ORIGINAL RESEARCH

# Health and economic consequences of projected obesity trends in Malta

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## ABSTRACT

**Background:** Globally, there is increasing concern about the potential health and economic consequences of current obesity trends. This study assessed the impact of unchecked obesity and the benefits of reducing population weight levels in Malta.

**Methods:** Body mass index rates, disease burden and direct health care costs for breast and colon cancer, coronary heart disease, diabetes, hypertension and stroke in Malta were projected to 2035 using a two-stage microsimulation model. Two scenarios were modelled for population weight reduction.

**Research:** By 2035, uncontrolled overweight and obesity are projected to result in a 62% increase in stroke prevalence, a 27% increase in obesity-related cancers and a 16% increase in prevalence of hypertension. The prevalence of coronary heart disease developing as a consequence of obesity is expected to double within the next two decades. Associated cumulative direct health care costs will amount to around €814 million by 2035. However, a 5% reduction in the average population body mass index by 2035 is projected to result in a saving of €141 million in health expenditure on obesity-related conditions over the intervening 20 years.

**Conclusion:** These findings have important implications for obesity policy in Malta and other European nations with similar health systems and levels of population obesity, thus highlighting the need for effective population-level preventive strategies.

Keywords: MALTA, PROJECTED OBESITY, HEALTH CONSEQUENCES, ECONOMIC CONSEQUENCES, MICROSIMULATION MODELLING

## INTRODUCTION

Obesity is a critical public health issue globally as its overall prevalence continues to rise *(1)*. Malta, a small Mediterranean island with a population of less than half a million *(2)*, leads the overweight and obesity rankings in Europe *(3)*. A recent study that measured the body mass index (BMI) of almost all school-aged children in Malta reported that around 41% are overweight or obese according to WHO cut-offs, with a greater proportion being obese (26%) than overweight (15%) *(4)*. Obesity is also a problem in Maltese adults: according to a recent nationally representative study, 36% are overweight and 34% are obese *(5)*. The same authors reported a type II diabetes mellitus prevalence of 10.4% among the Maltese adult population.

These figures are a particular concern for policy-makers in Malta because obesity is a major risk factor for noncommunicable diseases (NCDs) including coronary heart disease (CHD), diabetes, hypertension, stroke and certain cancers, and there is a well-established link between obesity, poor health outcomes and all-cause mortality *(6)*. Given that health services in Malta are mainly provided by the state and free at the point of use (albeit with a substantial private sector acting as a parallel, complementary system for health care coverage and service delivery), the direct and indirect economic implications of overweight and obesity are significant *(7)*. Health expenditure has increased steadily in recent years, exceeding the rise in gross domestic product (GDP) *(8)*. The cost of obesity in Malta for 2016 was conservatively estimated to be around €36.3 million, or 5.6%

of total health expenditure *(9)*. Concern about childhood obesity continuing into adulthood and its potential to substantially burden the health care system has led to the publication of a national strategy aimed at obesity prevention *(10)*. The strategy recognizes the increasing burden of obesity in Malta and highlights the need for a whole-of-population approach to address its key determinants, with the involvement of a range of stakeholders across different sectors. However, the emphasis is on behavioural, promotional and educational measures to address obesity, particularly in children, rather than on measures to modify the overall obesogenic environment to achieve sustained reductions in population weight *(11)*.

Modelling the future obesity burden is helpful to policy-makers, who might need to consider adopting politically controversial measures to meet the increase in obesity-associated health outcomes and costs *(12)*. The aim of this study was to model the potential trajectory of unchecked obesity in Malta, estimate its economic and health consequences from 2015 to 2035, and outline the potential benefits of reducing the mean population BMI by 1% and 5%. Our results may help guide national resource allocation and emphasize the positive health and economic outcomes of implementing preventive measures in Malta and other nations with similar levels of population overweight.

# METHODS

## MICROSIMULATION MODEL

A two-stage modelling process developed by the United Kingdom's Foresight working group and described in more detail elsewhere *(13)* was used to project the future obesity-related disease burden in Malta. Based on the assumption that an individual's BMI status does not change over time, cross-sectional data were used to simulate longitudinal BMI trajectories from 2015 to 2035. Briefly, the first module fits multivariate, categorical regression models to cross-sectional BMI data. A BMI value is probabilistically and stochastically assigned to simulated individuals as a function of age, sex and calendar year, and the predicted proportions of the population in each BMI category are constrained, resulting in a longitudinal growth model for the population. An individual's BMI percentile within the same age cohort is assumed to stay the same over time. Size and age distributions were based on medium variant projections from the United Nations population database *(14)*. The availability of obesity-related disease data enabled the consequences of these BMI trends to be determined so that the risk of contracting, surviving or dying from this set of conditions could be simulated for each virtual individual. The subsequent health care costs associated with these trends could then be calculated. The effects of constraints on future BMI growth were also modelled to provide insight into how the levels of obesity-related chronic disease prevalence, mortality and health care costs might change following one of three distinct scenarios:

- scenario 0: baseline scenario, i.e. obesity trends continue unchecked;
- scenario 1: mean population BMI decreases by 1%; and
- scenario 2: mean population BMI decreases by 5%.

A total of 20 million Monte Carlo simulation trials were performed for each scenario, in which reductions in mean population BMI were applied at the baseline year (2015). For reference purposes, it was estimated that reducing the average weight of a population by 1.25% (i.e. less than 1 kg for a person weighing 70 kg) would reduce the rate of obesity by 25% *(15)*. Data sources for the model are shown in Table 1.

## BMI DATA

Databases were included if they contained nationally representative BMI data. Adult data were categorized by WHO cut-offs for normal weight (< 25 kg/m$^2$), pre-obesity (25–29.99 kg/m$^2$) and obesity (≥ 30 kg/m$^2$), whereas child height and weight data were converted into BMI equivalents using International Obesity Task Force cut-offs *(16)*. When microsimulation modelling was carried out in 2014, the only nationally representative BMI trend data available for Maltese adults were for two rounds of the European Health Interview Survey (EHIS), conducted in 2002 and 2008 *(17, 18)*. Both measured and self-reported data for several cohorts of Maltese children were used as inputs for the microsimulation model. Additionally, the School Health Service within the Maltese Ministry for Health provided anthropometric data for three national cohorts of schoolchildren born in 2001, 2003 and 2005, measured at approximately 7 years of age. Anthropometric measurements for the 2001 cohort were repeated in 2009 and 2010, when children had a median age of 9 and 10 years, respectively. In addition, self-reported BMI data from four rounds of the Health Behaviour in School-aged Children survey conducted in Malta in 2002, 2006, 2010 and 2014 were available for children aged 11, 13 and 15 years *(19, 20, 21, 22)*. Outlier data falling outside the 95% confidence limits were removed. Data were inputted into the model and BMI distribution in the population was estimated using regression analysis stratified by sex and age group. At the time of this study, these were the most up-to-date data available.

**TABLE 1. DATA SOURCES FOR THE MICROSIMULATION MODEL**

| Category | Source (year of data) |
|---|---|
| **Population characteristics** | |
| BMI distribution | EHIS (2002, 2008) *(17,18)*<br>School Health Services, Malta (2007–2010, 2013)[a]<br>HBSC (2002, 2006, 2010, 2014) *(19, 20, 21, 22)* |
| Population size | National Statistics Office (2012) *(23)* |
| **Incidence/prevalence** | |
| CHD, diabetes, hypertension | EHIS (2008) *(18)* |
| Stroke | DHIR & CPU (2013)[b] |
| Cancer | National Cancer Registry (2013) *(24)* |
| Relative risk of obesity to disease risk | International Association for the Study of Obesity (2010) *(25)* |
| **Survival** | |
| CHD | DHIR & CPU (2013)[b] |
| Stroke | DHIR & CPU (2013)[b] |
| Cancers | EUROCARE-5 study (2007) *(26)* |
| **Direct costs** | |
| CHD, diabetes, hypertension, stroke | DHIR (2013)[c] |
| Cancer[d] | Luengo-Fernandez et al. (2009) *(27)* |
| **Disease-specific mortality** | |
| CHD, diabetes, stroke | National Mortality Register (2013) *(28)* |
| Cancer | National Cancer Registry (2013) *(24)* |

[a] Victoria Farrugia Sant'Angelo, Primary Child, Youth Health and Immunization Unit, Primary Health Directorate, Ministry of Health for Malta, personal communication, July 2015.

[b] Kathleen England and Alexandra Distefano, DHIR, personal communication, July 2015.

[c] Calculated by Dorothy Gauci.

[d] Breast and colorectal cancer only.
CPU: Clinical Performance Unit, Mater Dei Hospital, L-Imsida, Malta; HBSC: Health Behaviour in School-aged Children study.

## DISEASE DATA

National epidemiological studies and routine databases were reviewed in 2014 to identify the incidence and prevalence rates of the following obesity-related diseases by age and sex: CHD, hypertension, obesity-related cancers (breast, colorectal, endometrial, kidney, liver, oesophageal and pancreas), stroke and type 2 diabetes. Incidence rates for CHD, diabetes and hypertension were derived from prevalence data obtained from the 2008 EHIS *(18)* by applying the WHO DisMod II model *(29)*. The Clinical Performance Unit within Mater Dei Hospital, Malta's national hospital, provided data on prevalence, incidence and survival rates for stroke; the Directorate for Health Information and Research (DHIR) provided data on the prevalence and incidence of obesity-related cancers *(24)*. Mortality and survival data were also collected for obesity-related cancers CHD, and stroke *(26,28)*. The relative comorbidity risks related to being overweight or obese for each of these diseases were obtained from the International Association for the Study of Obesity *(29)*.

## COST DATA

Direct costs of non-cancerous disease include the cost of inpatient stays, day patient stays, and general practitioner and specialist consultations. Estimated attributable costs for 2013 were calculated by DHIR based on 2008 disease prevalence estimates. It was assumed that disease prevalence had not changed since 2008 and that any increase in cost was due to inflation (2% yearly) and an ageing population. Expenses related to medication, surgery and ancillary services were unavailable. Approximate direct health care costs for breast cancer and colorectal cancer for 2009 were obtained from a European

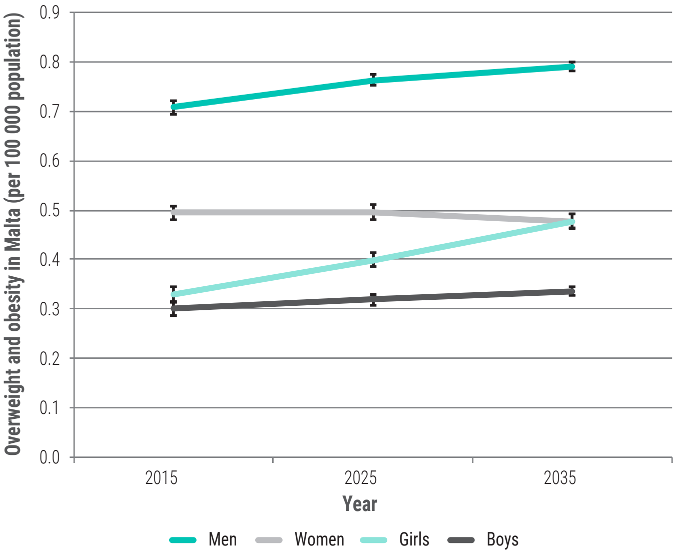
Union cost analysis study informed by a mixture of national and proxy data *(27)*; cost data on other specific obesity-related cancers were unavailable. Indirect costs such as those associated with premature mortality, productivity losses or loss of income due to absenteeism from work were also omitted from the study owing to a lack of national data on these topics at the time of the study.

# RESULTS

## BMI DISTRIBUTION

The projected prevalence of overweight and obesity (≥ 25 kg/m$^2$) in the Maltese population by 2035 (scenario 0) is shown in Fig. 1: prevalence in men is projected to increase over this period to 79%, while prevalence in women (currently around 50%) is predicted to decrease slightly to approximately 48%. The proportion of adults in the overweight category is generally predicted to increase at the expense of the normal weight and obese categories, with the exception of young (25–34 years) and elderly (> 70 years) adults, who are predicted to have an increased obesity prevalence. The results also suggest an increase in the prevalence of overweight and obesity in children up to age 14 years by 2035 of around 17% and 3% in girls and boys, respectively.

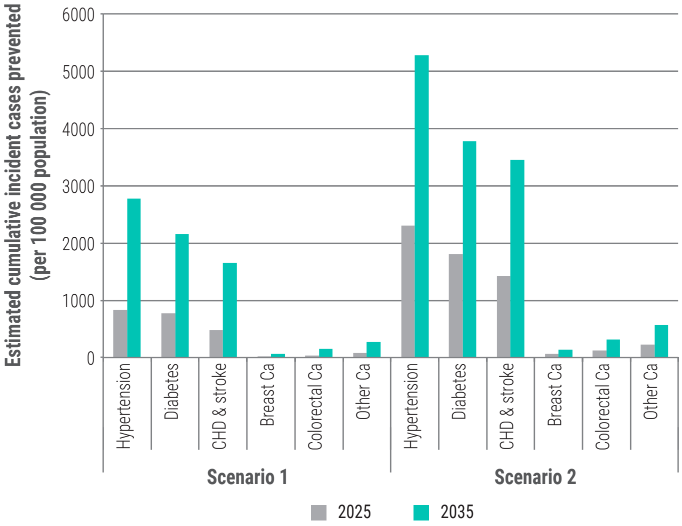
**FIG. 1. PROJECTED PREVALENCE RATES FOR OVERWEIGHT AND OBESITY IN THE MALTESE POPULATION BY 2035.**




## DISEASE PREVALENCE AND PROJECTED OUTCOMES

If current obesity trends continue unabated, then the prevalence rates of almost all related diseases are expected to increase. The exception is type II diabetes: the prevalence of this disease is projected to continue increasing until around 2025, followed by a prolonged slow decline (data not shown[1]). Any reduction in population BMI would substantially reduce disease prevalence and incidence. Fig. 2 shows the projected number of incident cases of obesity-related disease that would be prevented by 2035 if 1% (scenario 1) and 5% (scenario 2) decreases in average population BMI were achieved.

**FIG. 2. ESTIMATION OF CUMULATIVE INCIDENT DISEASE CASES AVOIDED PER 100 000 POPULATION IN SCENARIO 1 (i.e. 1% decrease in mean population BMI) and scenario 2 (i.e. 5% decrease in mean population BMI), relative to scenario 0 (i.e. obesity trends continue unchecked). Ca: cancer.**




Using United Nations total population projections for Malta, by 2025 scenario 1 is projected to decrease the number of CHD and stroke cases by 2037, the number of diabetes cases by 3264 and the number of all cancer cases by 554. Scenario 2 has a greater impact: by 2025, the number of CHD and stroke cases is projected to decrease by 6025, the number of diabetes cases by 7674 and the number of all cancer cases by 1743. There is also a projected reduction in hypertension cases of 3566 and 9847 for scenarios 1 and 2, respectively. Fig. 2 provides an estimate of the reductions in cumulative incidence due to intervention by 2025 and 2035.

## ECONOMICS

Conservative estimates for 2015 suggest direct health care costs for diseases associated with obesity (including breast and

1 Supplementary information is available from the corresponding author upon request.

colorectal cancer, the most common obesity-related cancers, but excluding endometrial, kidney, liver, oesophageal and pancreatic cancers, for which cost data were unavailable) of around €32 million. In 2015, hypertension comprised 34% of this value, followed by diabetes (28%) and CHD and stroke combined (25%). The projected increase in obesity-related diseases has a substantial impact on health care expenditure: assuming current trends remain unchanged, by 2035 the associated direct health care costs are conservatively projected to reach €43.6 million per year. By 2035, the proportion of direct health care costs attributable to CHD and stroke will increase to 35% and the proportion attributable to breast and colorectal cancers and arthritis will increase slightly. In contrast, the proportions attributable to hypertension and diabetes is expected to decrease by 5% and 8%, respectively. This result is consistent with findings in modelling studies for other European countries, which indicate that increases in CHD and stroke prevalence will be disproportionately responsible for rising expenditure *(30–33)*. Table 2 shows that a 1% decrease in population BMI is estimated to result in an annual reduction in expenditure on obesity-related morbidity of €2.9 million by 2025 and of €7.1 million by 2035. This translates to a cumulative saving of €65.5 million by 2035. A 5% decrease in population BMI will clearly have a greater impact, resulting in cumulative savings of €141 million by 2035 due to reductions in direct annual health care costs of €7.8 million and €12.2 million by 2025 and 2035, respectively.

# DISCUSSION

This study modelled the impact of potential reductions in average population BMI on the future obesity-related disease burden, and is the first to report the direct health care costs of five key obesity-related conditions for Malta.

The results are consistent with those found elsewhere in Europe *(34)*. In all countries, the projected rise in overweight and obesity levels is expected to lead to substantial increases in both the NCD burden and associated health care spending. Given the organization of the health system in Malta, a large proportion of this burden is likely to be shouldered by the state: public expenditure comprised almost 69% of the total health expenditure in 2014, with most of the remaining costs resulting from out-of-pocket payments and voluntary health insurance *(8)*. In 2014, the total health expenditure for Malta was 9.75% of GDP *(8)*, equivalent to around €678 million (at current market prices). Our results suggest that obesity-related diseases currently account for at least 4.7% of this expenditure, or 0.43% of GDP. This financial burden would probably be substantially higher if more accurate direct and indirect costs were included in these calculations. A recently published report on the cost of obesity in Malta based on EHIS BMI data also included some indirect costs (i.e. absenteeism, presenteeism, government subsidies for disability due to obesity, loss of earnings and loss of taxes). The total cost of adult obesity in 2016 was estimated at around €36.3 million: €23.8 million in direct costs and €12.5 million in indirect costs *(9)*. Our estimate of the direct cost is higher, at €33.2 million in 2016, probably because we used a different modelling technique that incorporates the relative comorbidity risks related to being overweight or obese.

The microsimulation model indicates that increased CHD and stroke incidence will have the greatest impact on the health care system, as the risk of developing cardiovascular diseases increases with age. Surprisingly, the modelled incidence and prevalence rates for diabetes reached a plateau and then gradually declined over the next two decades, possibly due to the combined effects of individuals with diabetes dying and a projected reduction in the birth rate (thus reducing the

**TABLE 2. DIRECT ANNUAL HEALTH CARE COSTS (IN MILLION EUROS), BY YEAR AND DISEASE**

| NCD | Scenario 0 | | | Scenario 1 | | Scenario 2 | |
|---|---|---|---|---|---|---|---|
| | 2015 | 2025 | 2035 | 2025[a] | 2035[a] | 2025[a] | 2035[a] |
| Hypertension | 11.0 | 12.2 | 13.0 | 11.7 (0.5) | 11.6 (1.4) | 10.9 (1.3) | 10.4 (2.6) |
| Diabetes | 9.0 | 9.2 | 8.8 | 8.1 (1.0) | 6.4 (2.5) | 6.8 (2.3) | 5.0 (3.9) |
| Breast + colorectal cancer | 4.0 | 5.8 | 6.6 | 5.5 (0.3) | 5.9 (0.7) | 5.0 (0.9) | 5.5 (1.1) |
| CHD + stroke | 8.0 | 12.1 | 15.2 | 11.0 (1.0) | 12.7 (2.5) | 10.3 (1.8) | 12.8 (2.4) |
| Total | 32.0 | 39.2 | 43.6 | 36.3 (2.9) | 36.5 (7.1) | 31.4 (7.8) | 31.4 (12.2) |

[a] Values in parentheses are estimated annual health care cost savings (in million euros), relative to scenario 0 (i.e. obesity trends continuing unchecked)

available population who can contract the disease). Projections of accurate, measured anthropometric data recorded over the past decade showed substantial increases in childhood obesity rates, particularly in girls (data not shown). However, this was inconsistent with the projected modest increase in overweight and obesity rates for men, and the reduction in rates for women. This is most likely due to the paucity of Maltese adult BMI data informing the model (only two data points were available at the time of the study) or to the inherent inaccuracy of self-reported BMI data used for adult projections. Cuschieri et al.'s nationally representative, cross-sectional study of measured adult BMI reported that 70% of Maltese adults are overweight or obese *(5)*. Men had significantly higher rates of overweight (39%) and obesity (37%) compared with women (32% and 31%, respectively). Although measured data for men are similar to the self-reported EHIS data used for this model, EHIS substantially underestimated the true overweight and obesity prevalence rates for women. This discrepancy is likely to have an impact on the accuracy of the projections; hence, the use of measured child *(4)* and adult *(5)* BMI data is warranted in future simulations.

Quantification of the NCD burden is important for patients and public health professionals because of the long-term consequences for functional abilities of patients and for health care demand. Such data are vital for the objective appraisal of national policies to control NCDs. This research expands on the results for Malta published in a WHO cross-European microsimulation study *(34)*, which did not explore the cost of obesity. We set out to add value to the findings by using the most up-to-date data available at the time of the study and by deriving disease cost estimates, while avoiding the use of proxy data where possible. Compared with those of the WHO modelling study, our results show that substantially more cumulative incident cases are prevented across all obesity-related diseases. While the cumulative incidence per 100 000 population of diabetes and all cancers across the two studies were broadly similar, our study found that intervention would result in a lower cumulative incidence for CHD and stroke, as well as for hypertension. There were also differences in estimated prevalence rates: our study found a slightly lower overall projected prevalence of cancer and a substantially lower prevalence of CHD, diabetes and stroke compared with WHO calculations. Prevalence estimates for hypertension in both studies were broadly similar. Projections for arthritis (another established obesity-related disease) that used United Kingdom proxy data were included in the WHO estimates; however, the self-reported prevalence data available from the EHIS 2008 survey were deemed insufficiently accurate to warrant the inclusion of this disease in the present study.

# LIMITATIONS

As with all models, the quality of microsimulation modelling output is dependent on the accuracy of surveillance data and the underpinning assumptions of the model. Limitations of the model have been described elsewhere *(13)*. For example, obesity cannot be considered to be the sole causal factor for the projected rise in NCDs, and it was not possible to incorporate the impact of economic growth or future increases in the cost of health care into the analysis. BMI projections for adults should be interpreted with caution because only two data points were available. Both disease prevalence and BMI data used in this study were self-reported and therefore likely to be biased. In addition, although the use of cross-sectional data to construct BMI trajectories may not be applicable to upcoming generations, the model assumed that any BMI changes occurring as a result of interventions would be fixed over time. Furthermore, high-quality health care data was difficult to locate, thus limiting the accuracy of our findings. Although bariatric surgery is still in its infancy in Malta (and hence unlikely to contribute significantly to overall costs), the lack of data related to ancillary services and medications prescribed for obesity-related disease is a key limitation of this study. Direct costs for endometrial, kidney, liver, oesophageal and pancreatic cancers were not included due to lack of accessible data; hence, study estimates are likely to be gross underestimations of the true cost. On the other hand, it is difficult to disentangle the potentially overlapping costs of related diseases such as CVD, diabetes, hypertension and stroke; hence, there may be some error in our cost estimates. Finally, no indirect cost data for Malta was available at the time of modelling; hence, these costs could not be included. Given these limitations, our results should be interpreted with caution as the actual cost of obesity-related disease is likely to be much higher than that outlined in our study. A similar analysis by a private company used measured BMI data from Cuschieri and colleague's study *(5)* (which was not available when this microsimulation modelling was conducted) and supplemented the direct health care cost estimates calculated by DHIR (which were used in this modelling study) with estimated indirect costs *(9)*. The analysis indicated that self-reported BMI data underestimates the total cost of obesity by around €20 million per year, with most of this additional expense due to indirect costs.

There remains a need to establish more accurate estimates for the prevalence of obesity-related disease in Malta, as well as the associated direct and indirect costs. Since this study was conducted, additional data which may help to address the study limitations have become available. The recently published measured BMI data for children *(4)* and adults *(5)* and indirect costs of obesity *(9)* should be used for future microsimulation modelling of obesity in Malta.

# CONCLUSION

Although the Maltese Government has developed a national strategic plan to improve the diet and physical activity patterns of the population, translating policy into tangible action is unlikely to be a straightforward process. Public health professionals may find it difficult to persuade budget-conscious policy-makers to consider preventive interventions that are likely to bear fruit years – rather than months – into the future. This research provides evidence of preventable direct health care costs for five major obesity-related illnesses using a recognized forecasting model, and thereby an impetus for policy-makers to adopt long-term objectives. Any reduction in population overweight and obesity levels will result in substantial cost savings for decades. Although the Maltese national obesity strategy focuses on behavioural and educational measures to address the obesity burden, multicomponent, population-level interventions addressing drivers of obesity at multiple levels (e.g. fiscal measures) are the most likely to be effective *(35, 36)*. Collecting disaggregated surveillance data related to disease costs and the indirect costs of obesity and using this along with recently published measured BMI data would enhance the accuracy of future modelling efforts.

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