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Review article

A consideration of group work processes in modern epidemiology

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ABSTRACT

Purpose: In the field of epidemiology, much attention has been given to the reduction of random or systematic errors in study design, analysis, and reporting. This article reviews relevant literature on group work processes. The review orients attention toward optimizing group work processes to enhance group decision making and optimize the conduct of epidemiologic work in the era of team science.
Methods: The review contrasts interactive open group work with group aggregate work. We define the latter as occurring without member to member communication. The impacts of group characteristics on process issues are examined.
Results: Group characteristics such as purpose, modality, size, and member incentives are shown to influence the likely optimal group structure for varying tasks. Open group work allows rapid communication and interactive feedback as well as the emergence of a collective intelligence above that of the individual members. However, productivity may be limited by large open group size and the multiple dyads of communication, limiting cognitive diversity and human resource capital. Furthermore, group-level biases and bias may be introduced within the group. Little quantitative work on these issues has been conducted in the epidemiologic work setting, but recent experimental research in other areas of science and management indicates that structured protocols to support dynamic group work can improve group decisions. The merit of often highly accurate group aggregate approaches, with parallel independent individual inputs such as crowd sourcing is becoming increasingly recognized. We outline several examples in recent medical research.
Conclusions: We outline principles that should be explicitly considered when setting up new work groups in epidemiology and recommend that further work on these issues be conducted.

Introduction

Human groups have worked collaboratively since ancient times. Humans now interact in a complicated social environment, leading to adaptations in group dynamics [1]. In the Internet age, groups are accomplishing increasingly complex tasks in areas such as scientific research including epidemiology, management, and other work endeavors [1,2].

However, relatively little attention is directed towards optimizing work group structures or processes to reduce random or systematic (bias) error and optimize group outcomes. In the field of epidemiology, careful attention is already given to the minimization of random error and bias in study design, implementation, analysis [3], reporting, and interpretation [4].

Epidemiologic research would further benefit by improved group work. In 2010, Woolley [2] reported on the group performance of over 700 individuals working in groups of two to five on a range of face-to-face tasks. A collective intelligence emerged from the group work, beyond the sum total of individual input. This collective intelligence was more strongly correlated with the proportion of conversational turn-taking, and social sensitivity, rather than the average or maximum intelligence of individual group members [2]. It was concluded that it may be easier to raise the intelligence of a group rather than the individual [2].

Collective intelligence is defined here as the intelligence arising from multiple individuals, working either independently or not. We define group work as where more than one individual works together on a shared task to produce an intellectual product. We distinguish between group aggregate and open group work. The first is characterized by the aggregation of individual decisions, either occurring once or iteratively in response to feedback on the

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overall group performance. A key feature is that no member-member communication exists and we term this as providing crowd intelligence. The second group dynamic, common in day-to-day work for many organizations, is that of open group work.

Traditionally, open group work has occurred face-to-face, but now is often performed electronically. It is characterized by a high level of communication and cooperation. Group dynamics will influence performance beyond the individual attributes of group members [5]. We term this group intelligence. Either type of group work can be structured to maximize informativeness and precision and reduce group-level bias. We define precision as a reduction in random error or noise to allow signal clarification and bias as a distortion or shift in the signal. In this review, we consider some of the characteristics of groups and how these, through inefficiency, bias or imprecision could impair the accuracy of group decisions.

The first issue to consider is that of group purpose, ranging from information elicitation or estimation, to problem solving requiring greater member-member coordination and communication, such as developing a multidisciplinary recommendation. Another issue is the modality of group work. Face-to-face group work can provide advantages such as social belonging and rapid iterative member-member communication but is also subject to open group bias. The Internet allows rapid and dispersed communication, which can be open or simply a summed aggregate of individual inputs. Features such as a potentially increased anonymity, decreased emphasis on physical or social cues, and greater individual control over interactions provide incentives for Internet participation [6]. However, virtual teams can, in some situations, have poorer decision making [7,8].

Optimal group size will vary depending on the nature of group task. In the context of very complex or uncertain situations requiring a high level of communication and interactive feedback, the group will be small, such as the forward scout team in war, where quick group decisions in a hostile changing environment occur. Another example is the development of highly conceptual cognitive work. In contrast, where no group communication is required, such as obtaining hidden information or conducting independent tasks, group numbers can be very large. The University of Washington had worked on solutions for folded proteins for over 15 years, but once integrated into social media, many people provided input into Foldit, a multiplayer online game [9], providing an algorithm solution to the protein-folding problem in just 10 weeks [9,10]. This group aggregate approach, using external unaffiliated individuals in parallel is also termed "crowd sourcing" [11].

However, group purpose and size is often intermediate between these extremes and often multilevel groups operate as a large group for some functions but comprise small subgroups for more specialized functions. Primates operate in large groups welding together smaller well-groomed groups [12]. The large neocortex of such primates appears to reflect the need for social intellect [12]. Neocortical size limits the number of dyad relationships that can be monitored, even in humans. Dunbar's number of 150 reflects the number of people that people may have as friends or traditional stable communities such as villages [12]. Social layering reflects the level of trust, communication, and time invested in a relationship. However, these group size estimates are disputed and Internet communication may be changing such group numbers [13]. A work group of eight to 12 persons can know each other well enough to maximize their talents [14]. In groups beyond this size, the possible combinations of communication between individuals may be too complex to handle. Tasks that cannot be handled by a group of eight to 12 are probably too complex and should be broken down further [14] This is consistent with a common management paradigm of smaller groups. Wheelan [15] examined the interplay between group size, productivity, and group development, over more than 6 months (groups of three to 25 members). They concluded groups of three to eight were generally more productive and developmentally advanced than groups of nine or more with groups of three to four often performing better than those of five to six [15].

Generally, larger teams have advantages of greater human resource capital and larger cognitive diversity [10,16]. However, individual performance is reduced [10]. This problem reflects impaired coordination, relational loss, and reduced motivation. As team size increases, it is harder to coordinate who should undertake and is performing specific roles. Relational loss occurs when a member perceives that supported assistance is less available.

A lack of individual reward or recognition linked to personal effort can tend to "social loafing" [17]. The impacts of such impediments depend on the nature of the group task. Thus, in many situations, group work may best be conducted in a large group consisting of smaller subgroups. The composition of such work groups is beyond the scope of this review but we mention some salient features for productive group work. The group size should not be too large for the given level of member-to-member communication required. In open group work, there should be a shared commitment to the group product and stability and clarity of group membership. The group task should also occur in a setting that provides the required materials and a reward system to encourage group cooperation and high performance. A superordinate identity should be promoted to enhance subgroup cohesion. Related research has supported these concepts. A 2006 meta-analysis concluded that intergroup problems within a larger group could be reduced by prejudice reduction with the promotion of equal group status; common goals; cooperation; and the support of authority including social customs [18].

There has been an exponential increase in research consortia articles listed in PubMed from 1985 to 2012 with an r^2 value for increasing calendar years of 0.84 [19]. For cancer epidemiology alone, there are 49 cancer epidemiology consortia supported by the Epidemiology and Genomics Research Program at the National Cancer Institute [19]. These provide opportunities for complex multidisciplinary, interdisciplinary, and transdisciplinary research [20].

To illustrate, we provide one concrete example. The Research on Energetics and Cancer research collaboration [21] has four centers and 1 coordinating centers, 1 steering committee, (comprising an investigator for each of the five centers) which meet biannually and 13 working group (undertaking monthly teleconference calls) to conduct 15 research projects 2011–2016 with a concurrent investigator program [21]. Thus, elements of a superordinate identity, comprising smaller groups with better, more frequent, internal communication exists [21].

Intriguingly, these Consortia structures have some parallels with the online self-organization of massive multiplayer online games. Here, the exchange of information and resources encourage large guilds, defined as an association of persons of the same pursuit, to protect mutual interests and standards [22]. These are then comprised of smaller subgroups. In massive multiplayer online games, the optimal guild size for creative and technical work is around 45–50 [12,22–24] with a quantitative evaluation demonstrating a 90th centile of 55 for guild size [22]. Within the guild, the complexity level of game activities encourage an optimal subgroup size of six [22]. Guild survival is predicted not only by size but also by composition—a wide level spread of new versus experienced players and member diversity and elements of communication such as higher density of intraguild communication and enhanced social grooming, that is, the development of interpersonal bonds [22–24].

The final group characteristic we consider is the pattern of incentives for group members. Greater individual effort occurs if