




RESEARCH ARTICLE

REVISED Increasing both the public health potential of basic research and the scientist satisfaction. An international survey of bio-scientists [version 2; peer review: 2 approved]

Carmen Sorrentino¹, Andrea Boggio ², Stefano Confalonieri¹, David Hemenway³, Giorgio Scita^{1,4}, Andrea Ballabeni³

¹IFOM - The FIRC Institute of Molecular Oncology, Milan, Italy

²Department of History and Social Science, Bryant University, Smithfield, RI, USA

³Department of Health Policy and Management, Harvard T.H. Chan School of Public Health, Boston, MA, USA

⁴Department of Oncology and Hemato-Oncology-DIPO, School of Medicine, University of Milan, Milan, Italy

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Abstract

Basic scientific research generates knowledge that has intrinsic value which is independent of future applications. Basic research may also lead to practical benefits, such as a new drug or diagnostic method. Building on our previous study of basic biomedical and biological researchers at Harvard, we present findings from a new survey of similar scientists from three countries. The goal of this study was to design policies to enhance both the public health potential and the work satisfaction and test scientists' attitudes towards these factors. The present survey asked about the scientists' motivations, goals and perspectives along with their attitudes concerning policies designed to increase both the practical (i.e. public health) benefits of basic research as well as their own personal satisfaction. Close to 900 basic investigators responded to the survey; results corroborate the main findings from the previous survey of Harvard scientists. In addition, we find that most bioscientists disfavor present policies that require a discussion of the public health potential of their proposals in grants but generally favor softer policies aimed at increasing the quality of work and the potential practical benefits of basic research. In particular, bioscientists are generally supportive of those policies entailing the organization of more meetings between scientists and the general public, the organization of more academic discussion about the role of scientists in the society, and the implementation of a "basic bibliography" for each new approved drug.

Keywords

Basic research , Public health , Scientist satisfaction , Policy , Nudges , Grant , Basic bibliography

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report



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report



report

1. **Nathan L. Vanderford** , University of Kentucky, Lexington, USA

2. **Viviane Callier**, Ronin Institute, Montclair, USA

Any reports and responses or comments on the article can be found at the end of the article.

Corresponding authors: Giorgio Scita (giorgio.scita@ifom.eu), Andrea Ballabeni (aballab@hsph.harvard.edu)

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REVISED Amendments from Version 1

We would like to thank the referees, for reviewing the paper.

Thanks to their comments we have made the following changes:

1. We have changed the title to emphasize that we aim at increasing both the public health potential and work satisfaction.
2. We have now inserted a new sentence in the abstract to clearly define the goals of the present study.
3. We have further clarified the differences and overlaps between Study 1 and Study 2 by adding a few sentences in the Introduction and Discussion sections.
4. We have performed statistical analysis to support some results and conclusions. In particular, we have calculated 'p values' for Figure 1 and correlation coefficient R for Figure 15.
5. We have divided the Conclusions section from the Discussion section.
6. We have added a sentence in the Discussion section to make it clear that an in-depth analysis of the relevant literature as well as a discussion on the conceptual framework are present inside the manuscript describing the results of the first study (i.e. Study 1) recently published (ref. 20).
7. We have added a new author that contributed to the production of the second version of the manuscript.

See referee reports

Introduction

Basic research has been crucial for the improvement of the human condition, including both research inspired solely by scientific curiosity and research driven by a vision of future applications. While basic knowledge is inherently valuable, all basic knowledge does not have the same potential for practical benefits. Of course, it is often difficult *a priori* as well as *a posteriori* to determine which knowledge will have, or has had, a greater impact on society, and some knowledge may never have any utility, neither direct nor indirect, in producing any practical outcome¹⁻¹⁷. However, although we cannot know the future practical benefits of basic research, it is generally possible to make rough estimates of the potential.

We created a survey to assess the attitudes and beliefs of basic scientific researchers concerning policies that might incentivize bioscientists to engage in basic research with a higher likelihood of creating public health benefits, without compromising the "basic" nature of their research. We focused on policies based on soft incentives (what behavioral economists call "nudges")¹⁸ because we believed that, if properly tailored to basic scientists motivations and goals¹⁹, soft policies could effectively stir (some) basic scientists towards research with a greater potential of creating larger public health benefits without overly constraining their research or decreasing their work satisfaction.

To determine which "nudges" might be effective, it is key to have a good grasp of what motivates basic scientists and of the intellectual framework in which they operate. To explore these questions,

we previously conducted a study (Study 1) at a single institution (Harvard University and affiliated institutions in the Boston (MA-USA) area) to collect preliminary data and refine our hypotheses²⁰. We found that the vast majority of the biological/biomedical scientists at Harvard University believe that, although it is often difficult to assess the potential future health benefits to society from basic research proposals, or actual research findings, some degree of estimation is possible. These bioscientists also supported the idea that softer policies are preferable to stricter ones for increasing the societal benefits of research.

Study 1 showed that increasing people's health and personal prestige are some of the strongest motivations for basic scientists. Moreover, it showed that basic scientists strongly support the idea of non-mandatory policies based on soft incentives to increase public health potential and work satisfaction. Based on these and other findings of Study 1, we designed this second study (Study 2) to obtain a larger sample of basic bioscientists, from multiple institutions and different countries. We used a slightly modified version of the Study 1 questionnaire. In particular, we added a few questions asking respondents to evaluate current policies used to evaluate/increase the public health potential, as well as six new soft policies that we developed after analyzing the results of Study 1. In the current paper, we present the results of Study 2.

Just under 900 basic bioscientists responded to the survey, completing an online questionnaire (see Methods section). Study 2 confirms the main findings of Study 1 with regard to motivations of basic scientists and how they conceptualize basic research. In particular, the vast majority of respondents reported being driven not only by curiosity or the desire of knowledge advancement but also by the aspiration of having an impact on people's health. Respondents also think that basic scientists can ponder future practical benefits of their research without losing their "basic status" and that it is possible to roughly estimate the practical potential of basic research proposals. Finally, participants, especially principal investigators (PIs), disfavor current policies requiring the discussion of the potential societal impact in research proposals but favor the new policies we propose.

Methods

The survey was an anonymous online questionnaire (see Questionnaire in the Data availability section) that was sent by email to scientists working at institutions where basic research in the biological/biomedical area is routinely conducted. The research instrument for Study 2 was a modified and expanded version of the questionnaire used in Study 1. In particular, we used a subset of the questions used in Study 1 and added questions on some current policies and on six policies that we propose.

Over seven thousand (7,786) scientists were contacted from over thirty institutions in four different geographical locations [Los Angeles-San Diego (CA-USA), London-Cambridge (UK), Milan (Italy), and New York City (NY-USA)]. Invited scientists from the Los Angeles-San Diego area were affiliated with Calibr (California Institute for Biomedical Research), Caltech (California Institute of Technology), Cedars-Sinai, Salk Institute, Sanford-Burnham

Medical Research Institute, Scripps Research Institute, UCI (University of California Irvine), UCLA (University of California Los Angeles), UCR (University of California Riverside), UCSD (University of California San Diego) or USC (University of Southern California). Invited scientists from the London-Cambridge area were affiliated with Francis Crick Institute, ICL (Imperial College London), ICR (Institute of Cancer Research), King's College, UCL (University College London), University of London Birkbeck, University of London Queen Mary, University of London St George's or the University of Cambridge. Invited scientists from the Milan area were affiliated with Humanitas Research Hospital, IEO (European Institute of Oncology), IFOM (FIRC Institute of Molecular Oncology), INGM (National Institute of Molecular Genetics), Istituto Nazionale dei Tumori (National Institute of Tumors), Mario Negri Institute, San Raffaele Hospital, University of Milan or University of Milan-Bicocca. Invited scientists from the New York City area were affiliated with Albert Einstein College of Medicine, Columbia University, CSHL (Cold Spring Harbor Laboratories), CUNY ASRC (City University of New York Advanced Science Research Center), CUNY Queens (City University of New York Queens college), Memorial Sloan Kettering Cancer Center, Mount Sinai Hospital, NYU (New York University) or Rockefeller University.

Email addresses were taken from the publicly accessible websites of the institutes. Invitations were sent to individual emails. The invitations contained a standard text of invitation and brief explanation of the study; emails of invitations differed one from another only with regard to the name of the invited scientist in the salutation ("Dear xxx").

Participation in the study was voluntary and entailed answering an online survey powered by Qualtrics software (www.qualtrics.com) through the Harvard T.H. Chan School of Public Health. Respondents could skip any questions they wanted to. They were asked to confirm their status as basic researchers (see Results section). We invited all types of bioscientists, with regard to their position/role, except that we tried not to invite undergraduate students and non-PhD technicians.

We tried to keep the proportion of invitations sent to PIs at over 50%. We did not invite every single scientist at every institute but for each institute decided *a priori* the number of scientists and then used the alphabetical order. Respondents had the option of indicating their geographical location but not their institution. The differences in gender invitations were not deliberate but a reflection of the actual proportions of females and males. Graphs describing the statistics of the invitations are shown in [Figures S1–S6](#).

The invitations were sent from August 24, 2015 to October 10, 2015. Force completion of the survey was set at 72 hours. The study was reviewed and approved by the Harvard T.H. Chan School of Public Health IRB (IRB15-2787) and by the FIRC Institute of Molecular Oncology Ethics Committee.

Results

Dataset 1. Questions and responses of the survey

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"QUESTIONNAIRE.pdf" contains the questions of the questionnaire.

"QUESTIONNAIRE DATA.csv" contains the responses of the questionnaire. "FINAL REPORT.pdf" contains the summary of the responses of the questionnaire.

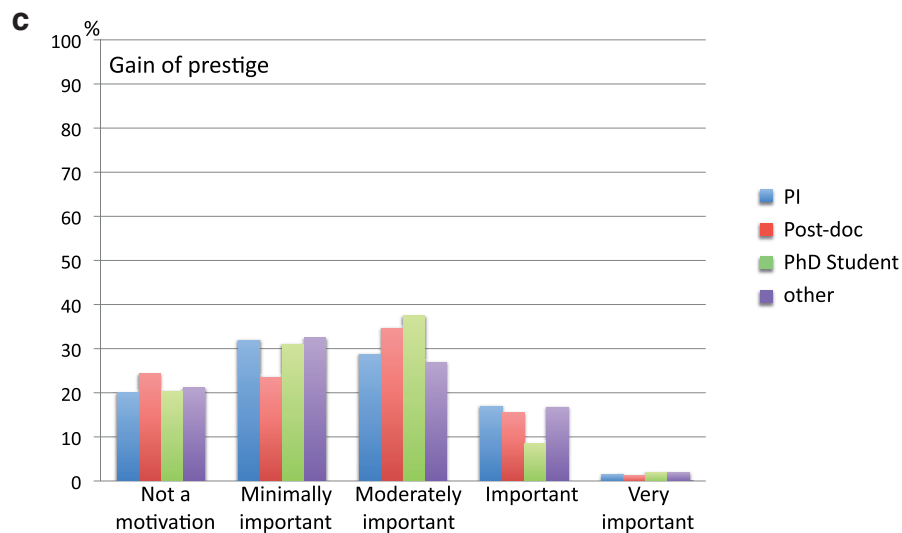
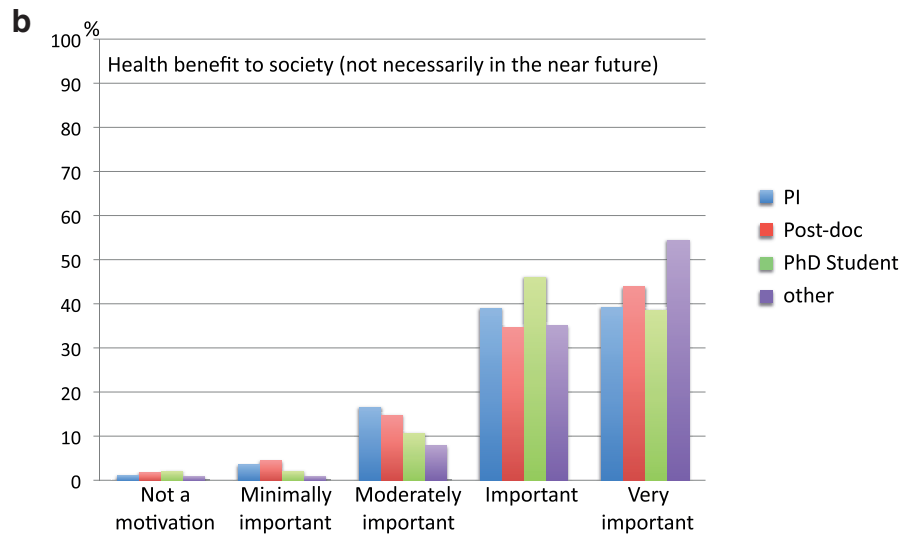
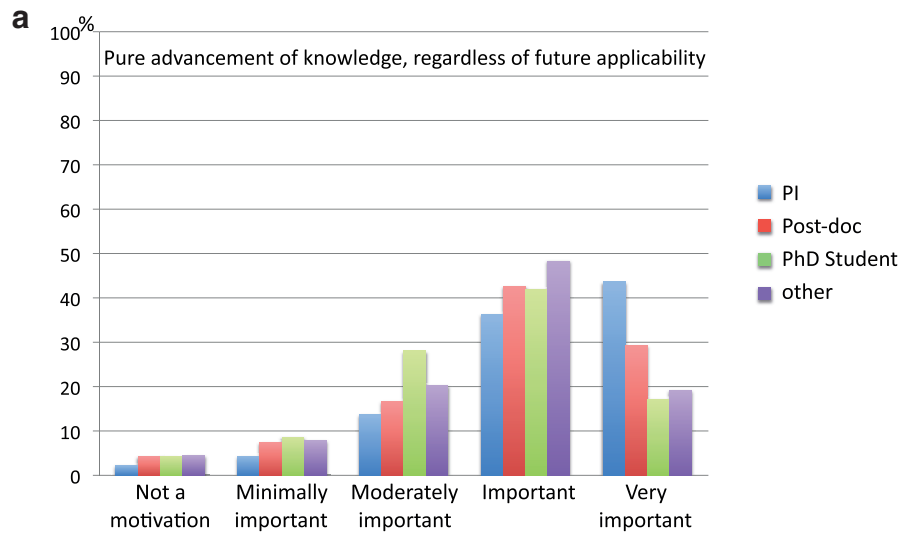
Overview of the sample

Close to 900 (885) scientists responded to the survey. The overall response rate was 11.4%. The response rates for females and males were 12.8% and 10.0%, respectively (the response rates for females were higher in all geographical locations). The response rate for PIs was 10.5% (12.4% for female PIs and 9.6% for male PIs). Detailed response rates are shown in [Figures S7–S11](#). There were 464 respondents who reported PI status, 219 post-docs, 94 PhD students and 109 other/unspecified roles.

More males (500) than females (359) participated in the study. The average age was 43.4 years old. 202 worked in the Los Angeles-San Diego area (CA-USA), 180 in the London-Cambridge area (UK), 223 in the Milan area (Italy), and 238 in the New York City area (NY-USA). From the question "Approximately, what percentage of your research do you consider to be basic?" the average level of involvement in basic research was 78.0% (2.7% of the respondents skipped this specific question). Only 3 respondents (0.3%) declared they were not involved in basic research at all (i.e. 0% of basic research). Questions were skipped in the range of 2.3% (question with the lowest skipping rate) to 13.7% (question with the highest skipping rate). The number of responses according to role, gender, geographical location and level of involvement in basic research are shown in [Figures S12–S18](#). All responses are presented in the Final report in the Data availability section.

The motivations of the basic scientists

We asked participants to rank their motivations for research by level of importance. "Health benefit to society", "satisfaction of curiosity", and "satisfaction from solving puzzling problems" were the most important motivations while "gain of prestige" and "gain of money" were less important motivations. "Pure advancement of knowledge" was a strong motivator, especially among principal investigators. These results confirmed the findings of Study 1 ([Figures 1a–f](#)) (detailed data for all figures in this paper are shown in the associated tables in [Supplementary material](#)). For the motivations we also performed analyses based on the roles of the scientists. We observed that some differences were statistically significant. In particular, PIs are more motivated from "Pure advancement of knowledge" ($p = 0.0042$) and less motivated from "Gain of money" ($p < 0.0001$) in comparison to post-docs. Moreover, PIs are more motivated from "Pure advancement of knowledge" ($p < 0.0001$) and "Satisfaction of curiosity" ($p = 0.0068$) and less motivated from "Gain of money" ($p = 0.0142$) in comparison to students.



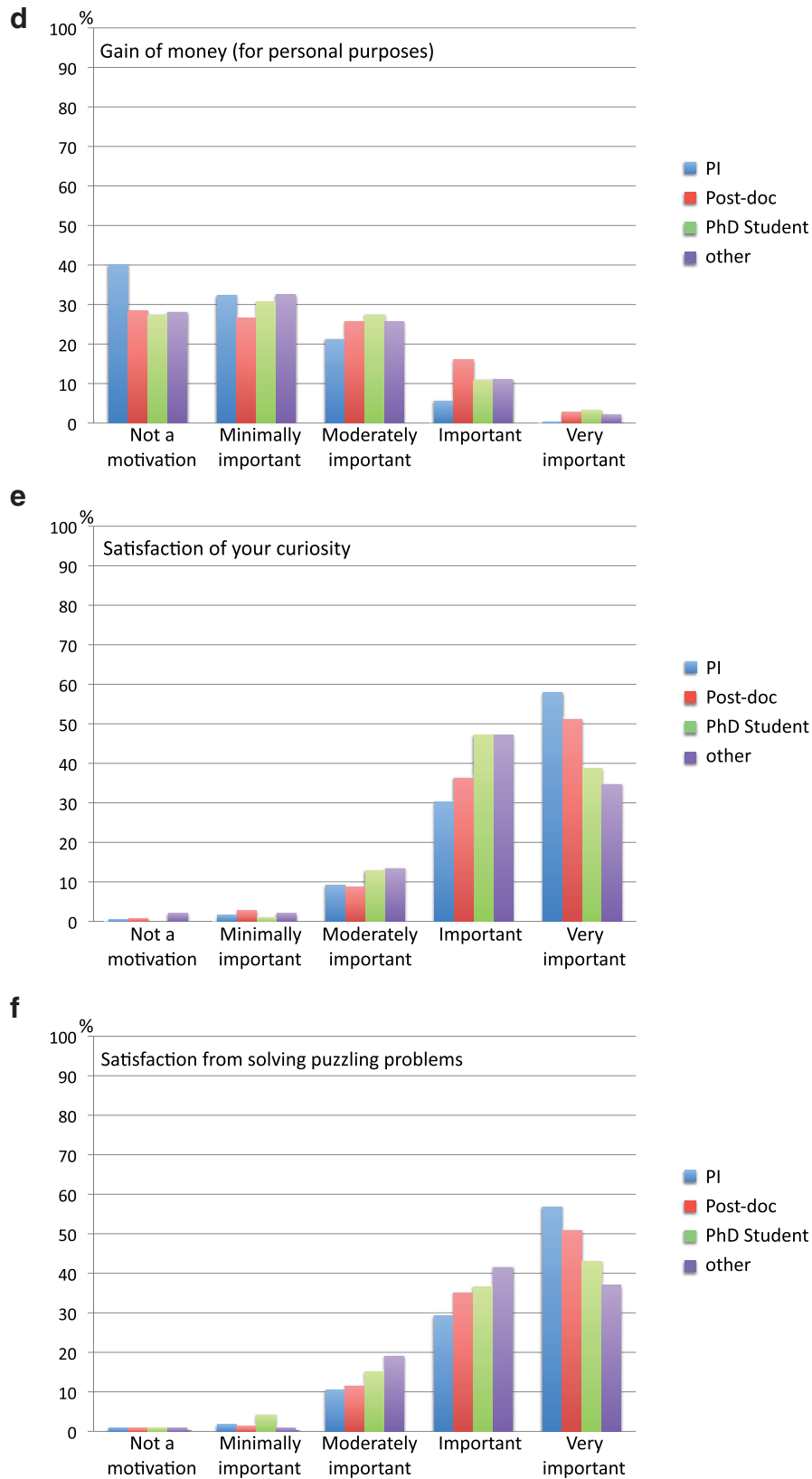
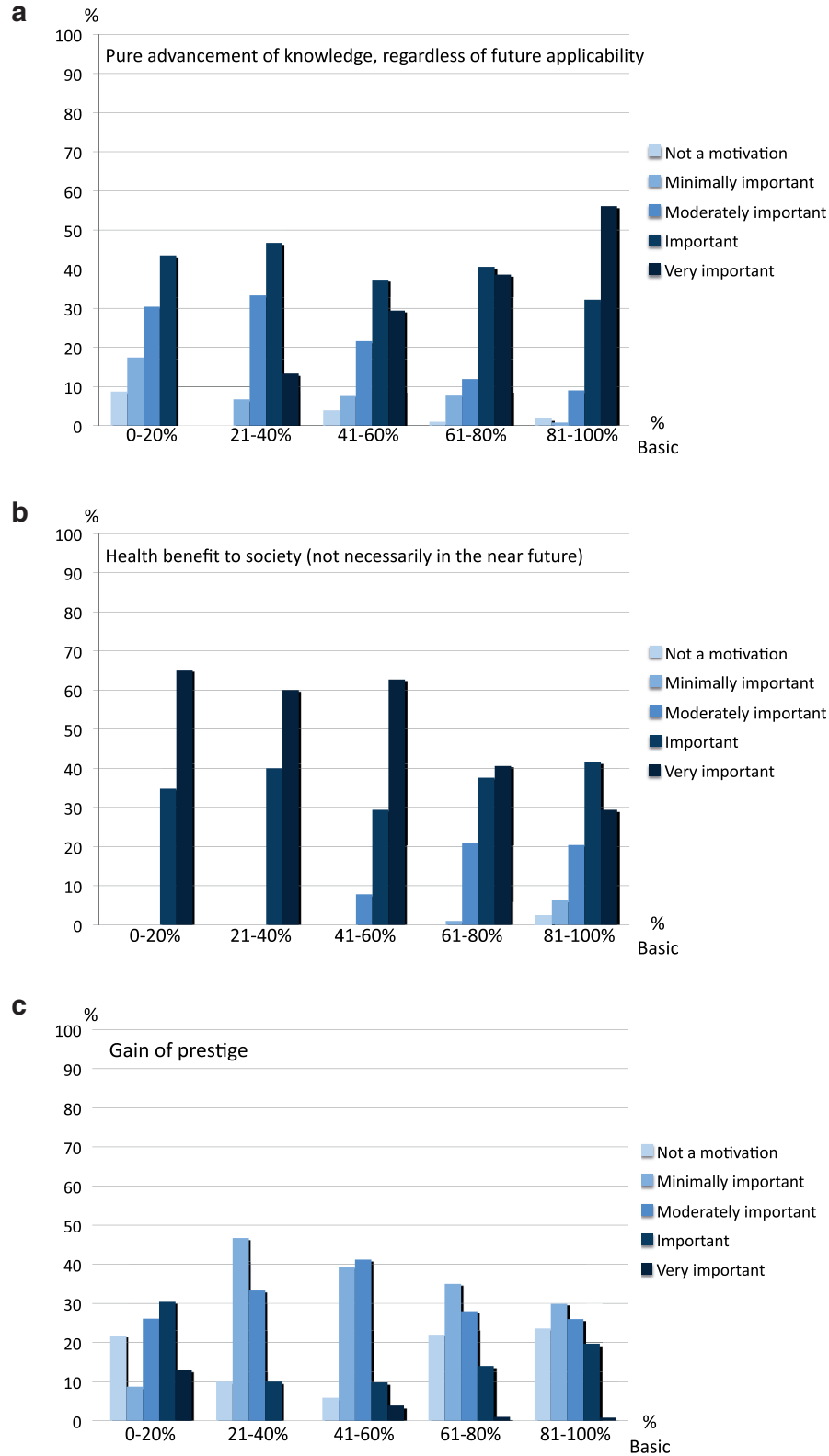


Figure 1. Your personal motivations as a scientist are from: (a) Pure advancement of knowledge, regardless of future applicability, (b) Health benefit to society (not necessarily in the near future), (c) Gain of prestige, (d) Gain of money (for personal purposes), (e) Satisfaction of your curiosity, (f) Satisfaction from solving puzzling problems.

For PIs, their level of involvement in basic research was positively correlated with the motivations “pure advancement of knowledge,” “satisfaction of curiosity,” and “satisfaction from solving

puzzling problems” and negatively correlated with the motivations “health benefit to society,” “gain of prestige,” and “gain of money” (Figures 2a–f).



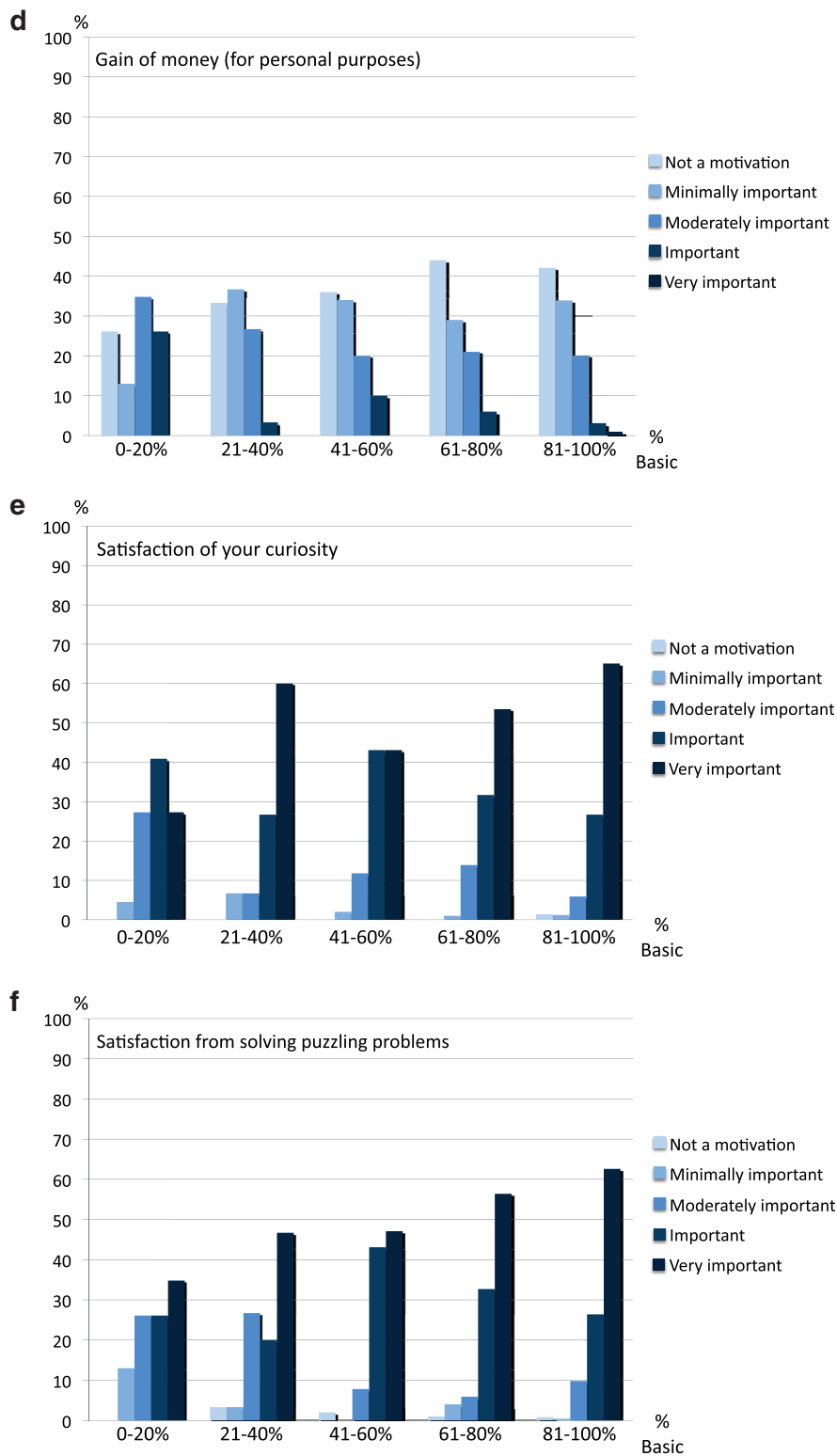


Figure 2. Your personal motivations as a scientist are from: (a) Pure advancement of knowledge, regardless of future applicability, (b) Health benefit to society (not necessarily in the near future), (c) Gain of prestige, (d) Gain of money (for personal purposes), (e) Satisfaction of your curiosity, (f) Satisfaction from solving puzzling problems. (Principal Investigators ordered by percentage of basic research).

The concept of basic research and its practical benefit potential

The vast majority of the surveyed scientists were in some or complete agreement with the statement: “basic scientists can ponder about the future indirect practical benefits of their research without losing their ‘basic status’” (Figure 3). The majority indicated that the most important goal of publicly funded basic *biological* research should be “pure advancement of knowledge, regardless of future applicability” (Figure 4a) and of funded basic *biomedical* research should be the “health benefit to society (not necessarily in the near future)” (Figure 4b). PIs with more involvement in basic research were more likely to agree with the statement “basic scientists can ponder about the future indirect practical benefits of their research without losing their ‘basic status’” (Figure 5) and that “pure knowledge advancement” is the main goal of basic research (Figures 6a–b).

The policy of discussing health benefits in research proposals

Over 70% of respondents expressed at least some agreement with the statement: “although it is difficult to assess the potential future health benefits to society from basic biological/biomedical research as described in written proposals, some degree of estimation is always possible” (Figure 7). However, the level of agreement was significantly lower with the statement: “written proposals about basic biological/biomedical research generally contain a section discussing potential future health benefits. These sections increase

the likelihood that a project benefits future public health.” The difference was especially important for PIs, who expressed the highest degree of disagreement with the second statement (Figure 8).

Almost half of respondents agreed with the statement that “writing the sections discussing potential future health benefits takes too much time” (Figure 9a). For the statement “the sections discussing potential future health benefits should be eliminated for [no/a few/most/all] grants”, over 70% of respondents declared that these sections should be eliminated at least for some grants, including a significant portion (especially of PIs) that indicated that these sections should be eliminated for “most” or “all” grants (Figure 9b).

For PIs, there was a negative correlation between their level of involvement in basic research and their level of agreement with the statement “although it is difficult to assess the potential future health benefits to society from basic biological/biomedical research as described in written proposals, some degree of estimation is always possible” although most PIs, even those with the highest involvement in basic research, were in agreement (Figure 10). There was also a negative correlation between the degree of involvement in basic research and the statement “written proposals about basic biological/biomedical research generally contain a section discussing potential future health benefits. These sections increase the likelihood that a project benefits future public health.” Here, over two thirds of the PIs with the highest involvement in basic research were in disagreement (Figure 11).

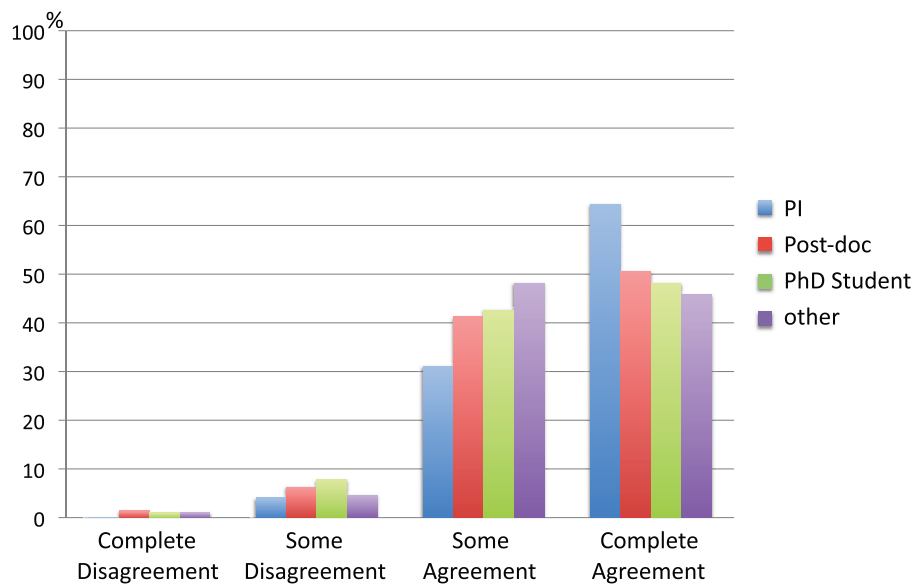


Figure 3. Basic scientists can ponder about the future indirect practical benefits of their research without losing their “basic status”.

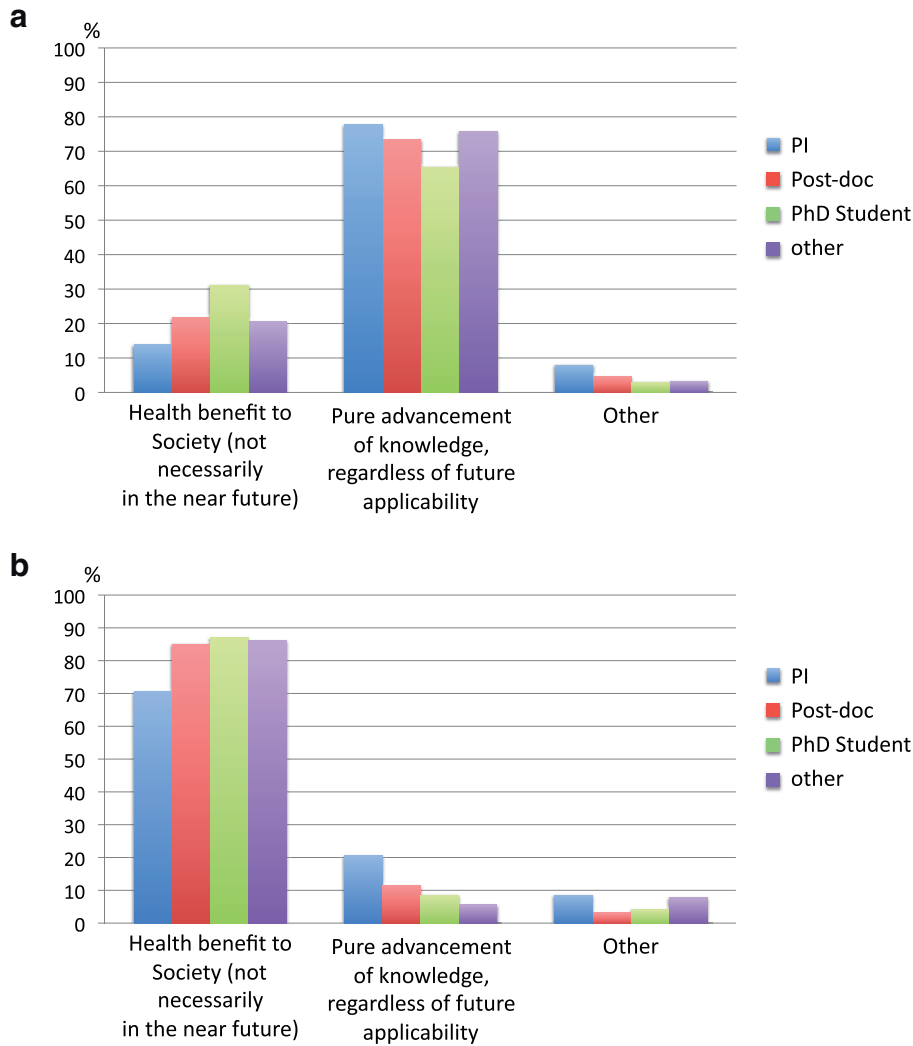


Figure 4. What should the most important goal of publicly funded basic: (a) **BIOLOGICAL** (not biomedical) research be? (b) **BIOMEDICAL** research be?

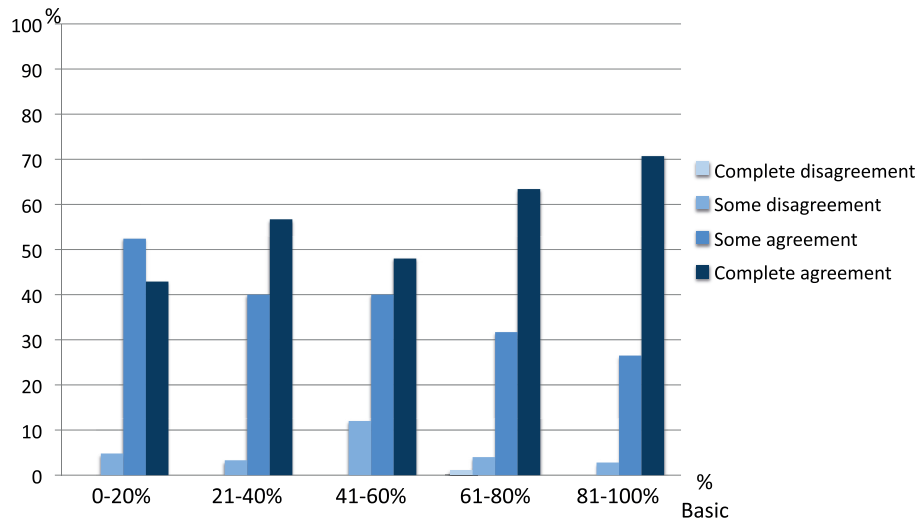


Figure 5. Basic scientists can ponder about the future indirect practical benefits of their research without losing their “basic status”. Principal investigators ordered by percentage of basic research.

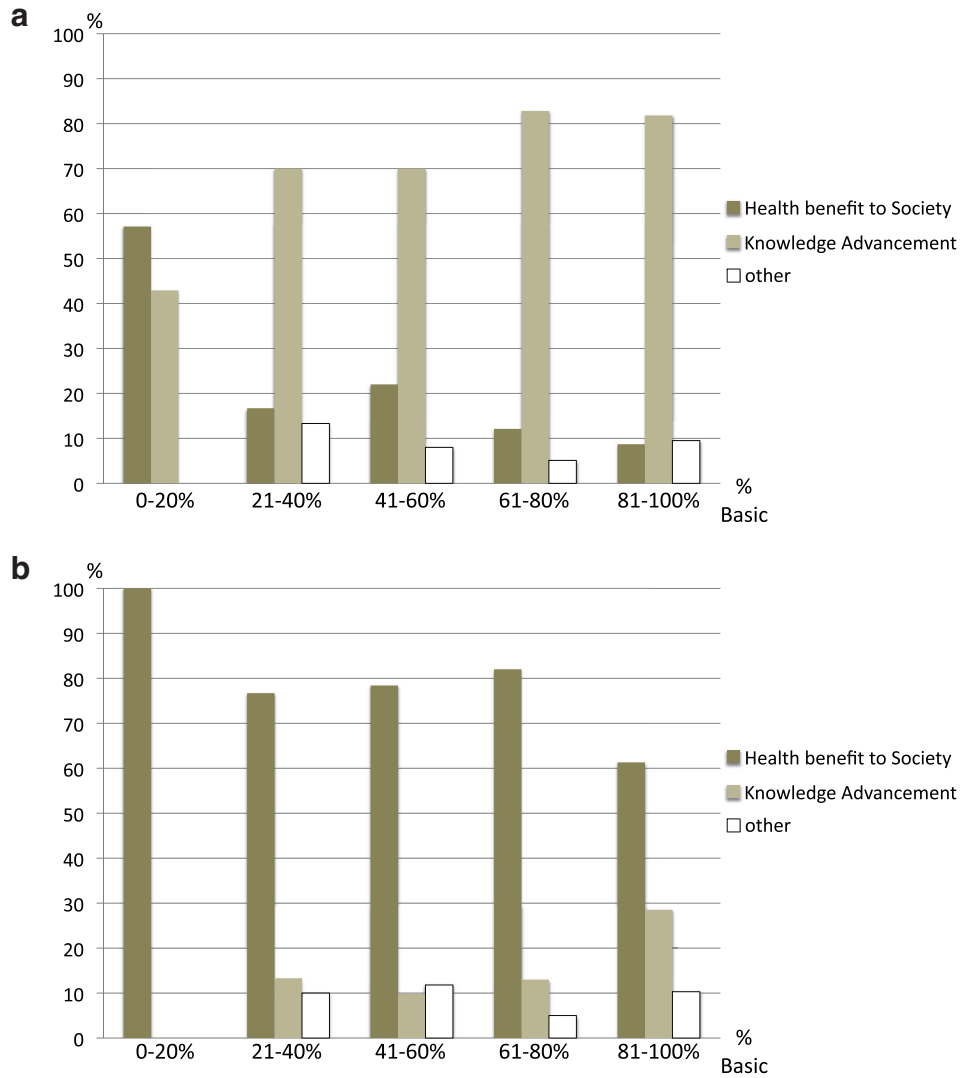


Figure 6. What should the most important goal of publicly funded basic: (a) **BIOLOGICAL** (not biomedical) research be? (b) **BIOMEDICAL** research be? (Principal investigators ordered by percentage of basic research).

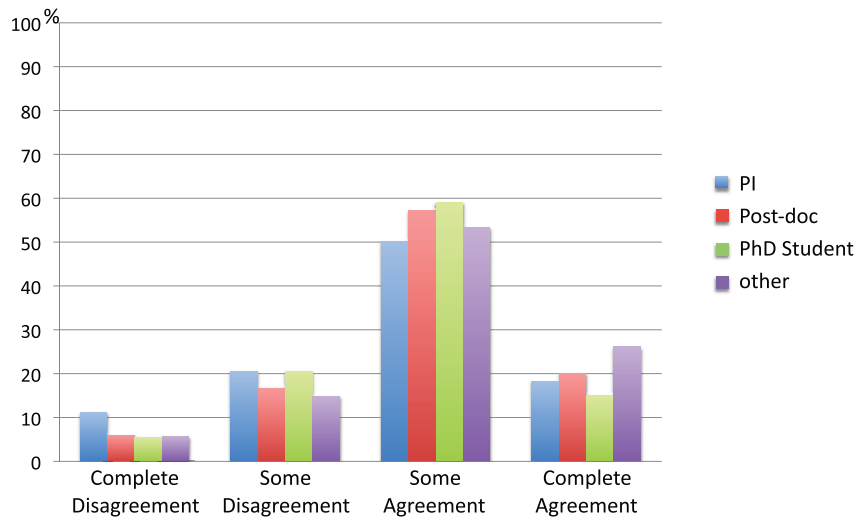


Figure 7. Although it is difficult to assess the potential future health benefits to society from basic biological/biomedical research as described in written proposals, some degree of estimation is always possible.

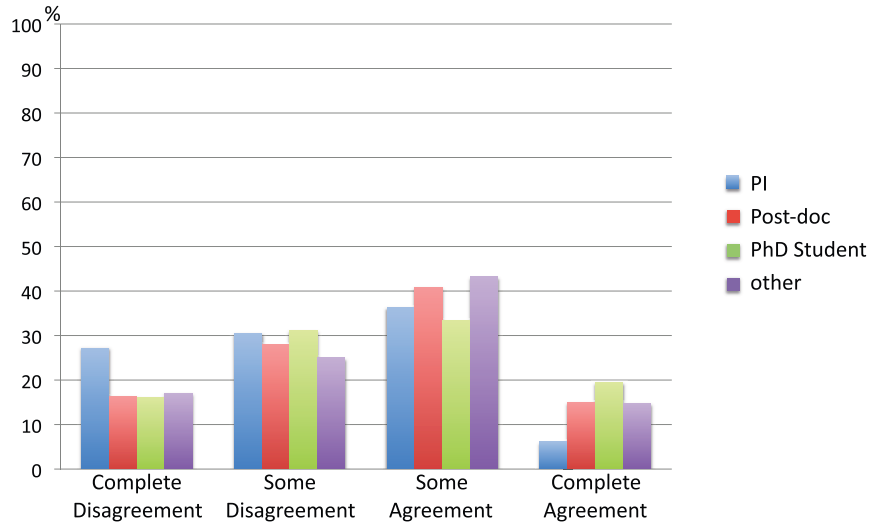


Figure 8. Written proposals about basic biological/biomedical research generally contain a section discussing potential future health benefits. These sections increase the likelihood that a project benefits future public health.

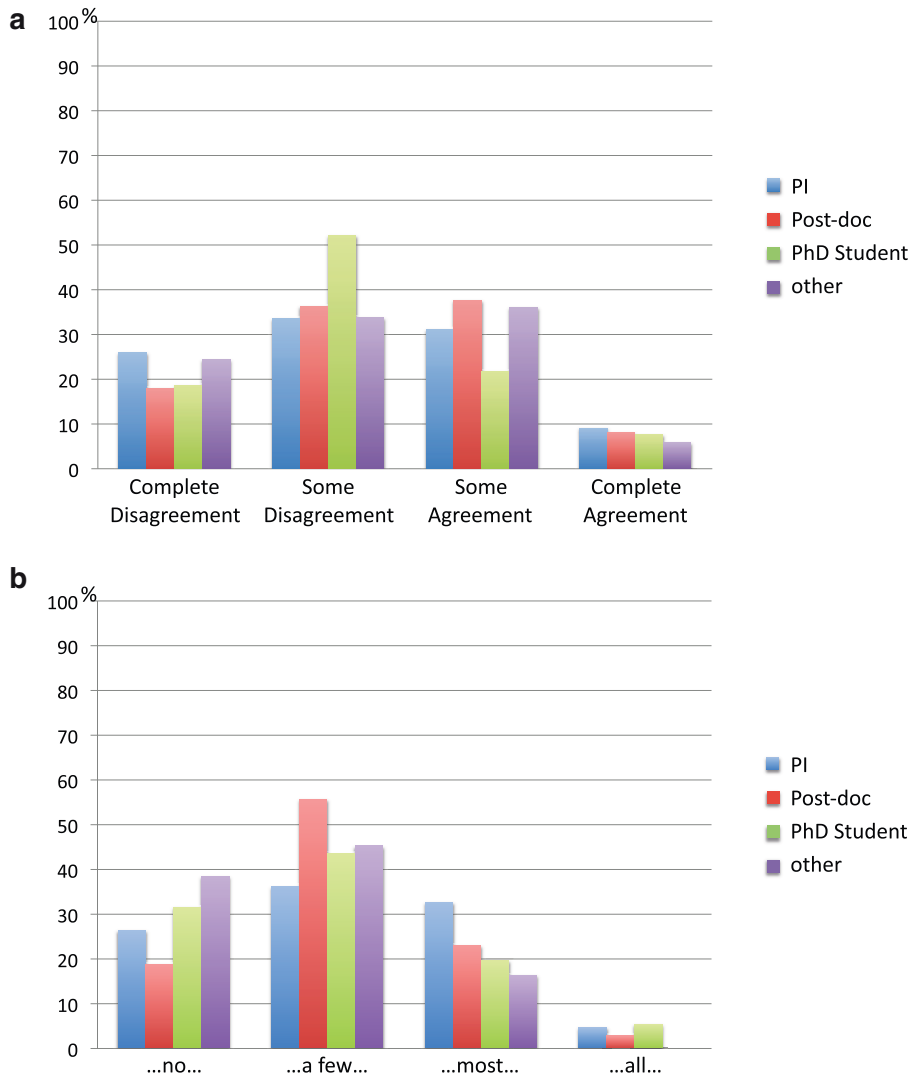


Figure 9. (a) Writing the sections discussing potential future health benefits takes too much time. (b) The sections discussing potential future health benefits should be eliminated for grants.

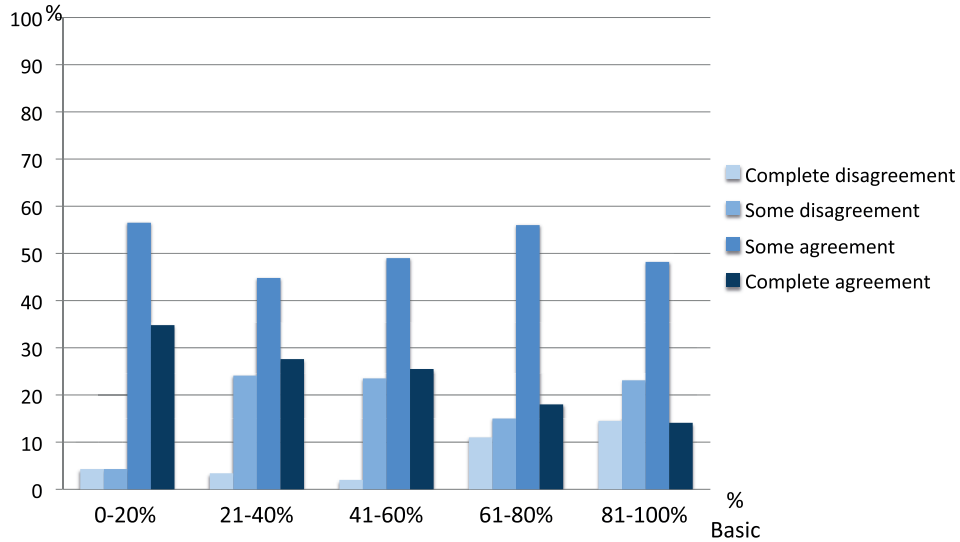


Figure 10. Although it is difficult to assess the potential future health benefits to society from basic biological/biomedical research as described in written proposals, some degree of estimation is always possible. Principal Investigators ordered by percentage of basic research.

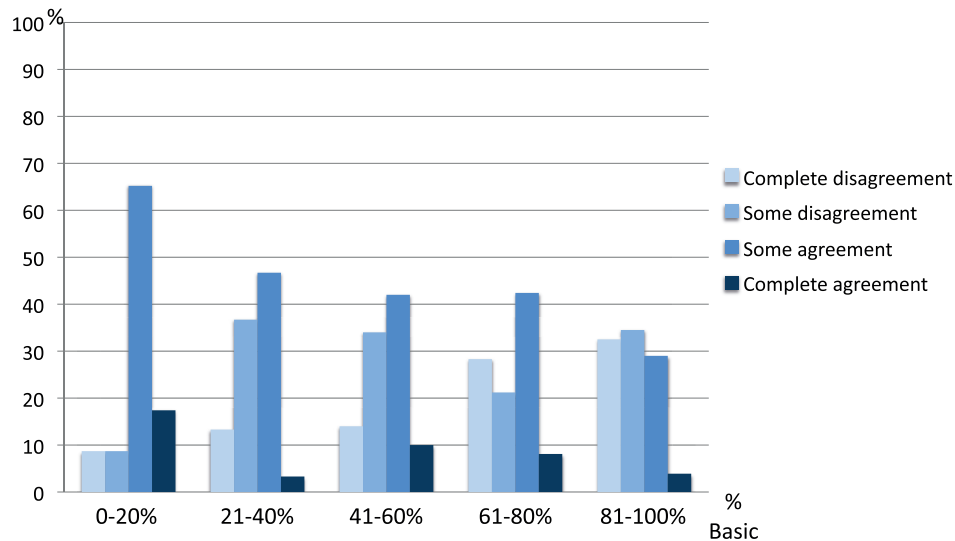


Figure 11. Written proposals about basic biological/biomedical research generally contain a section discussing potential future health benefits. These sections increase the likelihood that a project benefits future Public health. Principal investigators ordered by percentage of basic research.

Among PIs, more involvement in basic research led to more support for the statement “writing the sections discussing potential future health benefits takes too much time” (Figure 12a) and more support for the idea that “the sections discussing potential future health benefits” should be eliminated for at least a subset of grants. This latter opinion was expressed by fewer than 50% of PIs with the least involvement in basic research but by almost 80% of PIs with the highest involvement in basic research (Figure 12b).

Overall, the results show that most of basic scientists believe that some degree of assessment of the health benefit potential of basic

biological or biomedical research is possible but that the current policy requiring the discussion of this potential in written research proposals is not very effective and should be eliminated for at least a portion of the grants, if not most or all of them.

Soft policies to increase the public health potential of basic research and the satisfaction of scientists

We tested scientists’ opinions concerning six soft policies that we designed based on the results of Study 1. These policies are intended to increase the public health potential of basic investigations and improve the work satisfaction of the basic scientists.

These are the policies:

- A. “Locate more basic research laboratories inside or in close proximity of hospitals.”
- B. “Organize more educational and discussion meetings between scientists and the general public or patient associations. Acknowledge participating scientists during grant assignments, promotion, hiring etc.”
- C. “Promote more seminars and academic discussion concerning the purpose of scientific research and the role of scientists in the society. Acknowledge participating scientists during grant assignments, promotion, hiring etc.”
- D. “Promote more seminars and academic discussion about the concept and definition of basic research. Acknowledge participating scientists during grant assignments, promotion, hiring etc.”

- E. “Have ethics consultation services for scientists inside research institutes, with easily accessible information about these services.”
- F. “Provide recognition to basic scientists who have contributed to acquiring key knowledge that leads to tangible health benefits by requiring a “basic bibliography” of seminal basic research articles for each new drug or other biological application.”

Respondents were asked to evaluate these policies on four criteria: the policy’s effectiveness in generating (a) societal benefit, (b) scientists’ work satisfaction, along with the policy’s (c) feasibility and (d) overall favorability. Respondents were asked to evaluate these policies using four scores: “none” (score 1), “low” (score 2), “medium” (score 3), “high” (score 4). The vast majority of scientists judged all six policies to have at least some degree of effectiveness,

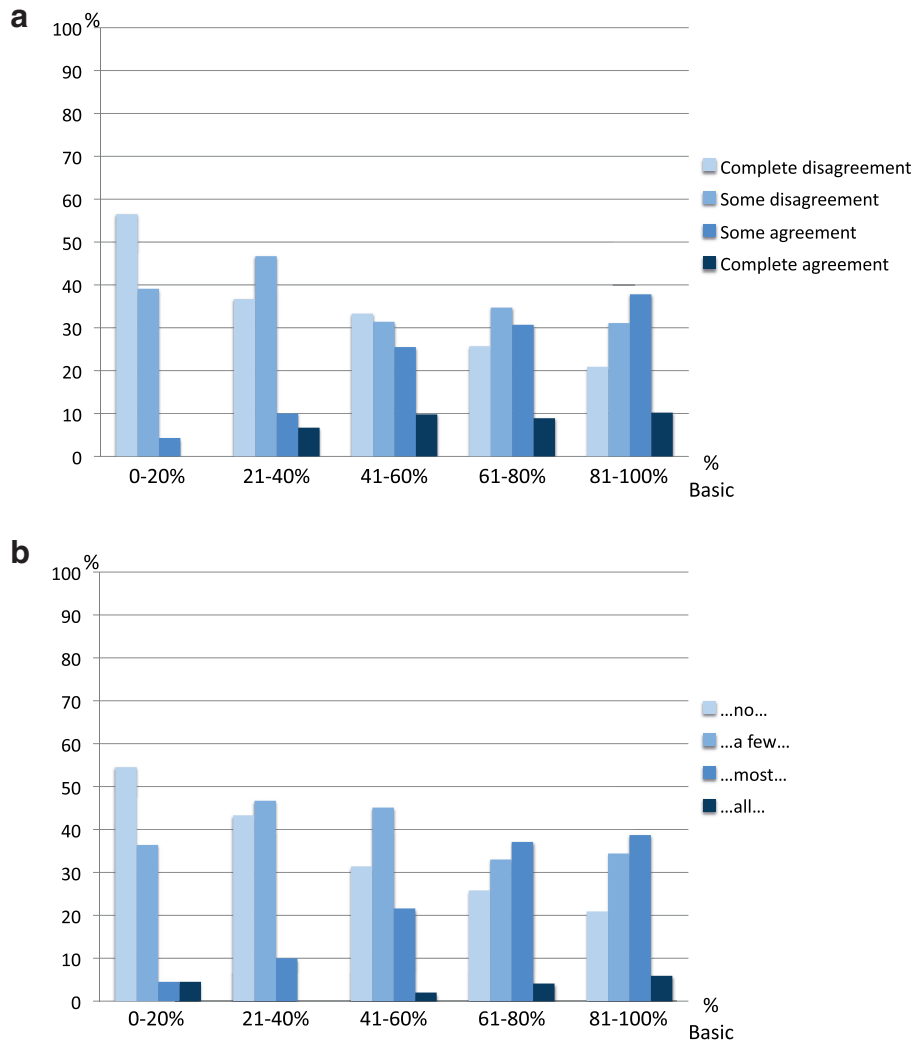


Figure 12. (a) Writing the sections discussing potential future health benefits takes too much time. (b) The sections discussion potential future health benefits should be eliminated for grants. Principal investigators ordered by percentage of basic research.

feasibility and favorability, with a substantial proportion of scientists giving scores of 3 or 4. The policies that scored highest with regard to the societal benefit were B (score 3.3), C (score 3.2) and F (score 3.2). The policy that scored highest with regard to the scientist satisfaction was F (score 3.4). The policies that scored highest with regard to feasibility were F (score 3.2), C (score 3.1) and E (score 3.1). The policies that scored highest with regard to overall favorability were F (score 3.3), B (score 3.2) and C (score 3.2). Policy F had the highest percentage of “high” responses (scores 4) (46.5%) and the highest percentage of “high” responses in terms of overall favorability (49.9%) (Figures 13a–f). Role of the respondent (i.e., PI, post-doc) did not substantially affect the favorability of these options (Figures 14a–f).

For PIs, in terms of degree of involvement in basic research, there were substantial differences in favorability only in relation to policy A, for which there was a small negative correlation ($R^2 = 0.986$) (Figures 15a–f). With regard to the influence of the gender of the PIs, there was a slight increase in favorability of female PIs for policy B–F and in favorability of male PIs for policy A (Figures 16a–f).

Conclusions

Ten main results deserve some emphasis:

- Basic scientists are strongly motivated not only by “satisfaction of curiosity” and “from solving puzzling problems” but also by the possible future practical benefits to society.
- There is a positive correlation between involvement in basic research and the importance of motivation from “pure advancement of knowledge,” “satisfaction of curiosity,” and “satisfaction from solving puzzling problems.”
- There is a negative correlation between involvement in basic research and motivation for the “health benefit to society.”
- PIs are more motivated than other types of investigators from “pure advancement of knowledge,” “satisfaction of curiosity,” and “satisfaction from solving puzzling problems.”
- While money is not a powerful motivation, prestige is an important to moderately important motivation for nearly half of PIs.
- Almost all scientists think that it is possible to ponder possible future applications of basic investigations without compromising the basic nature of the research.
- On the other hand, most basic scientists disfavor policies mandating the discussion of these practical applications in research proposals.
- There is a positive correlation between PIs’ involvement in basic research and their rejection of the requirement

of discussing the health benefit potential in research proposals.

- There is a large consensus on the effectiveness, feasibility and favorability for all six soft policies designed to increase the public health potential of basic research and the scientist satisfaction.
- Among these six policies, those entailing the organization of more meetings between scientists and the general public, the organization of more academic discussion about the role of scientists in the society, and the implementation of a “basic bibliography” for each new approved drug received the highest approval rates.

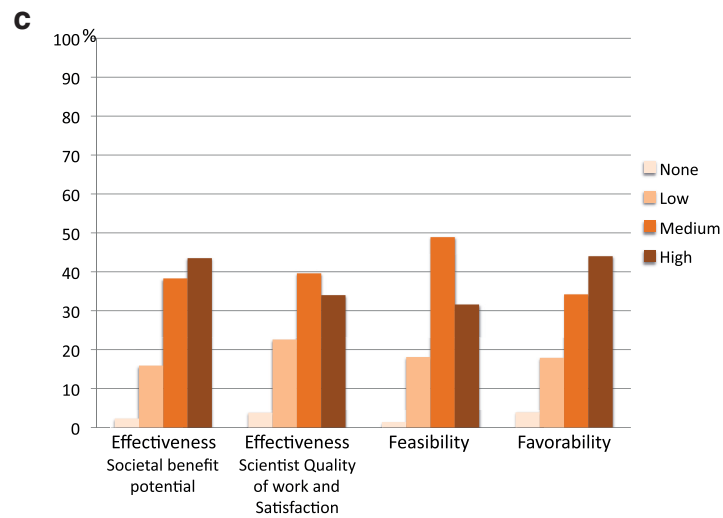
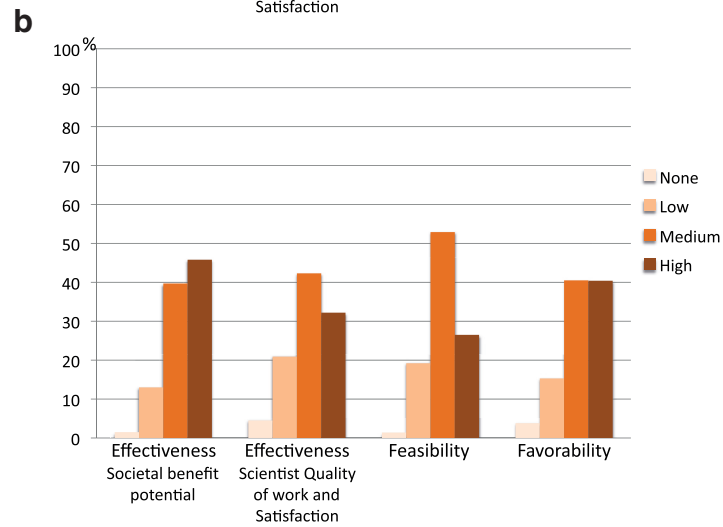
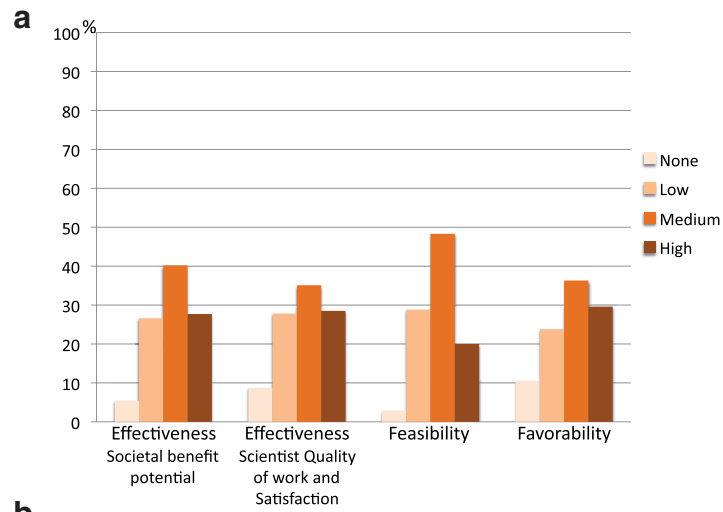
Discussion

This study is a follow-up to a preliminary study of a smaller sample of basic scientists working at a single institution (Harvard University) in a single geographical area (the Boston area in the United States). The results of the preliminary study have been recently published alongside an in-depth analysis of the related literature and conceptual framework²⁰. Based on the results of that survey, we expanded the study to include questions on six specific soft policies and a larger sample of scientists working at different institutions in four geographical areas (see Figures S19–S26 for differences between locations) in three countries.

The current study substantially confirmed what we had discovered in Study 1. In particular, the new study confirmed what we had previously observed with regard to basic scientists’ motivations and conceptualization of basic research. Moreover, it further reinforces the notion that, while some estimate of the public health potential of basic investigations is always possible, basic scientists believe that the requirement of discussing this potential in research proposals is not effective and should be eliminated for at least a portion of the grants (see also Figures S27–S30). The six proposed “nudge”-based policies were judged positively in terms of their future public health impact, scientist work satisfaction, and feasibility, with policies B, C and F receiving the highest approval ratings.

This study has several strengths. First, we gathered data from a large and diverse population of basic scientists. Second, we analyzed responses not only with respect to the role of the scientist (e.g., PI, post-doc) but also with the self-reported (from 0 to 100%) level of involvement with basic research. As far as we could determine, this has not been done before. Third, the survey has a depth and level of detail rarely seen in surveys of the motivations and perspectives of biological and biomedical scientists. Finally, and most important, this study provides information on specific policies, some of these new policies (B, C, D, F), and the findings can be used by policymakers to improve the governance of basic research.

The study has also weaknesses. First the survey results may not be fully representative of the views of all basic biomedical and biological scientists. Although based on a large and multinational sample, it still only presents the views of scientists in three



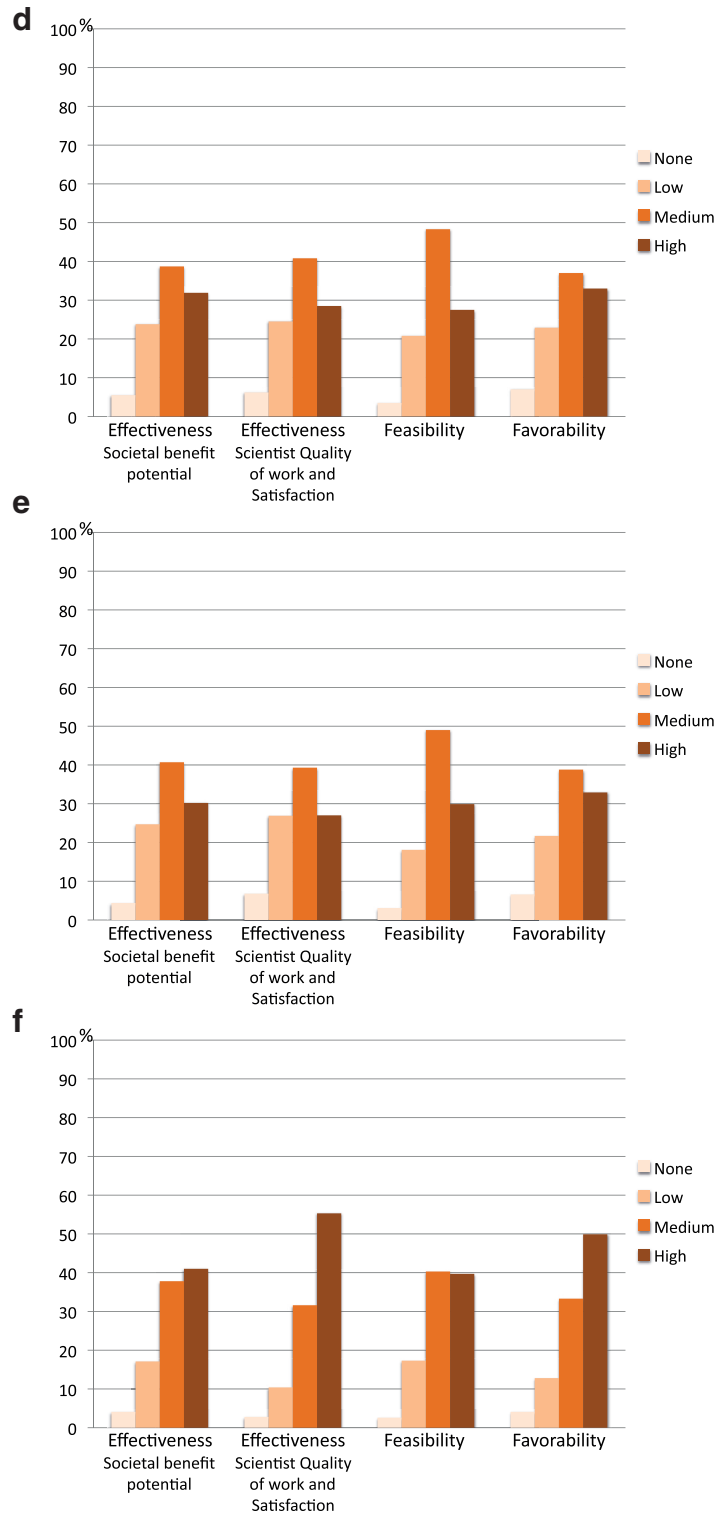
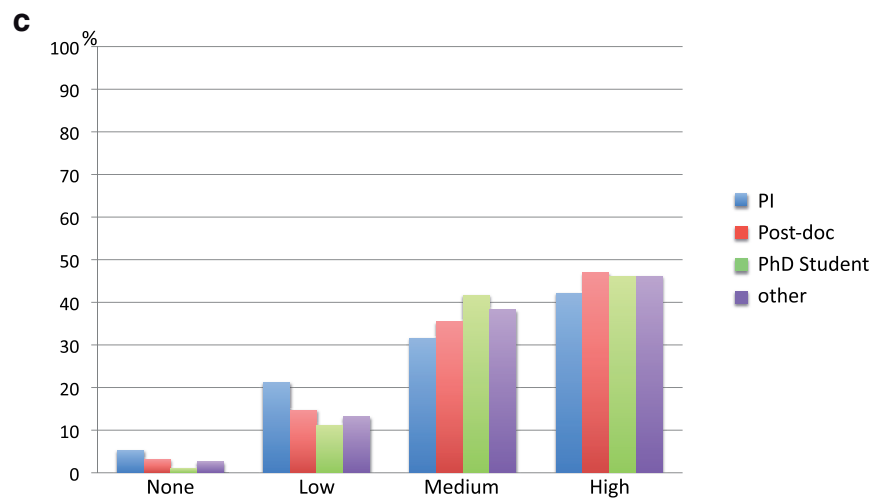
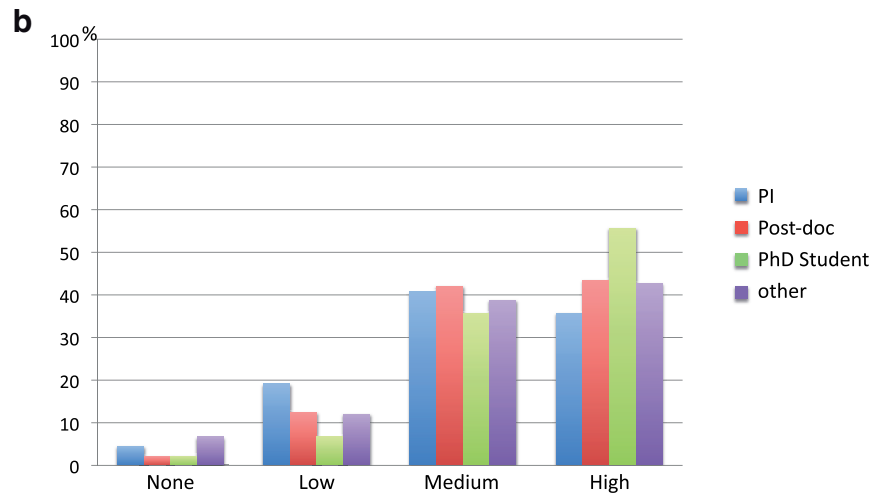
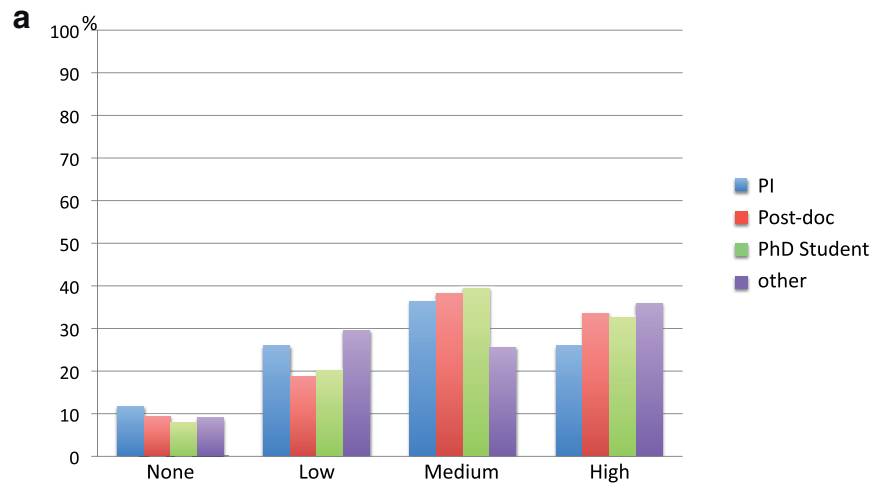


Figure 13. (a) POLICY A “Locate more basic research laboratories inside or in close proximity of hospitals”. (b) POLICY B “Organize more educational and discussion meetings between scientists and the general public or patient associations. Acknowledge participating scientists during grant assignments, promotion, hiring etc.” (c) POLICY C “Promote more seminars and academic discussion concerning the purpose of scientific research and the role of scientists in the society. Acknowledge participating scientists during grant assignments, promotion, hiring etc.” (d) POLICY D “Promote more seminars and academic discussion about the concept and definition of basic research. Acknowledge participating scientists during grant assignments, promotion, hiring etc.” (For example, should basic research be conceptualized as purely curiosity-driven, or could basic scientists also consider future indirect practical benefits of their research?). (e) POLICY E “Have ethics consultation services for scientists inside research institutes, with easily accessible information about these services”. (f) POLICY F “Provide recognition to basic scientists who have contributed to acquiring key knowledge that leads to tangible health benefits by requiring a “basic bibliography” of seminal basic research articles for each new drug or other biological application”.



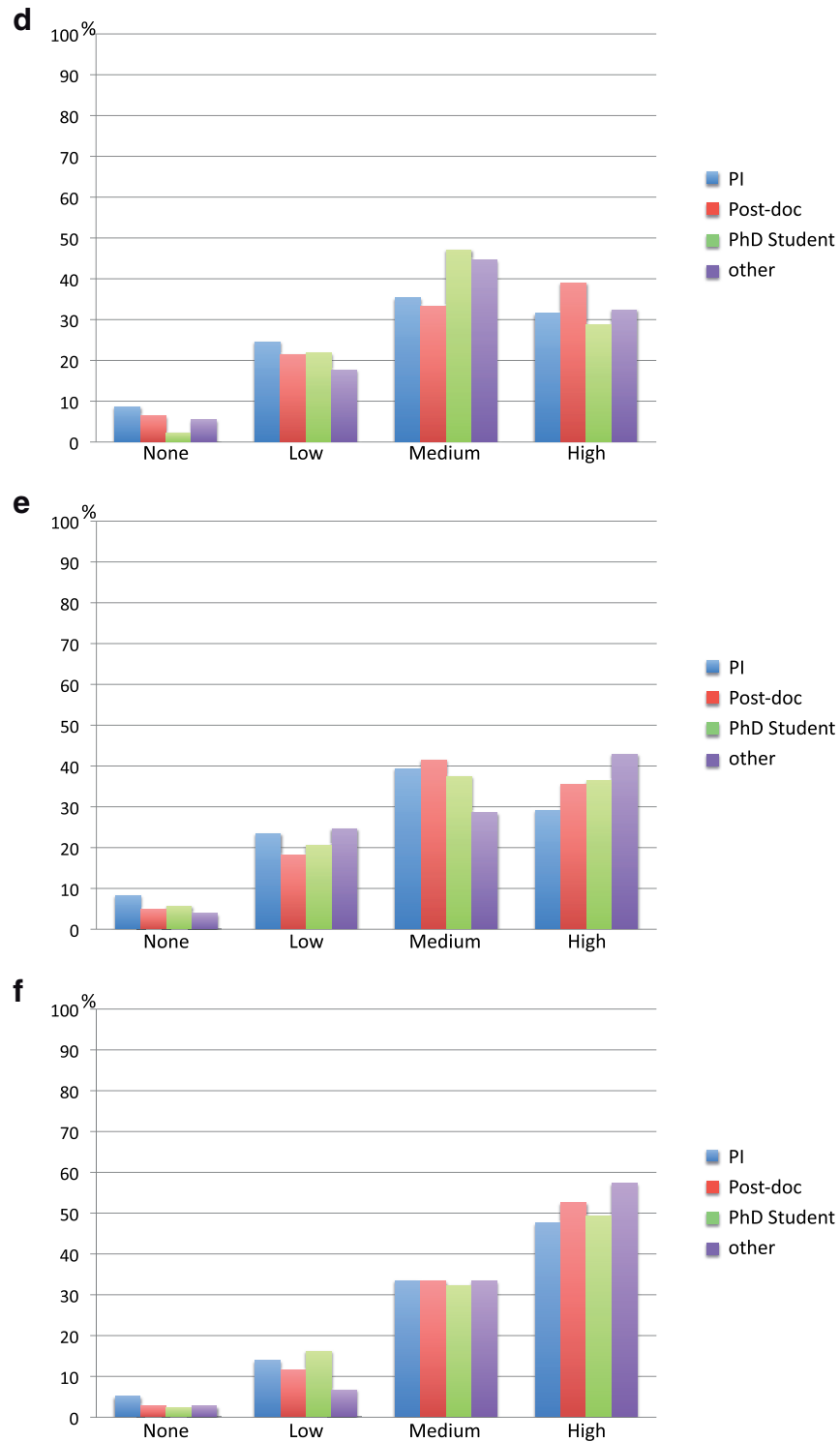
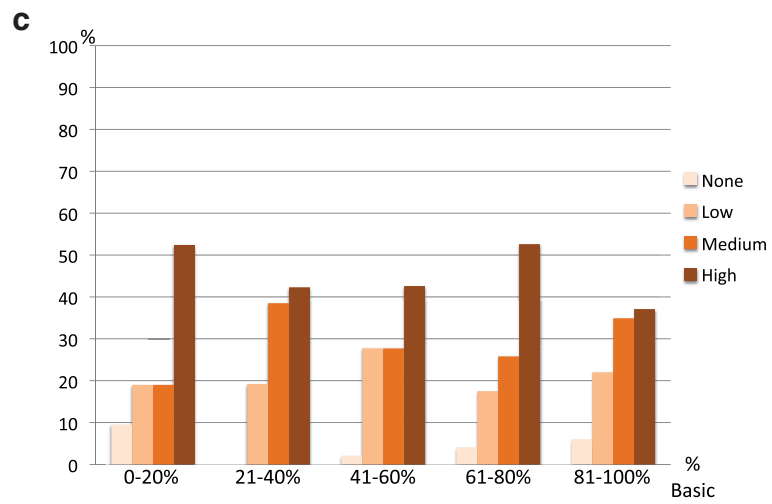
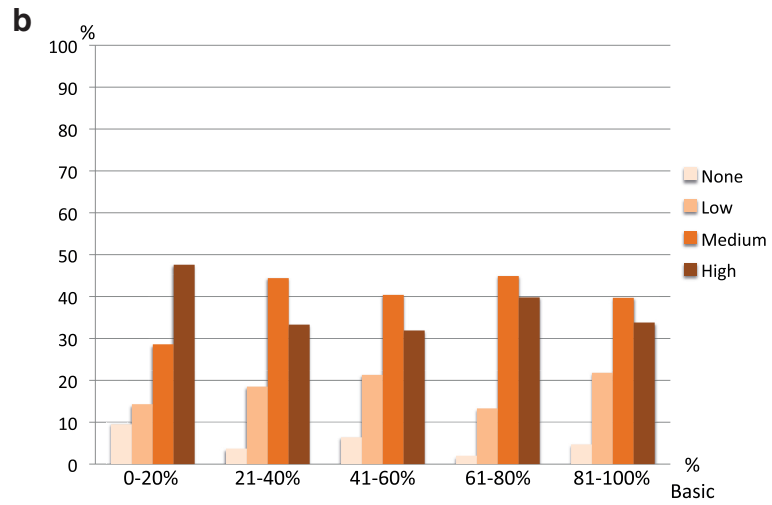
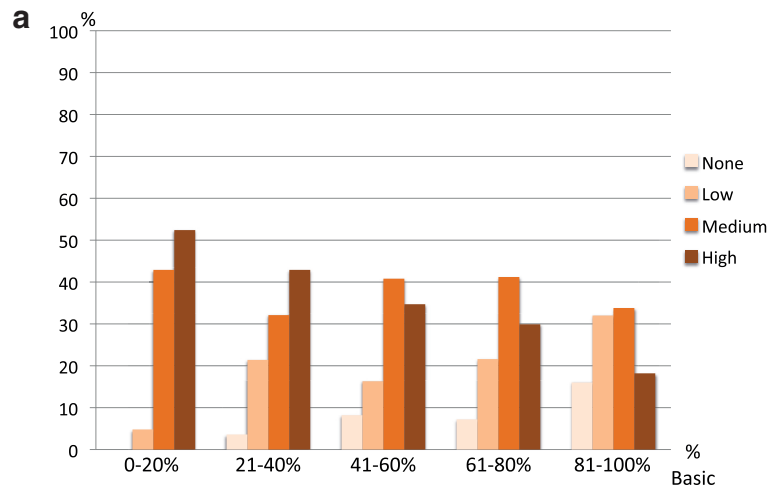


Figure 14. (a) Favorability for POLICY A “Locate more basic research laboratories inside or in close proximity of hospitals”. (b) Favorability for POLICY B “Organize more educational and discussion meetings between scientists and the general public or patient associations. Acknowledge participating scientists during grant assignments, promotion, hiring etc.” (c) Favorability for POLICY C “Promote more seminars and academic discussion concerning the purpose of scientific research and the role of scientists in the society. Acknowledge participating scientists during grant assignments, promotion, hiring etc.” (d) Favorability for POLICY D “Promote more seminars and academic discussion about the concept and definition of basic research. Acknowledge participating scientists during grant assignments, promotion, hiring etc.” (For example, should basic research be conceptualized as purely curiosity driven, or could basic scientists also consider future indirect practical benefits of their research?). (e) Favorability for POLICY E “Have ethics consultation services for scientists inside research institutes, with easily accessible information about these services”. (f) Favorability for POLICY F “Provide recognition to basic scientists who have contributed to acquiring key knowledge that leads to tangible health benefits by requiring a “basic bibliography” of seminal basic research articles for each new drug or other biological application”.



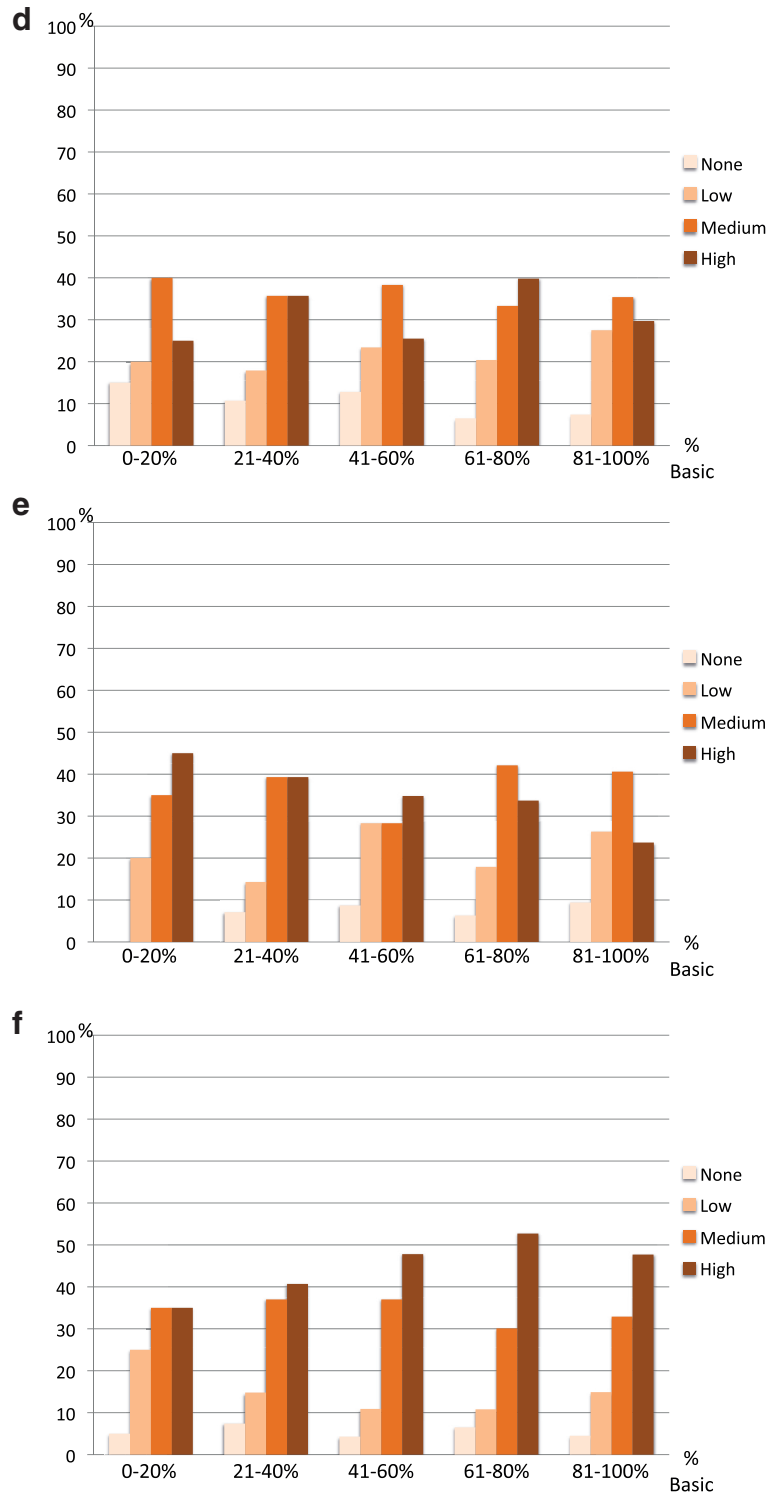
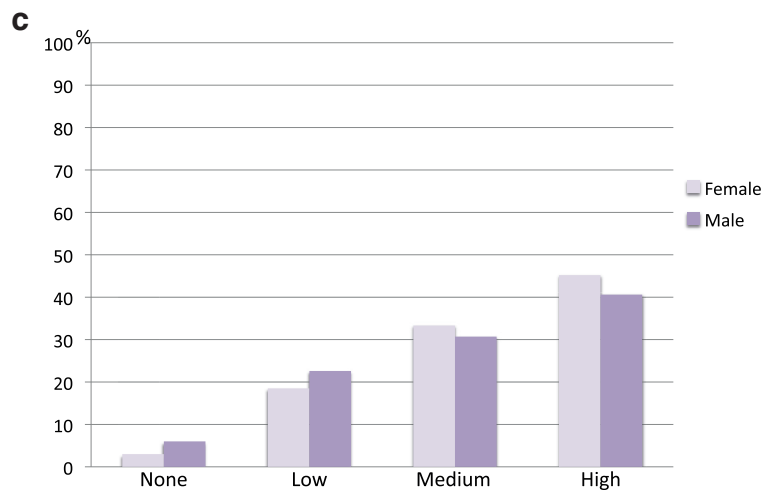
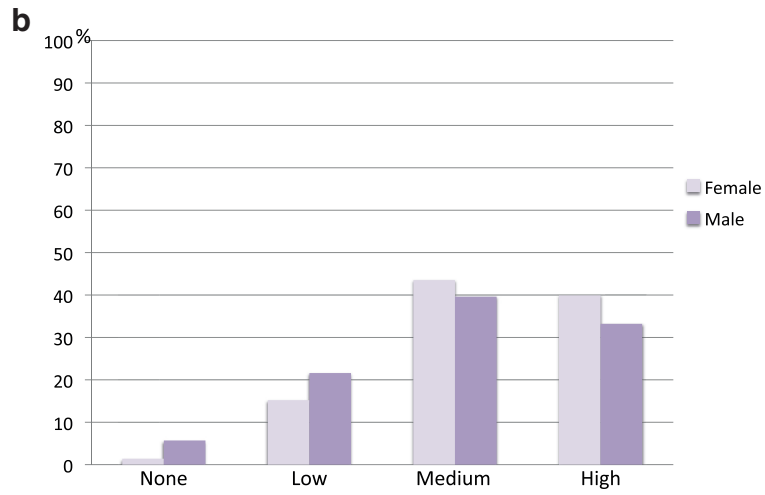
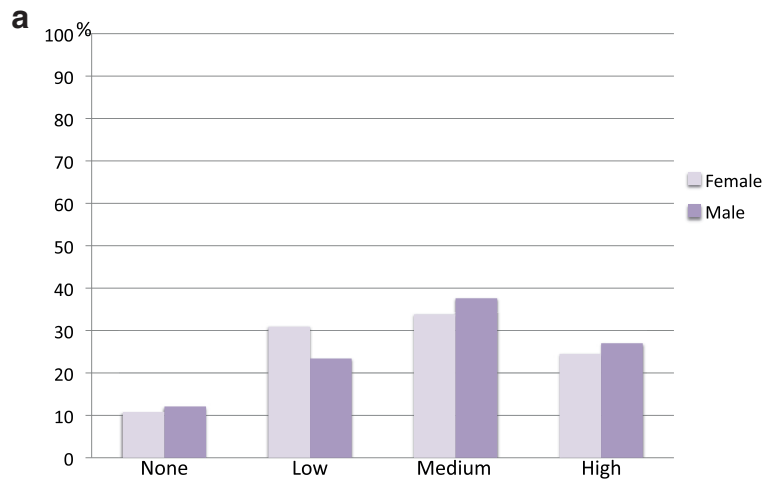


Figure 15. (a) Favorability for POLICY A “Locate more basic research laboratories inside or in close proximity of hospitals”. (b) Favorability for POLICY B “Organize more educational and discussion meetings between scientists and the general public or patient associations. Acknowledge participating scientists during grant assignments, promotion, hiring etc.” (c) Favorability for POLICY C “Promote more seminars and academic discussion concerning the purpose of scientific research and the role of scientists in the society. Acknowledge participating scientists during grant assignments, promotion, hiring etc.” (d) Favorability for POLICY D “Promote more seminars and academic discussion about the concept and definition of basic research. Acknowledge participating scientists during grant assignments, promotion, hiring etc.” (For example, should basic research be conceptualized as purely curiosity driven, or could basic scientists also consider future indirect practical benefits of their research?). (e) Favorability for POLICY E “Have ethics consultation services for scientists inside research institutes, with easily accessible information about these services”. (f) Favorability for POLICY F “Provide recognition to basic scientists who have contributed to acquiring key knowledge that leads to tangible health benefits by requiring a “basic bibliography” of seminal basic research articles for each new drug or other biological application”. (Principal Investigators ordered by percentage of basic research).



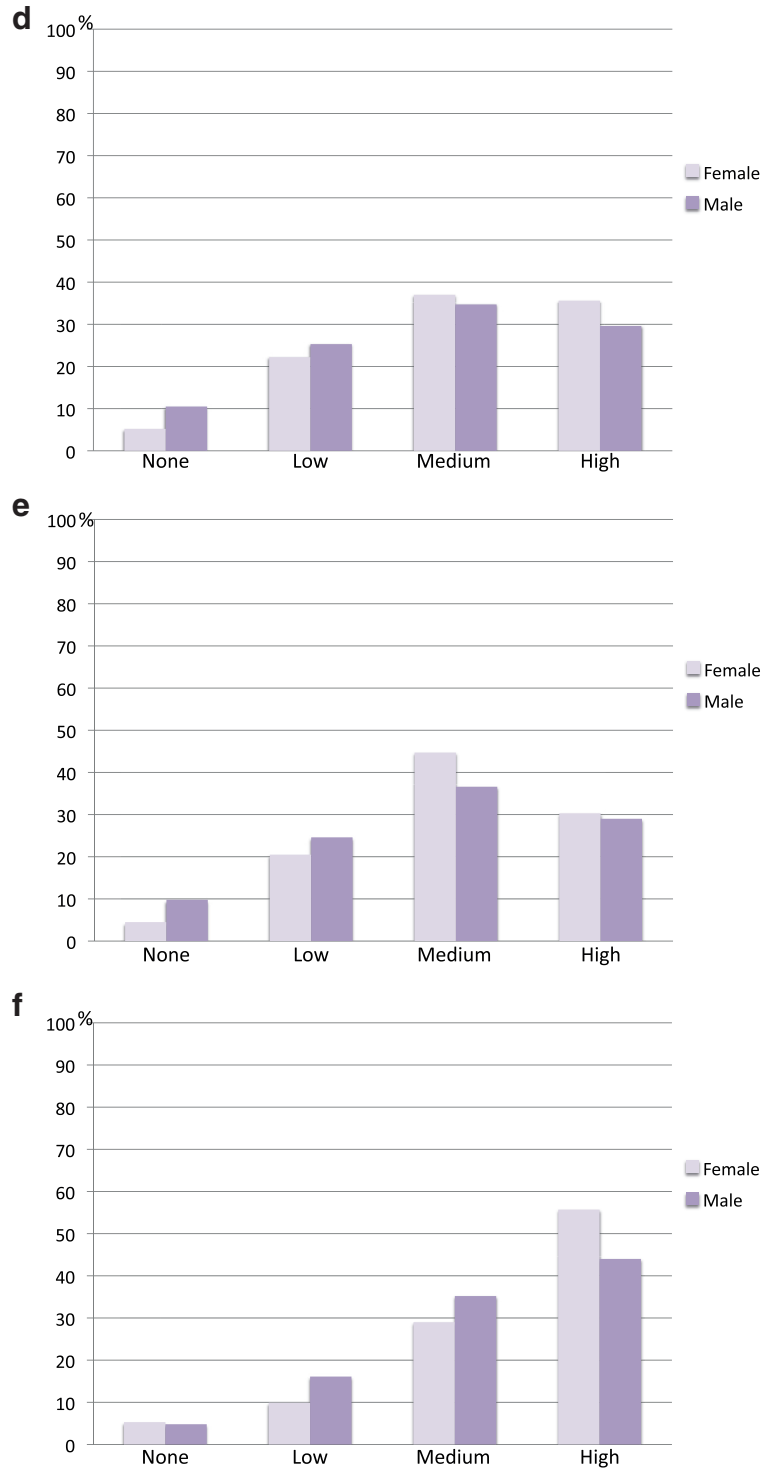


Figure 16. (a) Favorability for POLICY A “Locate more basic research laboratories inside or in close proximity of hospitals”. (b) Favorability for POLICY B “Organize more educational and discussion meetings between scientists and the general public or patient associations. Acknowledge participating scientists during grant assignments, promotion, hiring etc.” (c) Favorability for POLICY C “Promote more seminars and academic discussion concerning the purpose of scientific research and the role of scientists in the society. Acknowledge participating scientists during grant assignments, promotion, hiring etc.” (d) Favorability for POLICY D “Promote more seminars and academic discussion about the concept and definition of basic research. Acknowledge participating scientists during grant assignments, promotion, hiring etc.” (For example, should basic research be conceptualized as purely curiosity driven, or could basic scientists also consider future indirect practical benefits of their research?). (e) Favorability for POLICY E “Have ethics consultation services for scientists inside research institutes, with easily accessible information about these services”. (f) Favorability for POLICY F “Provide recognition to basic scientists who have contributed to acquiring key knowledge that leads to tangible health benefits by requiring a “basic bibliography” of seminal basic research articles for each new drug or other biological application”. (Principal Investigators and Gender).

countries. Moreover, since we focused our study mainly on PIs and post-docs, this study is less representative of the opinions of students or other types of scientists such as staff scientists or research technicians. In addition, although we had a large sample, only 11% of possible respondents answered the survey. Finally, although most of the surveyed scientists were positive about the effectiveness and feasibility of the proposed policies, that alone does not ensure these policies will in fact be effective and/or feasible. Similarly, it does not imply that other parts of the society (e.g. the general public and the policymakers) have the same views.

We hope the information and discussion provided in this paper will be useful to scholars, policymakers and advocates. We encourage them to foster the discussion and work for the implementation of policies that can benefit both society and science. The results provided in this paper suggest that the proposed policies are well grounded in the motivations and perspectives of the basic bioscientists and have their approval. We believe this is an important asset with respect to what would be the actual effectiveness of these policies and the potential for implementation.

Data availability

F1000Research: Dataset 1. Questions and responses of the survey, [10.5256/f1000research.7683.d110888](https://doi.org/10.5256/f1000research.7683.d110888)²¹

Supplementary material

Figures S1–S6. Data on the invitations to the questionnaire.

Figures S7–S11. Data on the response rates of the questionnaire.

Figures S12–S18. Data describing the sample of scientists participating to the questionnaire.

Figures S19–S26. Data describing the differences in the responses based on geographical location.

Figures S27–S30. Additional data on scientists views on criteria of evaluation and funding of basic research.

Tables showing the detailed percentages of responses for all the figures of the paper (Figures 1–16).

Author contributions

Study design: Andrea Ballabeni, David Hemenway, Giorgio Scita. Data collection: Andrea Ballabeni, Stefano Confalonieri, Carmen Sorrentino. Data analysis: Andrea Ballabeni, Andrea Boggio, Stefano Confalonieri, David Hemenway, Carmen Sorrentino, Giorgio Scita. Manuscript writing: Andrea Ballabeni, Andrea Boggio, David Hemenway, Giorgio Scita.

Competing interests

The authors declare no competing interests.

Grant information

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We confirm that the funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Acknowledgements

We thank Celeste Ungaro (IFOM) for her administrative and organizational support, Assunta Croce (IFOM) for her feedback during the preparation of the study, Ivan Lago (IFOM) and Manuele Malizia (IFOM) for their IT support. We thank Cariplo foundation (<http://www.fondazionecariplo.it/en/index.html>) for funding the study and Silvia Pigozzi (Cariplo foundation) for her assistance on behalf of the funding organization.

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Reviewer Report 02 June 2016

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 **Nathan L. Vanderford** 

Markey Cancer Center, Department of Toxicology and Cancer Biology, College of Medicine, University of Kentucky, Lexington, KY, USA

Sorrentino *et al.* have been highly responsive to my previous review and the article is much improved. I find the article acceptable at this stage. With that said, if the authors wish to further improve the article, I believe that it would be helpful to incorporate the details of the statistical analysis within the methods section and it would be helpful to include a table(s) summarizing all the results of the statistical analysis.

I appreciate the authors' responsiveness and I have enjoyed reviewing their work.

Competing Interests: No competing interests were disclosed.

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

Version 1

Reviewer Report 05 April 2016

<https://doi.org/10.5256/f1000research.8273.r13079>

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 **Viviane Callier**

Developmental Physiology, Ronin Institute, Montclair, NJ, USA

This research paper reports the results of a survey of biomedical and biological scientists about their motivations and attitudes with respect to basic research. They found that basic scientists are mainly driven by a goal to satisfy their curiosity and to advance fundamental knowledge. They also have an aspiration to impact human health, usually in an abstract or yet-undefined way. Prestige is a motivator for some.

The thoroughly reported survey results showed that researchers feel ambivalent about the "statement of public health relevance" sections that accompany most grant proposals to biomedical funding agencies. Some favor getting rid of this section. This is important information for the scientific community and for funding agencies to consider.

This research paper is timely because the importance of basic research has been on the mind of the leaders at NIH, the largest biomedical funding agency in the world, as shown in their recent [letter](#) to *Science*. In it, the NIH leadership says that the research community erroneously believes that the "statement of public health relevance" means that the agency does not value basic research, when in fact, the NIH leadership says it does. However, at several agencies including NINDS and NCI, the proportion of basic science proposals received is going down, while the proportion of "hybrid" or applied/clinical research proposals is going up. This means that many investigators are shifting their application strategy towards applied research because they think it is more likely to gain funding.

Ultimately, it is the scientists on review panels, not just NIH leadership, who determine which research gets funded. So, if the agency and the research community values basic research, there needs to be a change in culture so that scientifically sound and meritorious proposals gain funding even if they do not have specific clinical applications. Reviewers in basic science study sections should be instructed to evaluate proposals on experimental design and novelty but not clinical relevance.

Future research on how the tight funding climate has impacted attitudes towards basic research, and ideas on how to reverse the trend of decreasing numbers of basic research proposals, would be very interesting to funding agencies and policy makers.

This is an interesting and well written paper. I have a few suggestions to improve the paper. There are many figures and the information contained in these figures could be consolidated into fewer figures to make it easier to interpret. Statistical analysis of the data would also make the conclusions stronger. All in all, the findings make intuitive sense and it is nice to have the data to confirm these intuitions.

Competing Interests: No competing interests were disclosed.

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

Author Response 13 May 2016

Andrea Ballabeni, Harvard T.H. Chan School of Public Health, Boston, USA

We would like to thank Dr. Viviane Callier for taking the time to read and review our manuscript. We have appreciated reading her thoughts on these topics.

Competing Interests: No competing interests were disclosed.

Reviewer Report 01 April 2016

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Nathan L. Vanderford 

Markey Cancer Center, Department of Toxicology and Cancer Biology, College of Medicine, University of Kentucky, Lexington, KY, USA

Scita *et al.* present survey research findings on basic scientists' perceptions of the public health relevance of their work as well as their attitudes toward their own personal satisfaction. This work is interesting especially as it relates to scientists' perceptions of their work versus the public's consumption of that work and the associated policies around that interaction.

There are several issues with the current version of the article that lead me to approving it with reservations.

1. The current title could be improved and clarified. The part on scientists' satisfaction seems to be an afterthought as written.
2. The specific research questions and/or hypotheses for the study should be clearly stated.
3. Clarification is needed to allow readers to better understand the differences and similarities between "study 1" versus "study 2." What is the overlap of the study design and findings? A better explanation as to how "study 1" informed "study 2" would be helpful.
4. The data on the respondent demographics and response rates should be clarified (the current figures and text are not clear). Adding this information into the main text, in table format, may be useful.
5. The clarity of the article would benefit from simplifying the presentation of the data: 16 figures in the main text is overwhelming. Can some of the data be summarized and collapsed into a couple of tables and/or can some of the data be included as supplemental material?
6. The findings would be greatly enhanced by including some statistical testing. Related to

that, what is the primary outcome variable(s) of the study? What are the independent and dependent variables? Testing for association of the outcome(s) with items such as career stage (eg, PI, postdoc, etc.), gender, age, and geographic location would be very interesting and informative.

7. At the beginning of the soft policies section on page 12 of the PDF, the statement “[w]e tested scientists’ opinions...” should be demonstrated through statistical analysis.
8. Without statistical analysis, the conclusions should not be written to suggest negative or positive correlations.
9. The results of this study should be discussed in context of the related literature in the “conclusions and discussion” section. Perhaps it would be best to have a separate conclusion and discussion section.
10. Why is it that the text in some of the figure legends is underlined and in other figure legends the text is not underlined?

I look forward to reviewing a revised version of the article.

Competing Interests: No competing interests were disclosed.

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Author Response 13 May 2016

Andrea Ballabeni, Harvard T.H. Chan School of Public Health, Boston, USA

We would like to thank Dr. Nathan Vanderford for reviewing our manuscript and for providing helpful suggestions and comments. We have revised the paper according to his feedback.

We summarize here our responses, point by point

1. We have changed the title to better emphasize that we aim at increasing both the public health potential and the work satisfaction.
2. We have now inserted a new sentence in the abstract to clearly define the goals of the study.
3. In the Introduction section we have edited the previous wording and this is the new wording: “We used a slightly modified version of the Study 1 questionnaire. In particular, we added a few questions asking respondents to evaluate current policies used to evaluate/increase the public health potential as well as six new soft policies that we developed after analyzing the results of Study 1.” In the Discussion section we have changed the text and this is the new wording: “The current study substantially confirmed what we had discovered in Study 1. In particular, the new study confirmed

what we had previously observed with regard to basic scientists' motivations and conceptualization of basic research. Moreover, it further reinforces the notion that, while some estimate of the public health potential of basic investigations is always possible, basic scientists believe that the requirement of discussing this potential in research proposals is not effective". Moreover, in the Introduction section we have also added the following revised text: "Study 1 showed that increasing people's health and personal prestige are some of the strongest motivations for basic scientists. Moreover, it showed that basic scientists strongly support the idea of non-mandatory policies based on soft incentives to increase public health potential and work satisfaction. Based on these and other findings of Study 1, we designed this second study (Study 2)...".

4. We would prefer to have the figures about the invitations (Figures S1-S6) and about the response rates (Figures S7-S11) in the "Supplementary material" section because not the main goals of our research. The manuscript appear already dense in information and we would like to include in the main text only the most relevant set of information related to the analysis of the responses. In addition, the "Overview of the sample" paragraph in the "Results" section already provides a summary of the sample and response rates. However, if the reviewer thinks that some additional information should necessarily be placed in the main text we would be happy to consider it.
5. We agree with the reviewer that 16 figures are more than the conventional research articles contain and this is also the reason why we would avoid adding more figures or tables (e.g. for sample description and response rates) in the main text. The flexible format offered by F1000Research actually encourages the inclusion of figures and graphs. Based on these guidelines, we chose to show the data and convey the messages more through the figures than through the text. Indeed, even if the figures (which are not particularly dense in information and relatively easy-to-read bar/column charts) are more than in the standard average research article, the length of the text is probably shorter than in the average published manuscript.
6. We have now performed statistical analysis on the association of the motivations (Figure 1) with the role of the scientists (PIs, post-docs, students). We have introduced the following new text: "For the motivations we also performed analyses based on the roles of the scientists. We observed that some differences were statistically significant. In particular, PIs are more motivated from "Pure advancement of knowledge" ($p = 0.0042$) and less motivated from "Gain of money" ($p < 0.0001$) in comparison to post-docs. Moreover, PIs are more motivated from "Pure advancement of knowledge" ($p < 0.0001$) and "Satisfaction of curiosity" ($p = 0.0068$) and less motivated from "Gain of money" ($p = 0.0142$) in comparison to students."
7. We are not sure about the problem but, after careful consideration we think that the use of the term "tested" is appropriate in this context.
8. There was indeed one point in which we suggested a negative correlation without providing statistical analysis. We have now performed the statistical analysis and

amended the text as it follow: "For PIs, in terms of degree of involvement in basic research, there were substantial differences in favorability only in relation to policy A, for which there was a small negative correlation ($R^2 = 0.986$) (Figures 15a-f)"

9. As suggested by the reviewer, we have separated the Conclusions from the Discussion section. Since the length of the manuscript and the emphasis on figures and results, we would prefer not add more text. However, we have added a note in the Discussion section to inform that an in-depth analysis of the relevant literature as well as a discussion on the conceptual framework are present inside the manuscript describing the results of the first study recently published (i.e. Study 1) (ref. 20).
10. In some of the figure legends the text is underlined because we wanted to emphasize the specific policies. However, we agree that in this way the text is not easily readable. Therefore, we have accordingly modified the figure legends of Figures 13-16.

We hope we have addressed all the reviewer's comments and suggestions. We would like to thank Dr. Nathan Vanderford one more time for taking the time to review the manuscript and provide his useful feedback and we look forward to hearing from Dr. Vanderford.

Competing Interests: No competing interests were disclosed.No competing interests were disclosed.

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