described here illustrate the potential to describe and monitor the state of preconception health nationally using routinely collected data. The proposed metrics are generally of high quality, reflecting a long UK tradition of public health surveillance. We have focused on England to illustrate how routine data can be used to build up a national picture of preconception health. While countries vary in the extent and quality of routinely available data (and capacity for data linkage[41]), similar principles can be applied. For example, an international report comparing health and wellbeing in adolescence and early childhood [42] used data from the Health Behaviour in School-aged Children survey (carried out every four years), the Global Burden of Disease (published annually), Eurostat (statistical office of the European Union) and other data sources to describe measures of obesity, exercise, smoking, alcohol and birth rate that all relate to preconception health.

Among women of reproductive age, irrespective of pregnancy planning, our data show impressive reductions in prevalence of smoking over time (Figure 1) but concerning rates of other preconception risk factors. In the NDNS, just over 50% of women aged 18-49 were overweight or obese, and over 70% were eating fewer than five portions of fruit or vegetables per day. Intake of iron and minerals are below the lower reference nutrient intakes (LNRIs) and therefore very likely to be inadequate for these women, particularly if they become pregnant. In the RCGP RSC, the proportion of women aged 15 to 45 who became pregnant each year was 4.0% in 2004, 6.7% in 2011 and 4.9% in 2017. Figure 1 shows a rising prevalence of common mental health problems (mostly depression and anxiety) and a persistent rate of prescribed medications that are known to be dangerous (e.g. valproate) or of doubtful safety in pregnancy (including some medications for hypertension and diabetes) among women not using contraception (Figure 1). Although pregnancy intention cannot be inferred from these data (they do not include condom use, or contraception obtained outside general practice), the anticipated inclusion of the LMUP in the MSDS will provide a new tool for surveillance of pregnancy intention at a national level. The LMUP is only applicable to women with a current or recent pregnancy, but work is underway to develop a robust measure of pregnancy intention for women who are not pregnant [43]; this could be useful in normalising discussions about planning for pregnancy in routine health care consultations.

Within the pregnant population (figures 2 and 3), there is clear clustering of social and medical risks among younger women (deprivation score, complex social factors, obesity (figure 2) and smoking (figure 3). These data indicate that early motherhood is a marker of vulnerability, emphasising the need for more effective ways of engaging with and supporting young women in high risk populations. Across all age groups, women are less likely to take folic acid supplements before conception or quit smoking for a subsequent pregnancy than for their first pregnancy, suggesting that preconception health messages need to be continued as part of interconception health promotion.

Using data to enhance accountability

An annual report card with robust metrics on preconception health and its implications should be used to hold responsible agencies to account. For example, in the UK, we call for the Ministry of Health and Social Care to allocate funding to generate annual reports. An independent monitoring body should also be established to ensure government accountability, similar to the Partnership for Maternal Newborn and Child Health. Civil society organisations, such as the Non-Communicable Disease Alliance, should play a role, alongside professional bodies including the UK Royal Colleges of Obstetricians and Gynecologists, of Midwives, of Nurses, of Paediatricians and of General Practitioners. Nutritional aspects of preconception health fall within the remit of UK Scientific Advisory Committee on Nutrition which should be tasked with periodic independent review of progress. Placing responsibility at these levels will help counter any misplaced tendency to ascribe it solely to individual women or couples, when those in most need of support lack the opportunity to improve preconception health.

Successive reports of the UK and Ireland confidential inquiries into maternal deaths and morbidity have concluded that improving preconception health is a priority for action. Indeed the latest report found it 'striking' that 'one recurring dominant theme emerges' from these inquiries, that is, the need for early planning of care for women with pre-existing conditions [44]. The Chief Medical Officer for England drew attention to preconception health in her 2015 annual report [8], as have international agencies [45, 46], but the necessary support to deliver strategies for better outcomes is lagging behind. The recent UK Government consultation on mandatory food fortification with folic acid is an important step in the right direction; another would be to ensure that every obesity strategy, nutrition strategy, non-communicable disease or adolescent health strategy includes preconception health [47]. Disappointingly, the UK Government's plan to halve childhood obesity by 2030 does not mention preconception health, even though the risk of obesity and the dietary behaviours of the children it intends to influence, who have yet to be conceived, will be significantly determined by the BMI and nutrition of their parents at the time of conception (1,2). For this reason, we propose content analysis of key documents in addition to routinely collected data, to reverse neglect of the preconception period in national health strategies. Since economic modelling of the impact of interventions can be a powerful means of leveraging resources [40], we look forward to estimates of the financial, as well as health and wellbeing, returns from investing in preconception interventions.

Word count 4069.

Key messages

- There is growing interest in preconception health as a critical period for influencing not only pregnancy outcomes, but also future maternal and child health and prevention of long term conditions.

- More and more national and international policy documents emphasise the need to improve preconception health, but resources and action have not followed.

- The preconception period (defined in biological, individual or public health terms) needs to become a focus of existing strategies that tackle obesity, smoking, nutrition, alcohol, maternal and child health, reproductive health, and non-communicable diseases.

- Preconception health can be assessed by metrics from multiple sources which will reflect awareness of preconception health, planning and preparation for pregnancy at public health and individual levels.

- An annual report card detailing these metrics should be used to hold governments and other relevant public and private agencies to account for delivering interventions to improve preconception health.

- Economic modelling of the return on investment in preconception interventions may prove useful in leveraging resources.

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